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TABLE OF CONTENTS

S.No.	Title	Page No.
1.	Analysis of Variance Components for Quantitative Traits in F2 Population of <i>Cucumis melo</i> L. derived from the Cross <i>Cucumis melo</i> ssp. <i>agrestis</i> (local cultivar) X <i>Cucumis melo</i> ssp. <i>omordica</i> (Snap melon). Afreen Mohammed Siraj B, Rekha B Chittapur, Satish D, Namita Raut and Shivayogi Rayavalad	197-202
2.	Assessment of Chrysanthemum Varieties for Enhanced Cut Flower Quality and Yield in Polyhouse Cultivation. Pallavi S, Satish R. Patil and Balaji S. Kulkarni	203-206
3.	Assessment of Different Varieties of African Marigold (<i>Tagetes Erecta</i>) for Growth and Flowering Attributes under the Northern Dry Zone. Shridevi Hirekumbi, Sateesh R. Patil and Balaji S. Kulkarni	207-210
4.	Assessment of Genetic Variability, Heritability and Genetic Advance in French Marigold (<i>Tagetes patula</i>) Genotypes. Pratheeksha C T, Balaji S. Kulkarni, Pavankumar P, A M Shirol, Thammaiah N, Satish D, Sandhyarani Nishani and Udaya T V	211-215
5.	Assessment of Gladiolus Varieties for Growth and Floral Yield in Open Field Cultivation. Aishwarya S. Jeevanagi^{1*}, Satish R. Patil² and Balaji S. Kulkarni⁴	216-219
6.	Assessment of Grafting and Budding Success in Different Varieties of Ber under In-situ Condition. Chandrasekhar, Sangeeta Lakshmeshwara, I B Biradar, Anand Nanjappanavar, Suhasini Jalwadi and Dhanavath Shanthi	220-225
7.	Assessment of per se Performance of Gomphrena (<i>Gomphrena globosa</i> L.) Genotypes for Productivity and Quality traits. G N Nagajyothi, Balaji S Kulkarni, D Satish and Sateesh R Patil	226-231
8.	Bioefficacy of chlorantraniliprole (AC 01) 0.4%GR against Early Shoot Borer and Termites in Sugarcane. B. Bhavani	232-237
9.	Communication Skills and Knowledge Transfer among Livestock Farmers through WhatsApp. Thangadurai R	238-242
10.	Comparative Economics of Groundnut Cultivation under Sprinkler and Conventional Irrigation Methods. Dharmik G Borisagar, O P Singh and Vaishnavi Singh	243-250
11.	Constraints Perceived by Rainbow Trout (<i>Oncorhynchus mykiss</i>) Fish Farmers in Adoption of Fish Farming Practices in Jammu and Kashmir. Hanuman Lal Verma and Nazir Ahmad Sofi	251-256

S.No.	Title	Page No.
12.	Determination of Alcohol in Botanical Extracts Using a Simple and Cost-Effective Oven-Based Assay. N Jayarama Naik, DL Rudresh and MM Yasmin Banu	257-260
13.	Effect of Dietary Xylanase enzyme Supplementation on the Performance of Growing Crossbred Pigs. Sourabh Nagwanshi, Sunil Nayak and Biswajit Roy	261-266
14.	Effect of Different Vase Solutions on Vase Life of Gladiolus (<i>Gladiolus grandiflorus</i>). G N Nagajyothi and Amreen Taj	267-272
15.	Effect of Evaporative Cooling on Colour and Quality Changes During Ripening of Grand Naine Banana. Shanmugasundaram K A, Gayathri S, Shudeepa P and Sibi Vishnu S.	273-277
16.	Effect of Foliar Application of Micronutrients and Plant Growth Regulators on Quality of Guava (<i>Psidium guajava</i> L.) Cv. Lalit . K Jawahar Srinith , CT Sathappan and Sharvesh S	278-281
17.	Effect of Foliar Application of Micronutrients on Growth and Yield of Marigold (<i>Tagetes Erecta</i> L.) A Anburani, Ajith D and B. Pavan Kumar Naik.	282-287
18.	Effect of Methyl jasmonate (MeJA) on Biochemical Constituents of Seed Treated Tomato. Vijaylaxmi Irayya Mathapati, A M Nadaf , M G Kerutagi , R B Hirekurubar , Mohana kumara P , Dileepkumar Masuti and S G Praveenakumar	288-291
19.	Effect of Secondary Nutrients and Biofertilizers on Growth, Yield and Quality of Chilli (<i>Capsicum annuum</i> L.). H Rashmi, V Srinivasa, Devaraju, M Shivaprasad and C S Ravi	292-296
20.	Effect of Various Potting Media on Growth Characteristics of Phalsa Cuttings (<i>Grewia subinaequalis</i> L.). V Jeevanantham, S Sharvesh, CT Sathappan and C Muruganandham	297-301
21.	Effect of Various Processing Methods on Nutritional and Anti-Nutritional Compositions of Brown Rice. Priyanka Thakur	302-311
22.	Efficacy of Growth Regulators on Sprouting of Bush Pepper Cuttings (<i>Piper nigrum</i> L.). Vigneswari G, Samlind Sujin G and Sharvesh S	312-315
23.	Efficacy of Integrated Nutrient Management on Rhizome Productivity in Mango Ginger (<i>Curcuma amada</i> Roxb.). Muruganandam C, Sharvesh S, Dharanidharan S and Madhan	316-319
24.	Efficacy of Pest Management Modules against Aphids and Pod Borer Complex of Indian bean. R B Hirekurubar, Suvarna Patil, R Raghunatha, Rekha Chittapur and Shweta Hiremath	320-324

S.No.	Title	Page No.
25.	Endophytic Potential of Indigenous <i>Beauveria bassiana</i> against <i>Spodoptera litura</i> Fabricius in Cabbage. T Yogananda, S H Ramanagouda, Lokesh and M Y Kumuda	325-330
26.	Enhancing Longevity: Extending the Vase Life of <i>Asparagus setaceus</i> (syn. <i>plumosus</i>) with Chemical Preservatives. Pratheeksha CT, Pavan kumar P, Shirol AM, Sateesh R. Patil, MD Jameel Jhaleghar and Udaya TV	331-337
27.	Evaluation of Chrysanthemum (<i>Dendranthema grandiflora</i> Tzvelve) Varieties for Growth, Quality and Yield Under Northern Dry Zone of Karnataka. Rajiyabegaum S. Hosalli, Sateesh R. Patil, Balaji S. Kulkarni, Laxman Kukanoor and Vidyashri Gundale	338-342
28.	Evaluation of Chrysanthemum Cultivars for Cut Flower Production Under Polyhouse Conditions. K N Punith Kumar, Sateesh R Patil, Balaji S Kulkarni and Sanganasava G Gollagi	343-346
29.	Evaluation of Different Hybrids of Petunia (<i>Petunia hybrida</i>) for Growth, Quality and Yield Attributes Under Northern Dry Zone of Karnataka. Vidyashri Gundale, Sateesh R. Patil, Balaji S. Kulakarni, Naveen M P and Rajiyabegaum S. Hosalli	347-352
30.	Evaluation of Gladiolus Cultivars for Cut Flower Production Under Open Field Conditions. Sangeetha R. Nair, Sateesh R. Patil, Mukund Shiragur, Balaji S. Kulkarni, Aishwarya S. Jeevanagi, Punith Kumar K N, Harshad Padasalagi and Pallavi S	353-356
31.	Evaluation of Indigenous Endophytic <i>Beauveria bassiana</i> UHSB-END1 against Grape Mealy Bug <i>Maconellicoccus hirsutus</i> (Green). MY Kumuda, C Satyanarayana and T Yogananda	357-362
32.	Evaluation of Marigold Varieties for Growth and Quality Parameters. R Shobha, S R Patil, M R Bhuvan1, B S Kulkarni and A M Shirol	363-367
33.	Evaluation of New Alternatives of Neonicotinoid Insecticides Against Sucking Pests of Okra. Suvarna Patil, RB Hirekurubar, R Raghunatha, BArunkumar and LH Kukanoor	368-372
34.	Farmers Field School – An Innovative Approach for Transfer of Technology to Dairy Farmers. B S Khadda Komal, Gulgul Singh, Parul Gupta, Harmeet Kaur and Parkash Singh Brar	373-378
35.	Fungal Endophytes from Chilli and their Antagonism against <i>Colletotrichum capsici</i> . Harshitha B H, Noorulla Haveri, Basavarajappa M P, Ramangouda S H and Hadimani H P	379-383

S.No.	Title	Page No.
36.	Genotypic and Phenotypic Correlation Analysis for Important Quantitative Characteristics in Okra Cultivars. Udit Joshi, D K Rana, Yogesh Kumar, Arun Prakash and Kamlesh Kumar Yadav	384-390
37.	Impact of Controlled Environment on Growth and Flowering of Gerbera (<i>Gerbera jamesonii</i> Bolus). Pooja V Kudiganur, Sateesh R. Patil, Balaji S Kulkarni, Basavarajappa HR, Vijayalakshmi Patil and Kirankumar Abbigeri	391-394
38.	Impact of Pre-Harvest Fruit Bunch Bagging on Yield and Quality of Different Litchi (<i>Litchi chinensis</i> Sonn.) Cultivars. Rajesh Das, Diya Ghosal, Nilesh Bhowmick, Mutum Preema Devi, Nandita Sahana and Aditi Chakraborty	395-401
39.	Impact of Rootstock Selection and Cane Regulation on the Organoleptic Characteristics of Wine. Suraj S Hanni, S N Patil, Anand G. Nanjapanavar, I B Biradar, Mallikarjun Awati, Venkateshalu and Pooja Murthy S	402-408
40.	Impact of Spacing and Fertilizer Levels on Quality Attributes of Pinwheel Flower (<i>Tabernaemontana divaricata</i> L.). Gowtham K M, Basavarajappa H R, Anasubai S. Hosagoudar, Sanjeevraddi G. Reddi and Ramanagouda Hadlageri	409-413
41.	In Vitro Shoot Induction of Highbush Blueberry (<i>Vaccinium corymbosum</i> L.). Roshani G Jagtap and Rohini M Kolekar	414-420
42.	Influence of Dwarf Interstock on Inter-stock Grafting in Cashew (<i>Anacardium occidentale</i>). Bhagya H P, Adiga J D, Thondaiman V, Manjesh G N, Babli mog, Veena G L, Rajashekara H, Siddanna Savadi and Manjunatha K	421-425
43.	Influence of Entomopathogenic Fungi <i>Beauveria bassiana</i> on Growth and Yield of Tomato (<i>Solanum lycopersicum</i> L.). Niveditha V, Sanjeevraddi G R, Prasanna S M, S A R Mulla and Venkateshalu B	426-434
44.	Integrated Management of Stem and Root Rot of Sesame caused by <i>Macrophomina phaseolina</i> (Tassi) Goid. Rohini Sutar, Prabhavathi, N M S S Anjum and Anisa M Nimbal	435-438
45.	Management of Grape Downy Mildew under Field Conditions Using Fungitoxicants. Noorulla Haveri, Basavarajappa M P, Manjunath Hubballi, Sateesh Pattepur and Gayathri V	439-443
46.	New Generation Combination Fungicide Famoxadone 16.6 % + Cymoxanil 22.1 % SC for the Management of Tomato Late Blight. Noorulla Haveri, Shashidhar K R, M Abdul Kareem, K Thulasiram and Umesh Naik	444-448
47.	Optimized Approach for Managing Post-Parturient Uterine Prolapse in Non-descript Goats. R Hema Sayee and G. Thirumalaisamy	449-452

S.No.	Title	Page No.
48.	Physiological Characteristics of <i>Colletotrichum gloeosporioides</i> : The Causal Agent of Arecanut Leaf Spot. Sangamesh M Kalyani, Lokesh M S, Ravikumar B, Vinaykumar M Mudenur, Y C Vishwanath, M P Basavarajappa, Noorulla Haveri and Manjunath Hubballi	453-456
49.	Screening of Bitter Gourd (<i>Momordica charantia</i> L.) Germplasm against Downy Mildew under Field Conditions. Kishorkumar, G K, R S Jawadagi, Noorulla Haveri, Namita Raut, Shashikant Evoor, Shivayogi Ryavalad and Sayeed W R Mulla	457-462
50.	Studies on Comparative Biology of Fruit Fly <i>Bactrocera caryae</i> (Kapoor). in <i>Garcinia</i> spp. Raghunatha R., Suvarna Patil, R B Hirekurubar , Aswathanarayana Reddy N , Javaregowda , C G Yadav and Harshavardhan M	463-466
51.	Surveillance for South American Tomato Leaf Miner <i>Tuta absoluta</i> Meyrick in Kolar and Chikkaballapur Districts of Karnataka. Shahid Muddebihal, Chandrashekar G S, Ramegowda G K	467-470
52.	Synergistic Effects of Gibberellic Acid and Brassinosteroids on Fruit Development, Yield and Quality in Kokum (<i>Garcinia indica</i>). Sharvesh S, Sathappan C T, Jawahar Srinith K. and Jeevanantham V	471-475



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Message

It is with immense pleasure and profound gratitude that I pen this message for this special issue of the Journal of Krishi Vigyan, dedicated to the Global Conference on Smart Horticulture for Prosperity and Nutritional Security (GCSH-2025). This landmark conference, successfully hosted by the University of Horticultural Sciences, College of Horticulture, Bagalkot, from February 12th to 14th, 2025, truly marked a significant milestone in our collective pursuit of a more sustainable and secure future. Smart Horticulture, as we highlighted throughout GCSH-2025, represents a transformative approach to farming. It's an innovative methodology that not only enhances crop yields and quality but also optimizes the crucial utilization of resources like water, energy, and land. By embracing smart horticultural practices, we can significantly reduce waste, promote sustainable methods, and ultimately improve the livelihoods of our farmers through reduced poverty and enhanced economic stability. The core tenets of Smart Horticulture — substantially improved land output rates, resource-use efficiency, and productivity — are vital for the overall sustainable development of the horticultural industry. Furthermore, its ability to enable year-round cultivation ensures a steady supply of fresh, nutritious produce and directly addresses micronutrient deficiencies, combating "hidden hunger" and fostering overall well-being.

More than 1500 delegates participated from all over the world. Global Conference was conducted under ten themes covering all the aspects of smart horticulture. Global conference yielded more than two thousand abstracts and more than fifty full-length articles

I am thankful to the editorial committee of the Journal of Krishi Vigyan for accepting to publish research articles of the conference in the esteemed journal. This special issue of the Journal of Krishi Vigyan serves as a testament to the insights gained during GCSH-2025. I am confident that the knowledge encapsulated within these pages will further catalyze advancements in Smart Horticulture, guiding us towards a future where prosperity and nutritional security are within reach for all.

(Balaji S. Kulkarni)



Analysis of Variance Components for Quantitative Traits in F₂ Population of *Cucumis melo* L. derived from the Cross *Cucumis melo* ssp. *agrestis* (local cultivar) X *Cucumis melo* ssp. *momordica* (Snap melon)

Afreen Mohammed Siraj B, Rekha B Chittapur, Satish D, Namita Raut and
Shivayogi Rayavalad

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ABSTRACT

An experiment was conducted during the *Kharif* season of 2023 at the College of Horticulture, Bagalkot, to evaluate the genetic variability of yield and quality traits in a 235-member F₂ population of *Cucumis melo* L. The study utilized an augmented block design with three checks. Analysis of variance revealed significant differences among the genotypes for nearly all traits, indicating substantial genetic variability. The range of variation was widest for individual fruit weight (110–930 g), yield per vine (480–5180 g), shelf life (5–16d), and total soluble solids (3.10–6.71°Brix). Genotypic coefficients of variation (GCV) were lower than phenotypic coefficients of variation (PCV) for all traits, suggesting environmental influence on trait expression. High heritability coupled with high genetic advance over mean (GAM) was observed for all traits except days to first male and female flower appearance. These findings suggest that selection for most traits can be effective, with the exception of flowering time traits.

Keywords: Coefficient of Variation, Genetic Advance, Genotype, Genotypic, Heritability, Phenotypic.

INTRODUCTION

Cucumis melo is an economically important plant belonging to the Cucurbitaceae family, widely cultivated in both temperate and tropical regions (Fernandez-Trujillo *et al*, 2011). It is a diploid species with a chromosome number of $2n = 24$ (Dane, 1991) and has a relatively small genome size, estimated between 4.5 and 5.0×10^8 base pairs (Arumuganathan and Earle, 1991; Wang *et al*, 2006). In India, melons are cultivated over 54,100 ha, yielding 1,230,660 t with a productivity of 22.74 t/ha (Anonymous, 2021). Melons are highly valued for their rich β -carotene and Vitamin-C content while being low in fat, salts, and cholesterol, and they provide essential nutrients such as potassium. The nutritional profile per 100 grams of fresh melon includes protein (0.54 g), fat (0.14 g), carbohydrates (9.09 g), fibre (0.8 g), calcium (6 mg), iron (0.17 mg), magnesium (10 mg), phosphorus (11 mg), potassium (228 mg), sodium (18 mg), zinc (0.15 mg) and ascorbic acid (18 mg) (Rachmi *et al*, 2020).

The *Cucumis melo* germplasm collections in India have not been extensively characterized for their potential to enhance overall production and improve fruit quality. As a cross-pollinated crop, muskmelon exhibits significant variability in plant architecture and

fruit traits, which can be harnessed for breeding purposes. The absence of improved varieties, coupled with production constraints, has resulted in low yields and poor fruit quality. Therefore, developing superior *Cucumis melo* varieties or hybrids tailored to specific agro-ecological conditions and end users is essential. Notably, the Indian *Cucumis melo* germplasm possesses genes associated with unique traits such as fruit quality and resistance to biotic and abiotic stresses, which can be introduced into existing cultivars through hybridization.

Conventional breeding's success hinges on the availability of genetic diversity for target traits (Ara *et al*, 2009). Plant breeders harness genetic resources to create novel gene combinations, developing crop varieties better suited to various agricultural systems (Glaszmann *et al*, 2010). However, direct selection for yield may not always lead to significant crop improvement, as yield is a complex quantitative trait. Therefore, assessing genetic parameters such as genotypic and phenotypic coefficients of variation, heritability, and genetic advance is essential to distinguish between heritable and non-heritable variations. Understanding genetic variability is a fundamental prerequisite for breeding programs. Considering these factors, this study aimed to estimate genetic variability, genetic advance, and heritability for

fruit yield and its component traits to predict the selection response in the F_2 population of *Cucumis melo*.

MATERIALS AND METHODS

The study was conducted at the College of Horticulture, Bagalkot, during the *Kharif* season of 2023. The experiment was designed using an augmented block design with three checks. F_2 population seeds were directly sown in the field with a row-to-row spacing of 1.5 meters and a plant-to-plant spacing of 1 meter. Standard agronomic practices were followed to ensure healthy, disease-free plant growth. Observations were recorded on individual plants for various traits, including vine length at 45 days and at harvest, number of primary branches, internodal length, days to first male and female flower appearance, node number to first female flower, days to first fruit harvest, number of male and female flowers, sex ratio, fruit length and diameter, individual fruit weight, number of fruits per vine, fruit yield per vine, pulp thickness, seed cavity size, moisture content, shelf life, total soluble solids (TSS), and β -carotene content.

Analysis of variance was performed for each character using standard statistical methods based on the augmented block design, as outlined by Panse and Sukhatme (1985). Genotypic and phenotypic variances were calculated using standard formulas. Genotypic and phenotypic coefficients of variation (GCV and PCV) were computed following the methods suggested by Burton (1952) and Johnson *et al* (1955), and classified as low (<10%), moderate (10–20%), and high (>20%). Heritability estimates (broad sense) were calculated using the formula by Johnson *et al* (1955) and categorized as low (0–30%), medium (30–60%), and high (>60%). Expected genetic advance (GA) as a percentage of the mean was determined using the method by Johnson *et al* (1955) and classified as low (<10%), moderate (10–20%), and high (>20%). This approach provided a comprehensive analysis of genetic variability, heritability, and genetic advance, which are essential for effective selection in breeding programs aimed at improving muskmelon traits.

RESULTS AND DISCUSSION

The analysis of variance (Table 1) conducted on the F_2 population of *Cucumis melo* at the College of Horticulture, Bagalkot, during the *Kharif* season of 2023 revealed significant differences among genotypes for all traits studied. This indicates considerable genetic variability, suggesting ample potential for improvement through selective breeding. The range of

variation was documented for the characters *viz.*, vine length at 45 days (0.40–2.40 m), vine length at harvest (0.80–3.50 m), inter nodal length (3.75–8.40 cm), number of primary branches (2–3), days to first male flower (30–38), days to first female flower (38–47), node at first female flower appears (5–7), number of male flowers (61–159), number of female flowers (5–14), sex ratio (6.8–14), days to first fruit harvest (64–84), fruit length (7–41.5 cm), fruit diameter (3.10–9.50 cm), pulp thickness (0.65–3.50 cm), seed cavity (1.20–5.10 cm), individual fruit weight (110–930g), number of fruits per vine (2–11), fruit yield per vine (480–5180 g), moisture content (82.50–93.10%), shelf life (5–16), total soluble solids (3.10 – 6.71°Brix) and beta carotene content (0.13–0.28 mg/100g).

The observed variations in fruit weight can be attributed to the increased translocation of assimilates into the fruits during the post-reproductive growth phases. Additionally, the ratio of male to female flowers is influenced by maternal changes, which are in turn affected by various environmental factors. These findings suggested that environmental conditions play a significant role in determining fruit characteristics. Overall, no single accession demonstrated superior performance across all traits studied. This indicates that while some genotypes may excel in specific characteristics, a comprehensive selection approach is necessary to improve multiple traits simultaneously. Such an approach would involve identifying and selecting genotypes that collectively exhibit desirable attributes, thereby enhancing overall crop performance.

Potekar *et al* (2014), Reddy *et al* (2013), and Janghel *et al* (2013) have reported similar findings. The analysis of the coefficients of variation at both phenotypic and genotypic levels indicated that, for most traits, the phenotypic coefficient of variation (PCV) was greater than the genotypic coefficient of variation (GCV). This suggests that environmental factors have a significant influence on the expression of these traits. However, the narrow difference between PCV and GCV implies that the environmental impact is relatively minor, allowing for effective selection based on phenotypic performance. Such findings are consistent with previous studies, which have observed similar patterns in various crops, indicating that while environmental factors do play a role, the genetic potential of the traits remains a crucial determinant of their expression (Table 2).

High magnitude of maximum GCV was recorded for number of primary branches (70.95%), fruit yield per vine (54.45%), Individual fruit weight

Analysis of Variance Components for Quantitative Traits in F2 Population

(46.41%), Vine length at 45 days (39.45%), Number of fruits per vine (32.80), Vine length at harvest (32.60), Pulp thickness (30.73%), Fruit length (28.00), Shelf life (23.90), Seed cavity (20.47%) and beta carotene content (132.14%). These high (>20 %) estimates of both GCV and PCV are showing a large range of variance and greater opportunity for selective improvement. The moderate GCV was recorded for traits viz., Number of male flowers (19.69%), Fruit diameter (18.64%), Number of female flowers (16.74%) Internodal length (15.66 %), Total soluble solids (15.57%), Moisture content (13.61%), Sex ratio (12.30%), Node at first female flower appears (11.80%), Days to first female flower (10.71%) observed low genotypic coefficients of variation (GCV) for traits such as days to first fruit harvest (8.75%) and days to first male flower (2.62%) suggest that these characteristics exhibit limited genetic variability. Additionally, the low phenotypic coefficient of variation (PCV) for days to first male flower (4.21%) indicates that environmental factors have a minimal influence on the expression of this trait. However, relying solely on GCV and PCV may not provide a complete understanding of the heritable and non-heritable components of variation. Estimating heritability and genetic advance would offer more comprehensive insights into the genetic potential of these traits.

These findings aligned with previous studies in related crops. Kumar *et al* (2011) observed similar patterns of genetic variability in sponge gourd, highlighting the importance of considering both genetic and environmental factors in breeding programs. Similarly, Chaudhari *et al* (2011) reported comparable results in muskmelon, emphasizing the need for comprehensive genetic analyses to inform selection strategies. In conclusion, while certain traits may exhibit low genetic variability, understanding their heritability and potential for genetic improvement is crucial for effective breeding programs aimed at enhancing crop performance.

High value of heritability were observed in most of the traits, such as vine length at 45 days (98.05%), vine length at harvest (79.37%), internodal length (94.50%), number of primary branches (99.78%), node at first female flower appears (96.28%), number of male flowers (95.53%), sex ratio (84.86%), days to first fruit harvest (65.52%), fruit length (93.05%), fruit diameter (96.93%), pulp thickness (97.22%), seed cavity (90.88%), individual fruit weight (98.70%), number of fruits per vine (95.11%), moisture content (95.24%), shelf life

(90.32%), total soluble solids (96.31 %) and β -carotene (98.88%). The findings indicated that these traits were genetically controlled and not influenced by environmental factors, suggesting that selection based on observable characteristics would be reliable. However, since broad-sense heritability includes total genetic variance comprising both additive (heritable) and non-additive (dominance and epistatic) effects such traits might not be ideal for further genetic improvement through selection. Moderate heritability was observed for days to first male flower (38.59%), days to first female flower (45.83%), and number of female flowers (59.50%), highlighting the role of non-additive gene actions like dominance and epistasis. None of the traits examined showed low heritability.

High GAM (above 20%) was observed for vine length at 45 days (79.79%), vine length at harvest (59.91%), number of primary branches (31.41%), internodal length (146.22%), node to first female flower appearance (23.96%), Days to first fruit harvest (39.71%), Number of male flowers (39.71%), number of female flowers (26.64%), sex ratio (23.45%), days to first fruit harvest (25.41%), fruit length (55.73 %), fruit diameter (37.84%), pulp thickness (61.63%), seed cavity (40.26%), individual fruit weight (95.61%), number of fruits per vine (66.00%), fruit yield per vine (109.55%), moisture content (26.70%), shelf life (46.90%), TSS (31.52%) and β -carotene (272.28%). Due to the influence of additive gene action, direct selection based on phenotypic expression of these traits could be effective. Similar observations were made in muskmelon by Janghel *et al* (2018). In contrast, moderate genetic advance as a percentage of mean (GAM) was recorded for days to first male flower (3.35%) and days to first female flower (3.78%), suggesting the involvement of non-additive genetic effects. Generally, traits exhibiting both high heritability and high genetic advance are predominantly controlled by additive genes, making phenotypic selection a reliable method for improvement. Traits with such a genetic pattern were observed in this study. These findings are consistent with those reported by Potekar *et al* (2014) and Janghel *et al* (2018) in muskmelon.

CONCLUSION

The results suggested that the analysis of variance revealed significant variability among the F2 population for most of the traits studied. Traits such as number of primary branches, fruit yield per vine, individual fruit weight, and beta carotene showed the highest values for both phenotypic and genotypic coefficients of variation (PCV and GCV). Moreover,

Table 1. Analysis of variance for yield and yield contributing traits in F₂ population derived from the cross UHSCS-12 X AHS-10.

Source of variation	Block (ignoring Treatments)	Treatment (eliminating Blocks)	Treatment: Check	Treatment: Test and Test vs. Check	Treatment (ignoring Blocks)	Treatment: Check	Treatment: Test	Treatment: Test vs. Check	Block (eliminating Treatments)	Residuals
d.f.	6	237	2	235	237	2	234	1	6	12
VL45	1.59 **	0.16 **	0.29 **	0.16 **	0.20 **	0.29 **	0.19 **	2.99 **	0.01	0
VLH	4.52 **	0.34 **	0.76 **	0.34 **	0.45 **	0.76 **	0.40 **	11.94 **	0.14	0.08
IL	2.116 **	0.796 **	5.59 **	0.755 **	0.849 **	5.59 **	0.791 **	5.036 **	0.023	0.043
NPB	1.942 **	3.799 **	0.003	3.832 **	3.848 **	0.003	3.893 **	1.031 **	0.003	0.009
DFMF	7.55 **	2.43	47.23 **	2.04	2.58	47.23 **	2.21	0.23	1.24	1.36
DFFF	7.36 *	3.16	40.87 **	2.83	3.28	40.87 **	2.86	28.58 **	2.28	1.55
NFFF	0.14 **	0.67 **	7.41 **	0.61 **	0.67 **	7.41 **	0.54 **	16.79 **	0.09 **	0.02
NMF	359.95 **	365.87 **	4956.62 **	326.80 **	374.73 **	4956.62 **	331.33 **	1367.87 **	9.74	14.82
NFF	2.93	3.99 *	85.14 **	3.30 *	4.01 *	85.14 **	3.11 *	51.99 **	2.25	1.26
SR	1.35 *	2.35 **	5.99 **	2.32 **	2.36 **	5.99 **	2.27 **	15.17 **	1.19 *	0.34
DFFH	14.38	15.87	455.12 **	12.13	15.9	455.12 **	8.39	895.03 **	13.23	8.33
FL	423.39 **	29.76 **	252.91 **	27.87 **	40.41 **	252.91 **	38.66 **	23.36 *	3.01	2.69
FD	5.08 **	1.56 **	50.34 **	1.15 **	1.69 **	50.34 **	1.27 **	2.90 **	0.06	0.04
PT	0.95 **	0.20 **	3.36 **	0.17 **	0.22 **	3.36 **	0.19 **	0.65 **	0	0.01
SC	1.49 **	0.497 **	12.21 **	0.398 **	0.534 **	12.21 **	0.436 **	0.002	0.052	0.04
IFW	61748.08 **	21444.88 **	169633.33 **	20183.70 **	23004.49 **	169633.33 **	21840.90 **	2027.78 **	143.51	64.88
NFPV	9.84 **	2.40 **	37.76 **	2.10 **	2.64 **	37.76 **	2.19 **	39.46 **	0.12	0.11
FYPV	2181163.8 **	548193.27 **	1681518.25 **	538547.95 **	602797.10 **	1681518.25 **	588496.05 **	1791799.79 **	24312.53	28761
MC	8.66 *	2.66	19.75 **	2.51	2.79	19.75 **	2.6	12.30 *	3.5	2.39
SL	0.77	4.29 **	57.33 **	3.83 **	4.29 **	57.33 **	3.84 **	3.20 *	0.79	0.37
TSS	1.37 **	1.01 **	36.43 **	0.71 **	1.04 **	36.43 **	0.65 **	22.81 **	0.12 **	0.02
BC	0.155 **	0.099 **	0.033 **	0.100 **	0.1039 **	0.033 **	0.104 **	0.002 **	0.00009	0.00012

*And ** indicates significance of values at $P=0.05$ and $P=0.01$, respectively

traits including fruit yield per vine, individual fruit weight, number of fruits per vine, number of primary branches, β -carotene content, and vine length at 45 days exhibited high heritability along with a high

genetic advance as a percentage of the mean. This indicates that these traits are largely influenced by additive genetic effects and should be prioritized during selection.

Analysis of Variance Components for Quantitative Traits in F₂ Population

Table 2. Estimation of genetic variability parameters for yield and yield contributing traits in F₂ population derived from the cross UHSCS-12 X AHS-10.

Sr. No.	Trait	Mean $\pm$ S.Em	Range		PCV (%)	GCV (%)	h ² _{bs} (%)	GAM (%)
			Min	Max				
1	Vine length at 45 days (m)	1.10 $\pm$ 0.03	0.40	2.30	39.45	39.06	98.05	79.79
2	Vine length at harvest (m)	1.72 $\pm$ 0.04	0.80	3.50	36.59	32.60	79.37	59.91
3	Internodal length (cm)	5.51 $\pm$ 0.06	3.75	8.40	16.11	15.66	94.50	31.41
4	Number of primary branches	2.65 $\pm$ 0.03	2.00	3.00	71.03	70.95	99.78	146.22
5	Days to first male flower	35.31 $\pm$ 0.10	30.00	38.00	4.21	2.62	38.59	3.35
6	Days to first female flower	42.23 $\pm$ 0.11	38.00	47.00	14.00	10.71	45.83	3.78
7	Node at first female flower	6.12 $\pm$ 0.05	5.00	7.00	12.00	11.80	96.28	23.96
8	Number of male flowers	90.24 $\pm$ 1.19	61.00	159.00	20.50	19.69	95.53	39.71
9	Number of female flowers	8.11 $\pm$ 0.12	5.00	14.00	21.70	16.74	59.50	26.64
10	Sex ratio	11.12 $\pm$ 0.10	6.80	14.00	13.39	12.30	84.86	23.45
11	Days to first fruit harvest	78.71 $\pm$ 0.19	64.00	84.00	12.30	8.75	65.52	25.41
12	Fruit length (cm)	21.42 $\pm$ 0.41	7.00	41.50	29.03	28.00	93.05	55.73
13	Fruit diameter (cm)	5.95 $\pm$ 0.07	3.10	9.50	18.92	18.63	96.93	37.84
14	Pulp thickness (cm)	1.43 $\pm$ 0.03	0.65	3.50	30.73	30.30	97.22	61.63
15	Seed cavity (cm)	3.08 $\pm$ 0.04	1.20	5.10	21.47	20.47	90.88	40.26
16	Individual fruit weight (g)	317.84 $\pm$ 9.64	110.00	930.00	46.48	46.41	98.70	95.61
17	Number of fruits per vine	4.38 $\pm$ 0.10	2.00	11.00	33.64	32.80	95.11	66.00
18	Fruit yield per vine (g)	1370.40 $\pm$ 50.04	480.00	5180.00	55.83	54.45	95.11	109.55
19	Moisture content %	88.52 $\pm$ 0.11	82.50	93.10	13.88	13.61	95.24	26.70
20	Shelf life (days)	7.78 $\pm$ 0.13	5.00	16.00	25.17	23.92	90.32	46.90
21	Total soluble solids (°B)	5.04 $\pm$ 0.05	3.10	6.71	15.86	15.57	96.31	31.52
22	Beta carotene (mg/100g)	0.24 $\pm$ 0.02	0.13	0.28	132.14	132.06	98.88	272.28

h²_{bs}-Heritability (Broad sense)

GCV-Genotypic coefficient of variation

PCV- Phenotypic coefficient of variation

GAM- Genetic advance over mean

S.Em-Standard Error deviation from mean

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Assessment of Chrysanthemum Varieties for Enhanced Cut Flower Quality and Yield in Polyhouse Cultivation

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ABSTRACT

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is appreciated for its diverse flower forms, vibrant colors, and multifaceted uses as cut flowers, loose flowers, and potted plants. Present study evaluated the growth and flowering performance of eight chrysanthemum cultivars namely Bontempi, Hamilton, Arctic Queen, Champagne Yellow, White Marble, Yellow Marble, Lollipop, and Green Button under controlled polyhouse conditions. A randomized complete block design with three replications was employed for the assessment. Significant variability was observed among the cultivars with respect to growth and floral characteristics. White Marble recorded the highest plant height (82 cm) and maximum flower production (15 flowers/plant), while Yellow Marble exhibited the greatest plant spread (25 cm North–South and 19 cm East–West), largest disc diameter (2.8 cm), and a flower diameter of 6.3 cm. Lollipop demonstrated the highest stem girth (10 mm) whereas Purple Majesty exhibited the longest internodal length (5 cm). In addition, Green Button excelled in the number of primary branches (22) and ray floret width (1.5 cm). The findings emphasized the genetic variability influencing growth and flowering attributes and highlighted the effectiveness of polyhouse cultivation in enhancing flower quality and productivity. Among the evaluated cultivars, Bontempi, Hamilton, Arctic Queen, and Champagne Yellow showed superior potential for commercial cultivation under protected conditions meeting the quality standards required for both domestic and export markets.

Keywords: Commercial Potential, Cultivars, Growth, Floral Traits, Polyhouse, Yield.

INTRODUCTION

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is a leading ornamental crop in the floriculture industry, widely esteemed for its remarkable diversity in flower forms and colours as well as its versatility in applications including cut flowers, loose flowers, and potted plants (Anderson, 2006). It is native to Asia and Europe with China recognized as its primary center of origin and domestication (da Silva, 2003). On a global scale, chrysanthemum ranks second to rose in the international flower trade, owing to its long vase life, adaptability to diverse climatic conditions, and growing market demand. The major chrysanthemum-exporting countries include the Netherlands, Colombia, and Japan (Prakash *et al*, 2023).

In India, chrysanthemum holds substantial commercial importance, being cultivated across 11,050 ha. with an annual production of approximately 106.76 MMT of loose flowers and 6.03 lakh cut flower stems (Prakash *et al*, 2023). Karnataka stands among

the top chrysanthemum-producing states, supported by favorable agro-climatic conditions conducive to year-round cultivation. The rising demand for premium-quality flowers in both domestic and export markets has spurred the adoption of advanced cultivation methods, notably polyhouse cultivation, which provides a controlled environment to optimize yield and floral quality (Prakash *et al*, 2023). Kavitha *et al* (2019) reported that there is a need to standardize the optimum dose of nutrients particularly the integrated nutrient management for improving the soil structure, physico-chemical properties and flower yield for CO 1 variety in Tamil Nadu.

Polyhouse cultivation facilitates the regulation of critical environmental variables such as light, temperature, and humidity, thereby establishing optimal growing conditions for chrysanthemum. As facultative short-day plants, chrysanthemums respond favorably to managed photoperiods under protected conditions, resulting in superior flower quality and enhanced yield compared to open-field cultivation (Singh and Mandhar, 2014). Nevertheless, the

Table 1. Growth Parameters of Cut Chrysanthemum Varieties Under Open Polyhouse Condition.

Variety	Plant height (cm)	Plant Spread (cm)		Primary branches (no.)	Stem girth (mm)	Internodal length (cm)
		NS	EW			
White Wonder	62	21	23	8	3.5	3
Purple Majesty	65	19	17	9	3.03	5
Yellow Marble	61	25	19	8	3.8	4.5
Lollipop	77	15	18	10	4	3.1
White Marble	82	19	21	8	3.5	4.3
Marcato	60	14	18	6	3	3
Green button	75	18	22	7	3.9	2.5
Bonita sunny	63	16	20	8	3.4	2.8
S.Em ±	0.83	0.20	0.29	0.14	0.05	0.05
CD at 5%	2.94	0.62	0.89	0.43	0.15	0.15

performance of cultivars is influenced by both genetic traits and environmental conditions, necessitating systematic evaluation to identify the most suitable varieties for polyhouse cultivation across different agro-climatic regions (Reddy *et al.*, 2016). The experiment was undertaken to assess the growth and flowering characteristics of selected chrysanthemum cultivars under controlled polyhouse conditions.

MATERIALS AND METHODS

The study was conducted during the 2024–25 period at the experimental field of the Department of Floriculture, College of Horticulture, Bagalkot. The site is situated at a latitude of 16.18° N, longitude of 75.7° E, and an elevation of 533 meters above mean sea level. The polyhouse environment provided a favorable microclimate with regulated light, temperature, and humidity, creating ideal conditions for chrysanthemum growth and floral development.

The cultivars evaluated in the study included White Wonder, Purple Majesty, Yellow Marble, Lollipop, White Marble, Marcato, Green Button, and Bonita Sunny. The experimental design followed was Randomized Complete Block Design with three replications, and each treatment plot comprised 40 plants. Rooted cuttings of chrysanthemum were planted at spacing adjusted according to the growth habits of each cultivar. To improve soil fertility and structure, well-decomposed farmyard manure (FYM) was applied at a rate of 2t per 560 m² of polyhouse area. Fertilization schedules were customized for each cultivar to ensure optimal nutrition for enhanced vegetative and reproductive performance.

A single pinching operation was carried out 45 d after planting to promote lateral branching and uniform flowering. In addition, supplemental artificial lighting was provided for up to eight weeks, particularly during periods of low natural sunlight, to maintain uniform photoperiodic conditions conducive to flowering. Observations were recorded for plant height (cm), plant spread in both North–South and East–West directions (cm), number of primary branches, number of flowers per plant, flower diameter (cm), stem girth (cm), and internodal length (cm). Plant height, spread, and internodal length were measured using a standard measuring scale, while flower diameter and stem girth were measured using a vernier caliper. The collected data were subjected to statistical analysis to evaluate the significance of differences among the treatments.

RESULTS AND DISCUSSION

The data related to plant height, plant spread (North–South and East–West directions), number of primary branches, stem girth and internodal length of different chrysanthemum varieties at the grand growth stage (90 d after planting) are presented in Table 1. Among the varieties, White Marble recorded the highest plant height (82 cm), followed by Lollipop (77 cm) and Green Button (75 cm). The maximum plant spread in the North–South direction was observed in Yellow Marble (25 cm), while White Wonder exhibited the highest East–West spread (23 cm). This was followed by Green Button with a spread of 22 cm in both directions and White Marble with 21 cm in the East–West direction and 19 cm in the North–South direction.

Assessment of Chrysanthemum Varieties for Enhanced Cut Flower Quality

Table 2. Floral traits of cut chrysanthemum varieties under polyhouse condition.

Variety	Number of flower/plant (no.)	Flower diameter (cm)	Disc Diameter (cm)	Ray floret (cm)	
				Length	Width
White Wonder	12	6.5	1.2	2.8	1.5
Purple Majesty	12	5.1	2.2	2.2	1.2
Yellow Marble	13	6.3	2.8	3	1.5
Lollipop	10	4.2	2.1	3.3	1.4
White Marble	15	6.4	1	3.5	1.4
Marcato	12	4.3	1.3	2.3	1.1
Green button	14	4	1.2	1.2	0.9
Bonita sunny	8	3.3	0.8	2.2	1.1
S.Em ±	0.18	0.07	0.02	0.05	0.02
CD at 5%	0.53	0.22	0.06	0.14	0.05

Green Button produced the maximum number of primary branches (22) followed by White Wonder (21) and White Marble (21). The variety Lollipop exhibited the highest stem girth (10 mm), followed by Purple Majesty (9 mm) and White Wonder (8 mm). The longest internodal length was recorded in Purple Majesty (5 cm), followed by Yellow Marble (4.5 cm) and White Marble (4.3 cm), while the shortest internodal length was observed in Green Button (2.5 cm).

The data related to the number of flowers per plant, flower diameter, disc diameter and ray floret length and width of different chrysanthemum varieties are presented in Table 2. Among the varieties, White Marble produced the maximum number of flowers per plant (15), followed by Green Button (14) and Yellow Marble (13), whereas Bonita Sunny recorded the least number of flowers per plant (8). The largest flower diameter was observed in White Wonder (6.5 cm), closely followed by White Marble (6.4 cm) and Yellow Marble (6.3 cm), while the smallest flower diameter was recorded in Bonita Sunny (3.3 cm).

The maximum disc diameter was recorded in Yellow Marble (2.8 cm) followed by Purple Majesty (2.2 cm) and Lollipop (2.1 cm), while the smallest disc diameter was observed in Bonita Sunny (0.8 cm). In terms of ray floret length, White Marble exhibited the longest (3.5 cm), followed by Lollipop (3.3 cm) and Yellow Marble (3 cm). The shortest ray floret was recorded in Green Button (1.2 cm). The widest ray floret was observed in both White Wonder and Yellow Marble (1.5 cm each), whereas the narrowest was found in Green Button (0.9 cm).

Shankar and Tiwari (1993) suggested that plant height is an important criterion for selecting chrysanthemum cultivars. The performance of standard and spray chrysanthemums was found to be good with artificial illumination during the Rovan cyclone period for one month. Raghava *et al* (1992) stated that better vegetative growth significantly contributes to flower yield in chrysanthemums. The difference in branches among cultivars could be due to the influence of the genetic makeup of the cultivars and the existing environment (Kanamadi and Patil, 1993). Similar variations in the number of branches were also observed in chrysanthemums (Baskaran *et al*, 2004; Dahiya *et al*, 2007). Joshi *et al* (2009) stated that a greater number of branches might result from a vigorous growth habit. Variations in internodal length were also recorded by Kumar *et al* (2014) in chrysanthemums. Variations in the number of flowers per plant were also reported by Behera *et al* (2002) and Dilda *et al* (2005) in chrysanthemums. The number of flowers per plant varied from 39.89 to 109.67. Among the 10 cultivars, the differences observed could be attributed to inherent genetic factors in chrysanthemums (Hemalatha *et al*, 1992). These findings align with the results obtained by Dilda *et al* (2005) and Negi *et al* (2015). Similar variations in the number of flowers per plant were also reported in chrysanthemums (Dahiya *et al*, 2007; Punetha *et al*, 2011).

CONCLUSION

Among the chrysanthemum cultivars evaluated, the cultivars Bontempi, Hamilton, Arctic Queen, and Champagne Yellow were found to be

highly suitable for commercial polyhouse cultivation under controlled conditions due to their high vegetative growth, floral characteristics, and flower quality as found in the current study.

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Assessment of Different Varieties of African Marigold (*Tagetes Erecta*) for Growth and Flowering Attributes under the Northern Dry Zone

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ABSTRACT

The objective of the study was to evaluate the growth and flowering characteristics of eight African marigold (*Tagetes erecta*) varieties. The field experiment was carried out at the experimental plot of the Department of Floriculture and Landscaping, University of Horticultural Sciences, Bagalkot, during the rabi season (October 2024 to January 2025). The study revealed significant differences in the growth and flowering parameters among the eight evaluated varieties of marigold. Yesh Orange recorded the maximum plant height (94.67 cm), followed by Dream Yellow (89.00 cm), whereas the minimum plant height was observed in Prime Orange (75.33 cm). The variety Prime Orange exhibited superior performance in terms of the number of secondary branches (76.67) and plant spread (62.33 cm East-West and 62.67 cm North-South). The highest number of primary branches per plant was recorded in Akash Orange (16) followed by Aradhana (15) with an lowest number of branches in Lemon Yellow (9.67). Variety Aradhana exhibited an exceptional vegetative and reproductive traits, recording the maximum stem girth (20.42 mm), leaf length (10.00 cm), leaf width (8.33 cm), flower diameter (43.33 mm) and the maximum individual flower weight (18.33 gm). In contrast, Lemon Yellow recorded the lowest leaf length (7.00 cm) and leaf width (5.67 cm). The smallest flower diameter (29.09 mm) and the lesser flower weight (8.93 gm) were recorded in the Akash Orange variety.

Keywords: Assessment, Flowering Attributes, Growth, Marigold, Variety.

INTRODUCTION

Marigold (*Tagetes erecta*), a member of the Asteraceae family has long been valued for both its medicinal and decorative uses (Mahantesh *et al*, 2018). Known as African marigolds, these tall plants can grow up to three feet, producing large, globe-shaped blooms that are ideal for bedding purposes (Dixit *et al*, 2013). Their vibrant orange to yellow flowers blend well with various colour schemes and are also a crucial raw material in industries due to their high content of carotenoids, essential oils and alkaloids (Pérez *et al*, 2006). The flowers are specifically used to extract compounds like 1-limonene, ecomene, 1-linalyl acetate and 1-linalool (Narsude *et al*, 2010). Marigolds thrive in diverse soil types and require a mild climate for optimal growth and abundant flowering.

Marigolds are primarily cultivated for pigment extraction, particularly xanthophyll, which is widely used in the poultry industry to enhance chicken skin colour and egg yolk pigmentation. Karnataka alone dedicates 3,000 ha to xanthophyll production.

Commercial extraction of carotenoids from marigolds is concentrated in regions like Cochin (Kerala), Hyderabad (Telangana), Satyamangalam forest (Tamil Nadu) and Telagi near Harihar and Bangalore (Karnataka). These pigments are exported to various countries, including Mexico, Peru, the USA, Japan, Spain, Romania, several European and African nations. It has been observed that marigold varieties exhibit a lot of variation for flowering characters, which varies with varieties (Nalawadi, 1982 and Sreekala *et al*, 2002). The performance of marigold cultivars varies significantly with region, season and growing conditions (Tomar *et al*, 1972). A variety that thrives well in one location may perform poorly in another with different climatic conditions. Thus, evaluating and selecting high-yielding and biotic stress-resistant varieties suitable for specific agro-climatic regions is essential. Despite of this, farmers often rely on recommendations from peers or seed retailers, lacking awareness of region-specific varieties (Palthe *et al*, 2019). Hence, evaluating different varieties in the Bagalkot region of Karnataka was crucial for identifying varieties with desirable growth and

Table 1: Growth attributes and performance of different African marigold varieties.

Sr. No.	Variety	Plant height (cm)	No. of primary branches	No. of secondary branches	Plant spread (E - W)	Plant spread (N - S)
1	Lemon Yellow	77.67	9.67	31.33	41.67	33.33
2	Pushpa	80.00	13.67	37.00	54.67	49.67
3	Dream Yellow	89.00	10.67	56.33	56.67	38.00
4	Yesh Orange	94.67	14.33	45.00	56.00	54.00
5	Prime Orange	75.33	14.33	76.67	62.33	62.67
6	Akash Orange	88.00	16.00	30.67	60.67	45.00
7	Aradhana	86.00	15.00	71.33	62.00	55.00
8	Siri	80.33	13.33	36.00	62.00	54.67
	S.EM	3.718	1.583	9.32	6.430	5.177
	CD at 5 %	11.278	4.802	30.126	19.503	15.702
	CD at 1 %	15.653	6.664	41.814	27.069	21.794

Table 2: Growth and flowering attributes, as well as performance of different marigold varieties.

Sr. No.	Variety	Stem girth (mm)	Leaf length (cm)	Leaf width (cm)	Flower diameter (mm)	Flower weight (g)
1	Lemon Yellow	15.56	7	5.67	32.54	17.33
2	Pushpa	14.83	8.03	6.67	36.70	18.00
3	Dream Yellow	18.12	7.70	6.40	29.01	8.93
4	Yesh Orange	16.83	8.83	6.50	33.00	14.67
5	Prime Orange	18.46	8.03	5.67	32.33	8.60
6	Akash Orange	16.75	8.83	7.50	35.33	18.00
7	Aradhana	20.42	10	8.33	43.33	18.33
8	Siri	14.87	9	6.33	35.33	9.00
	S.EM	1.338	0.794	0.765	1.265	1.026
	CD at 5 %	4.057	2.408	2.319	3.838	3.111
	CD at 1 %	5.631	3.342	3.219	5.327	4.317

flowering traits. This will enable farmers to maximize profitability and ensure the sustainability of marigold cultivation. As floriculture advances, there is a growing need to recommend suitable varieties to farmers based on rigorous evaluations, thereby unlocking the full potential of marigold production (Palthe *et al*, 2019)

MATERIALS AND METHODS

The field experiment was conducted during the *rabi* season 2024 - 2025 at the experimental plot of the Department of Floriculture and Landscaping, University of Horticultural Science Bagalkot. It involved 8 varieties of marigold, such as Lemon yellow, Puspa, Dream Yellow, Yesh Orange, Prime Orange, Akash Orange, Aradhana and Siri. The study followed a Randomized Completely Block Design (RCBD) with three replications in the open field condition and the field was properly prepared through ploughing, leveling and manual weeding. Harrowing was done to break the clods, followed by criss-cross

ploughing with cultivator, then the field was pulverized by rotavator. During harrowing well-rotten farmyard manure was incorporated @ 5 kg/m² into the soil at the time of field preparation. Fertilizer was applied as NPK @ 10:10:10 kg/ha (Mahanta *et al*, 2020). Half the quantity of nitrogen and the full dose of phosphorus and potash were applied at the time of transplanting, while the remaining dose of nitrogen was applied one month after transplanting. Planting was done at a spacing of 45 cm × 45 cm, and the plot size was 3 m × 2.5 m.

The various observations were taken on growth and flowering parameters, *Viz.*, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of leaves per plant, leaf length (cm), leaf width (cm), plant spread (N - S), plant spread (E - W), Stem girth (cm), flower diameter (cm), fresh weight of individual flower (gm) and flower colour. The plant height, plant spread, leaf length and leaf width were measured by using the

Assessment of Different Varieties of African Marigold

measuring scale. The diameter of marigold flower and stem girth were measured with a Mitutoyo Vernier caliper. Three readings were taken from each treatment and the data were recorded once in a peak season of flowering during the experimental period. The data obtained on various characters were subjected to statistical analysis as per Randomized Completely Block Design and interpretation of the data was carried out in accordance with Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Growth attributes

Analysis of variance revealed significant differences in traits among the different varieties of marigold for growth and flowering characteristics. The vegetative growth parameters of marigold varieties were evaluated based on plant height (cm), number of branches, plant spread, leaf length (cm), leaf width (cm) and stem girth (cm). The data (Table 1) showed a considerable range of variation in plant height among the different 8 varieties. Significantly, the maximum height was recorded in Yesh Orange (94.67 cm), Dream Yellow (89.00 cm) and Akash Orange (88.00 cm), which were at par. The minimum plant height was recorded in Lemon Yellow (77.67 cm) and Prime Orange (75.33 cm), both of which were at par. Plant height is a critical varietal trait influenced by the genetic composition of the plant. The variation in plant height among the different varieties may be due to genotypic differences in phenotypic expression of plant height and the impact of environmental factors. Similar variation in plant height due to genotypes was also reported by Rao *et al* (2005), Singh and Singh, (2006) and Khanvilkar *et al* (2003) in marigold. Number of primary branches were significantly higher in variety (Akash Orange 16.00) followed by Aradhana (15.00) and lowest in Lemon Yellow (9.67). Prime Orange (76.67) recorded higher number of secondary branches followed by Aradhana (71.33) and lowest in Akash Orange (30.00). Variation in the number of secondary branches per plant is attributed to genetic characters (Singh and Singh, 2005, Jauhari and Singh, 2006). The maximum plant spread was observed in Prime orange (62.33 cm in E-W and 62.67 cm in N-S) at par with Aradhana (62.00 cm in E-W and 55.00 cm in N-S) and Siri (62.00 cm in E-W and 54.67 cm in N-S), while lowest spread was recorded in Lemon Yellow (41.67 cm in E-W and 33.33 cm in N-S). Differences in plant spread may be due to the inherent characteristics of the varieties, resulting from variations in their genetic makeup and adaptability. Similar findings were reported by (Bhusaraddi *et al* 2022).

The data (Table 2) revealed that the maximum stem girth was highest in Aradhana (20.42 cm) followed by Prime Orange (18.67 cm) and lowest in Pushpa (14.83 cm). Highest leaf length was found in Aradhana (10.00 cm) followed by Siri (9.00 cm) as compared to Yesh Orange (8.83 cm) and Akash Orange (8.83 cm) while lowest in Lemon yellow (7.00 cm) and Aradhana (8.33 cm) exhibited highest leaf width followed by Akasha Orange (7.50 cm), Yesh Orange (6.50 cm) and the lowest leaf width was observed in Lemon Orange and Prime Orange (5.67 cm). The variation in leaf length and width was due to genetic factor and environmental influence. The similar variations for growth attributes were found by Sharma *et al* (2019) in French marigold.

Flowering Attributes

The (Table 2) showed significant differences among the varieties. The maximum weight of an individual flower was recorded in Aradhana (18.33 gm) followed by Akash Orange and Pushpa (18 gm), whereas the lowest was observed in Prime Orange (8.60 gm). The largest flower diameter was recorded in Aradhana (43.33 mm) followed by Pushpa (36.70 mm), Akash Orange and Siri (35.33 mm) while the smallest flower diameter was found in Dream Yellow (29.01 mm). The differences in flower diameter were primarily due to genetic and environmental conditions. Similar variability was also observed by Bhusaraddi *et al* (2022) in different marigold genotypes.

CONCLUSION

Among the eight varieties evaluated, Aradhana exhibited superior performance in flowering parameters, while Prime Orange excelled in growth parameters during the rabi season in the northern dry area of Karnataka.

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Assessment of Genetic Variability, Heritability and Genetic Advance in French Marigold (*Tagetes patula*) Genotypes

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ABSTRACT

A study was done in 2021-2022 at the Department of Floriculture and Landscape Architecture, College of Horticulture, Bagalkot. The research examined 17 different growth and flower traits in French marigold (*Tagetes patula*) plants to check for genetic differences, inheritance patterns and improvement potential. The results showed clear variations among the plants for all traits studied. Flower yield per plant (204.66) and flower yield per hectare (7.01) exhibited high genetic coefficient of variation (GCV) values of 55.98% and 61.10%, respectively. Both traits demonstrated exceptional heritability estimates of 99.03% and 99.01%, indicating a strong genetic foundation for improvement through selection. The genetic advance (GA) for flower yield per plant was 234.87 (114.76% GAM), highlighting the potential for substantial yield improvements. Individual flower weight, another critical yield-related trait, showed considerable variability with a GCV of 58.94%, a heritability estimates of 98.37%, and a genetic advance of 2.02 (120.42% GAM). These findings emphasized the potential of using flower yield per plant, flower yield per hectare and individual flower weight as key traits for selection in breeding programs focused on improving marigold productivity. Additionally, shelf life, though exhibiting moderate variability, also showed heritable potential, contributing to both yield and marketability. These results underscored the efficacy of breeding programs targeting enhanced yield traits, as they exhibit high heritability and genetic advance, making them suitable characters for genetic improvement in French marigold.

Keywords: Breeding potential, Flower, French marigold, Genetic variability, Heritability, Yield.

INTRODUCTION

Floriculture is rapidly expanding as a global industry due to its diverse applications such as fulfilling aesthetic needs, creating employment, increasing rural incomes, and boosting foreign revenue. Flowers also serve as essential raw materials in the production of essences, fragrances, pharmaceuticals, and confectioneries. In India, a large share of land used for floriculture is allocated to growing traditional or loose flowers. Over two-thirds of the total area under floriculture is used to cultivate flowers such as marigold, crossandra, jasmine, rose, chrysanthemum, and tuberose. Among the states, Tamil Nadu ranks first in the production of loose flowers, with Karnataka following closely behind in both cultivated area and yield. Other key states involved in the production of loose flowers include Andhra Pradesh, Maharashtra, West Bengal, Delhi, Punjab, and Uttar Pradesh. (Anonymous, 2019).

Marigold is the leading traditional flower crop in India, contributing to over 50% of the country's total

loose flower production. It covers approximately 66.13 thousand hectares, yielding around 603.18 thousand metric tons annually (Anumala and Kumar, 2021). Among the major producing states, Karnataka ranks second, with 12.10 thousand hectares under marigold cultivation and an output of 121.93 thousand metric tons. Madhya Pradesh leads with the highest production, covering 14 thousand hectares and yielding 224.87 thousand MT. Other key contributing states include Gujarat, Andhra Pradesh, Haryana, West Bengal, and Maharashtra (Anonymous, 2019). Marigold (*Tagetes* spp.) is a highly valued commercial flower globally, prized for its vibrant colors, striking appearance, diverse sizes, shapes, and fragrance, along with its extensive applications in industrial and medicinal sectors (Priyambada *et al*, 2015). Among the 33 species in the *Tagetes* genus, only two are commercially cultivated: *Tagetes erecta* L. (African marigold) and *Tagetes patula* L. (French marigold). These species are widely used in landscaping and as loose flowers due to their varying plant heights and colorful blooms.

French marigolds play a vital role in landscaping, offering vibrant hues that span from golden yellow to rich orange and crimson. In addition to their visual appeal, they serve as a natural pest deterrent, promoting the growth and well-being of nearby plants. Their compact size and abundant blooms make them ideal for defining garden edges, filling empty spaces in flower beds, or adding lively color to potted arrangements. Beyond their ornamental benefits, these flowers help sustain ecological balance by deterring harmful pests while attracting pollinators that support a healthy garden ecosystem.

MATERIALS AND METHODS

A field experiment was carried out at the Department of Floriculture and Landscape Architecture, College of Horticulture, UHS Bagalkot, situated at approximately 75°42' E longitude, 16°10' N latitude, and an elevation of about 533 meters above mean sea level. The study was laid out using a randomized block design with two replications. The study utilized genotypes of French marigold (*Tagetes patula*). Seeds were sown in pro trays containing a 3:1:1 soil less mixture of cocopeat, perlite, and vermiculite, and planted in a polyhouse during August 2021. Daily irrigation was maintained using a rose can, and seedlings were drenched with 0.5% 19:19:19 fertilizer 15 days after sowing. Transplanting was carried out at the four- to five-leaf stage with a spacing of 60 × 45 cm. A basal application of N:P:K at 225:60:60 kg/ha was given at planting, followed by a foliar spray of urea one month post-transplanting. During the rainy season, irrigation was applied weekly, with hoeing and weeding carried out as required.

For data collection, five central plants were selected, excluding border plants. The data were collected on various parameters of vegetative, flowering and flower yield from the five randomly tagged plants in each plot at grand growth stage.

Analysis of variance (ANOVA) was performed following Panse and Sukhatme (1967), using mean values from randomly selected plants across replications. Genotypic and phenotypic coefficients of variation were calculated based on genotypic and phenotypic variances as per Burton and Devane (1953).

$$a) \text{ PCV (\%)} = \frac{\sqrt{\sigma_p^2}}{\bar{X}} \times 100$$

$$b) \text{ GCV (\%)} = \frac{\sqrt{\sigma_g^2}}{\bar{X}} \times 100$$

Where,

σ_p^2 = Phenotypic variance

σ_g^2 = Genotypic variance

$\bar{X}$ = Grand mean

PCV and GCV were classified as suggested by Sivasubramanian and Madhavamenon (1973).

0-10 % = Low

10-20 % = Moderate

> 20 % = High

Broad-sense heritability was estimated for all the traits using the following formula which was given by Johnson *et al* (1955).

$$h^2 (\%) = \frac{\sigma_g^2}{\sigma_p^2} \times 100$$

Where,

σ_p^2 = Phenotypic variance

σ_g^2 = Genotypic variance

The heritability percentage was categorized as suggested by Robinson *et al*. (1949)

0-30 % = Low 30-60 % = Moderate > 60 % = High

The extent of genetic advance expected for each character was estimated by using the following formula as suggested by Johnson *et al* (1955).

$$GA = h^2 \times k \times \sigma_p$$

Where,

h^2 = Heritability in broad sense

k = Selection differential (2.06) at 5 per cent selection intensity

σ_p = Phenotypic standard deviation

RESULTS AND DISCUSSION

The results (Table 1) revealed significant differences among the genotypes for all seventeen characters studied. In this study, the phenotypic coefficient of variation (PCV) was consistently higher than the genotypic coefficient of variation (GCV) for

Assessment of Genetic Variability, Heritability and Genetic Advance

Table 1: Genetic variability estimates for growth, yield and quality parameters in French marigold genotypes

Sr. No	Character	Mean	Range		GCV (%)	PCV (%)	h ² (%)	GA	GAM (%)
			Min	Max					
1	Plant height	35.17	25.50	60.50	24.62	24.98	97.16	17.59	50.00
2	Plant spread [E -W] (cm)	34.08	26.42	51.15	21.62	21.85	97.94	15.05	44.08
3	Plant spread [N -S] (cm)	33.83	26.19	49.15	18.28	18.43	98.40	12.64	37.36
4	Primary branches	12.97	10.48	15.57	8.56	8.63	98.39	2.27	17.57
5	Secondary branches	22.95	16.43	30.05	13.41	13.52	98.40	6.29	27.40
6	Leaf length (cm)	7.43	5.12	19.90	39.92	40.11	97.15	6.08	81.83
7	Leaf width (cm)	4.90	3.48	12.87	43.76	43.98	97.17	4.40	89.41
8	Days to first flowering	34.00	27.60	60.20	20.34	20.63	97.16	14.04	41.29
9	Days to 50% flowering	47.75	39.50	71.50	16.35	16.43	99.02	16.00	33.58
10	Duration of flowering	46.90	40.40	51.00	4.98	5.00	99.02	4.79	10.20
11	Number of flowers /plant	121.93	94.97	175.77	15.26	15.34	99.02	38.14	31.28
12	Shelf life (days)	3.45	2.30	5.05	21.98	22.16	98.42	1.55	44.93
13	flower weight (g)	1.67	0.87	4.75	58.94	59.43	98.37	2.02	120.42
14	Flower diameter (mm)	36.25	31.14	45.97	11.87	11.97	98.39	8.79	24.26
15	Flower yield /plant (g)	204.66	105.33	500.32	55.98	56.26	99.03	234.87	114.76
16	Flower yield per plot (kg)	6.37	3.55	15.58	54.49	54.76	99.68	7.11	111.71
17	Flower yield per ha (t)	7.01	3.53	18.38	61.10	61.40	99.01	8.78	125.25

GCV: Genotypic coefficient of variance
 PCV: Phenotypic coefficient of variance
 h²: Heritability (Broad sense)

GA: Genetic advance
 GAM: Genetic advance as percent mean

all traits, with a narrow difference between the two, indicating minimal environmental influence. Similar observations in marigold were reported by Sreekala *et al* (2003), Namita *et al* (2008), and Tamut and Singh (2019) in French marigold.

This highlights the role of environmental interactions in character expression. The narrow gap between PCV and GCV across all traits indicates minimal environmental influence. Estimates of genetic parameters, including PCV, GCV, heritability (broad sense), and genetic advance as a percentage of the mean (GAM), are summarized in Table 1.

High genotypic and phenotypic coefficients of variation were observed for plant height (24.62% and 24.98%), plant spread (East-West) (21.62% and 21.85%), leaf length (39.92% and 40.11%), leaf width (43.76% and 43.98%), days to first flowering (20.34% and 20.63%), shelf life (21.98% and 22.16%), individual flower weight (58.94% and 59.43%), and flower yield (g/plant: 55.98% and 56.26%; kg/plot: 54.49% and 54.76%; t/ha: 61.10% and 61.40%). These results suggested substantial genetic diversity among the genotypes, indicating that selection based on these traits would be effective and offers significant scope for genetic improvement (Fig. 1). Similar findings have

been reported by Anuja and Jahnavi (2012), Singh and Singh (2010), Yuvraj and Dhatt (2014), and Kumar *et al* (2014) in marigold.

Moderate genotypic and phenotypic coefficients of variation were recorded for plant spread (North-South) (18.28% and 18.43%), number of secondary branches (13.41% and 13.52%), days to 50% flowering (16.35% and 16.43%), flower diameter (11.87% and 11.97%), and number of flowers per plant (15.26% and 15.34%). These findings are consistent with those reported by Kavitha and Anburani (2010), Sahu *et al* (2017), and Patel *et al* (2019) in marigold. Low genotypic and phenotypic coefficients of variation were observed for the number of primary branches and flowering duration, in agreement with the results of Santhosh *et al* (2018) in marigold.

High heritability is essential for plant breeders, as it enables selection based on phenotypic performance. With high heritability, the genotype closely corresponds to the phenotype, making selection more effective by minimizing environmental influence on trait expression.

Heritability is a key genetic parameter that indicates the transmissibility of traits to the next

generation. In the present study, high heritability (in the broad sense) was recorded for all traits evaluated. This suggests that genetic factors predominantly govern the expression of these characters, making them suitable targets for direct selection to improve flower yield. Similar high heritability estimates have been reported by Yuvraj and Dhatt (2014) and Patel *et al* (2019) in African marigold, and by Sharma and Raghuvanshi (2011) in French marigold. These findings were also supported by earlier studies in marigold (Singh and Singh, 2010; Kavitha and Anburani, 2010; Singh and Saha, 2006) and chrysanthemum (Talukdar *et al*, 2003). Heritability estimates exceeded 80% for most traits, except for the number of harvests of loose flowers.

High genetic advance as a percentage of the mean was observed for plant height, plant spread (East-West and North-South), secondary branches, leaf length, leaf width, days to first flowering, days to 50% flowering, flower diameter, individual flower weight, number of flowers per plant, and flower yield. These findings are consistent with those reported by Anuja and Jahnnavi (2012) in French marigold.

Moderate genetic advance was observed for the number of primary branches per plant, duration of flowering, and shelf life. Similar results were reported by Sahu *et al* (2017) and Giri *et al* (2019) in marigold.

CONCLUSION

The analysis revealed high phenotypic (PCV) and genotypic (GCV) coefficients of variation for flower yield and number of flowers per plant, reflecting significant genetic diversity within the germplasm. Moderate variability was observed for morphological traits, including plant height, plant spread, leaf length, leaf biomass, biomass at flowering initiation, and flower diameter, indicating a wide genetic base for these characteristics.

Notably, flower yield, flower count per plant, biomass at flowering initiation, and leaf biomass exhibited both high heritability and substantial genetic advance. This combination suggests that additive gene effects predominantly govern these traits, making them particularly suitable for selective breeding. Their strong genetic control and minimal environmental influence enhance their potential for rapid improvement through selection. Consequently, these traits represent promising selection criteria in breeding programs aimed at developing superior French marigold cultivars.

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Assessment of Genetic Variability, Heritability and Genetic Advance

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Assessment of Gladiolus Varieties for Growth and Floral Yield in Open Field Cultivation

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ABSTRACT

Gladiolus (*Gladiolus grandiflorus* L.) a widely cultivated ornamental bulbous crop, valued for its vibrant flower spikes, diverse color range and extended vase life. This study evaluated the growth and floral performance of eight gladiolus cultivars under open-field conditions in Karnataka, India. The experiment was conducted at the College of Horticulture, Bagalkot by following a Randomized Complete Block Design (RCBD) with three replications, assessing 8 cultivars including Arka Ayush, Arka Amar, Arka Tilak, Arka Darshna, Punjab Pink Elegance, Manhattan, S. Lady and Dhanvantari. Significant variations were observed in growth traits such as plant height, leaf number, leaf length and leaf area. Arka Amar recorded the tallest plants (111 cm) and the highest leaf number (12), while Dhanvantari exhibited the largest leaf area (114.72 cm²). In terms of floral traits, Arka Darshna produced the highest number of spikes per plant (2.54) and Arka Amar demonstrated superior spike length (75 cm), rachis length (42.3 cm) and floret count (13). The largest floret diameter (9.1 cm) was observed in Arka Tilak, whereas Dhanvantari and Manhattan consistently displayed lower growth and floral metrics. The findings highlighted the diverse performance of gladiolus cultivars under local conditions, with Arka Amar and Arka Darshna emerging as promising options for enhanced productivity and ornamental value. This study provides valuable insights for selecting cultivars suited to open-field cultivation in Karnataka.

Keywords: Evaluation, Field Conditions, Flower, Gladiolus, Growth, Performance.

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is renowned for its attractive flower spikes, broad color range and long vase life, making it an ideal choice for cut flowers (Kumar and Singh, 2022). Gladiolus belongs to the family Iridaceae and is cultivated in many parts of the world, including India, where it thrives in regions with moderate climatic conditions (Sharma *et al.*, 2015). There are over 180 known species of the gladiolus today but only a few of them are found in most gardens. The orchids like flowers of the Butterfly gladiolus and recently a strain of miniatures have also been introduced (Bharti *et al.*, 2021). In India, gladiolus cultivation is prominent in states like Karnataka, Himachal Pradesh, Maharashtra and Uttarakhand. Karnataka, with its favorable climate and well-drained soils, provides an optimal environment for growing gladiolus under open-field conditions

(Singh *et al.*, 2017). Gladiolus cultivation in open fields in Karnataka has gained significant popularity, as it allows for the crop's optimum growth and flower production, contributing to the state's floriculture industry (Reddy *et al.*, 2014). The performance of gladiolus depends on several factors, including cultivar choice, soil type and climatic conditions. Different gladiolus cultivars exhibit variations in key traits such as flower size, spike length, blooming duration and overall flower quality, making cultivar evaluation critical for commercial success (Kumar *et al.*, 2018). The current study was conducted to evaluate various gladiolus cultivars under open-field conditions in Karnataka. The primary goal was to identify high-performing cultivars with superior growth, flowering and spike quality traits, with a focus on improving the overall commercial potential of gladiolus cultivation in the region.

Table 1: Growth performance of Gladiolus varieties evaluated under open field conditions.

Variety	Plant height (cm)	Number of leaf/plant	Leaf length (cm)	Leaf area (cm ²)
Arka Ayush	95	9	38.5	91.63
Punjab Pink Elegance	87	10	44	83.78
Arka Amar	111	12	50.6	89.46
Arka Tilak	103	9	47	79.90
S. Lady	79	10	38.6	60.37
Arka Darshna	93	11	47.6	90.63
Manhattan	96	8	52	102.54
Dhanvantari	89	9	48.2	114.72
S.Em ±	1.57	0.105	0.80	1.43
CD at 5%	4.78	0.319	2.43	4.343

Table 2: Floral traits of Gladiolus varieties assessed under open field conditions.

Variety	Number of spikes/plant	Spike length (cm)	Rachis length (cm)	Number of floret/spike	Floret diameter (cm)
Arka Ayush	1.82	59.6	26.6	12	8.7
Punjab Pink Elegance	1.39	53.3	39.7	11	7.8
Arka Amar	2.18	75	42.3	13	8.5
Arka Tilak	1.23	63.3	38.2	12	9.1
S. Lady	1.08	52.6	33.3	10	6.6
Arka Darshna	2.54	53.6	27.8	11	7.1
Manhattan	1.82	53.4	24	9	5.4
Dhanvantari	1.29	42.6	21	12	5.2
S.Em ±	0.028	0.96	0.42	0.197	0.12
CD at 5%	0.085	2.76	1.26	0.598	0.38

MATERIALS AND METHODS

The present investigation was conducted at the Department of Floriculture and Landscape Architecture, College of Horticulture, Bagalkot, Karnataka, located in the Northern Dry Zone of Karnataka at a latitude of 16.18° N, a longitude of 75.7° E and an elevation of 533 meters above mean sea level. The region experiences semi-arid climatic conditions with moderate rainfall and distinct summer and winter seasons, which are suitable for gladiolus cultivation. The experiment was laid out in a Randomized Complete Block Design (RCBD) with eight gladiolus varieties as treatments, replicated thrice. The varieties evaluated included Arka Ayush, Punjab Pink Elegance, Arka Amar, Arka Tilak, S. Lady, Arka Darshna, Manhattan and Dhanvantari. Uniform and healthy corms, free from pests and diseases, were selected for planting. The plots were prepared with a spacing of 30 cm between rows and 20 cm between plants, accommodating 20 plants per plot. The soil was

thoroughly ploughed, leveled and raised beds were prepared to ensure proper drainage. A basal dose of 30:20:30 kg NPK/ha was applied at planting, with nitrogen applied in two splits at 30 and 60 days after planting. Regular irrigation was provided at intervals of 7-10 days, depending on soil moisture levels. Manual weeding was carried out as required to maintain weed-free plots and recommended practices were followed to manage pests and diseases, ensuring healthy crop growth. Observations were recorded from five randomly selected plants in each treatment to ensure unbiased data collection. Growth parameters such as plant height, number of leaves per plant, leaf length and leaf width were measured using a measuring tape. Floral parameters, including the number of spikes per plant, spike length and rachis length, were measured using a measuring scale. Floret diameter was recorded using a vernier caliper. All data were collected systematically and averaged to assess the overall performance of each variety.

Assessment of Gladiolus Varieties for Growth and Floral Yield in Open Field Cultivation.

RESULTS AND DISCUSSION

Growth characteristics of Gladiolus cultivars

The analysis of growth parameters across gladiolus cultivars revealed significant variation among them influenced by both genetic and environmental factors (Table 1). The tallest plants were recorded in the cultivar Arka Amar (111 cm) followed by Arka Tilak (103 cm) and Manhattan (96 cm), which showed similar heights. In contrast, the shortest plants were observed in S. Lady (79 cm), with slightly taller plants in Punjab Pink Elegance (87 cm) and Dhanvantari (89 cm). This variation in plant height can be attributed to the genetic potential of each cultivar, in line with the findings of Reshma *et al.* (2017). Similarly, the number of leaves per plant varied significantly across the cultivars. Arka Amar exhibited the highest number of leaves per plant (12), followed by Arka Darshna (11). Conversely, Manhattan had the lowest number of leaves (8), which was statistically similar to Dhanvantari (9), Arka Ayush (9) and Arka Tilak (9). These differences reflect the genetic variability among cultivars, influencing their growth patterns, as also noted by Reshma *et al.* (2017). Leaf length showed a significant range among the cultivars, with Manhattan having the longest leaves (52 cm), followed by Arka Amar (50.6 cm) and Dhanvantari (48.2 cm). On the other hand, Arka Ayush and S. Lady had the shortest leaves, measuring 38.5 cm and 38.6 cm, respectively. These differences in leaf length highlight the genetic influence on growth potential, consistent with earlier studies that reported similar variations in gladiolus cultivars (Kumar, 2009). Regarding leaf area, significant differences were also observed among the cultivars. The largest leaf area was found in Dhanvantari (114.72 cm²), followed by Manhattan (102.54 cm²) and Arka Darshna (90.63 cm²). S. Lady exhibited the smallest leaf area (60.37 cm²), with Arka Tilak (79.90 cm²) and Punjab Pink Elegance (83.78 cm²) showing lower values. These differences in leaf area are crucial, as they are indicative of the plant's photosynthetic efficiency and nutrient utilization, directly impacting growth and yield. The findings align with previous research that emphasized the role of genetic factors in determining leaf area and plant productivity (Kumar *et al.*, 2009).

Floral characteristics of Gladiolus cultivars

The number of spikes per plant showed significant variation among the gladiolus cultivars. The highest number of spikes per plant was observed in Arka Darshna (2.54) followed by Arka Amar (2.18), while the lowest number of spikes per plant was

recorded in Dhanvantari (1.29). This variation in spike numbers can be attributed to the genetic differences among the cultivars, as noted by Rani *et al.* (2007), who highlighted the genetic potential's role in determining spike production. Spike length also varied significantly among the gladiolus cultivars. The highest spike length was recorded in Arka Amar (75 cm), followed by Arka Tilak (63.3 cm) and the lowest spike length was recorded in Dhanvantari (42.6 cm). This variation in spike length can be attributed to the genetic differences between cultivars, as supported by Islam *et al.* (2017) and Chourasia *et al.* (2015) who observed similar results emphasizing the role of genetic potential in determining spike length in gladiolus. The rachis length of gladiolus cultivars exhibited significant variation, with the maximum rachis length recorded in Arka Amar (42.3 cm), followed by Punjab Pink Elegance (39.7 cm) and Arka Tilak (38.2 cm). The shortest rachis length was observed in Dhanvantari (21 cm). This variation in rachis length can be attributed to the genetic traits of the cultivars and their interaction with environmental conditions. Swaroop (2010) and Pandey *et al.* (2012) also reported significant differences in rachis length among gladiolus cultivars due to both genetic and environmental factors. Regarding the number of florets per spike, significant differences were observed among gladiolus cultivars. The maximum number of florets per spike was recorded in Arka Amar (13), followed by Arka Ayush (12) and Arka Tilak (12), while the minimum number of florets per spike was recorded in Manhattan (9). The variation in the number of florets per spike can be attributed to the genetic potential of the cultivars. Similar findings were reported by Sindhu *et al.* (2016) and Meena *et al.* (2016), who noted the significant role of genetic variability in determining the number of florets per spike in gladiolus. The floret diameter also showed significant variation among gladiolus cultivars. The maximum floret diameter (9.1 cm) was observed in Arka Tilak, while the minimum floret diameter (5.2 cm) was recorded in Dhanvantari. Other cultivars had floret diameters ranging from 5.4 cm (Manhattan) to 8.7 cm (Arka Ayush). The variation in floret diameter can be attributed to the inherent genetic differences of the cultivars, which influence their flower morphology. These findings are consistent with earlier reports indicating that genetic factors play a crucial role in determining the flower size in gladiolus (Chopade, 2011; Singh *et al.*, 2017).

CONCLUSION

This study evaluated the growth and floral traits of various gladiolus cultivars under open-field

conditions, revealing significant variability driven by genetic and environmental factors. These variations reflect the genetic potential and adaptability of the cultivars to different conditions, offering insights into their ornamental and commercial value. The study highlights significant differences in growth and floral traits among gladiolus cultivars, emphasizing the role of genetic variability and environmental interaction. Cultivars such as Arka Amar and Arka Darshna demonstrated superior traits, making them ideal for enhancing productivity and ornamental appeal. These findings provided valuable insights for breeders and growers in selecting cultivars for specific commercial and aesthetic applications.

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Assessment of Grafting and Budding Success in Different Varieties of Ber under *In-situ* Condition

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ABSTRACT

Ber (*Ziziphus mauritiana*), a valuable indigenous fruit tree of the Rhamnaceae family offers significant nutritional and mineral benefits. However, its cultivation is limited due to the lack of quality planting material, with seed propagation causing variability in plant vigor, delayed fruiting and inconsistent fruit quality. In this context, vegetative propagation, particularly grafting and budding, plays a crucial role in maintaining genetic uniformity and preserving cultivar identity. Successful grafting involves callus formation and vascular union between scion and rootstock. However, graft incompatibility can hinder success when different genotypes or species are involved. This study aimed to identify the best vegetative method and variety for ber propagation under *in situ* conditions. The results showed that grafting the *Dandan* variety onto *Ziziphus mauritiana* var. *rotundifolia* which is resistant to biotic and abiotic stress gave the best results. The *Dandan* variety exhibited the highest graft height (29.83 cm, 33.83 cm, and 39.21 cm), graft diameter (0.68 cm, 0.91 cm, and 1.2 cm), number of leaves (28.00, 33.66, and 38.16), graft success (91.16%, 86.00%, and 87.83%) and graft survival rate (91.16%, 88.83%, and 87.83%) 30, 60 and 90 days after grafting respectively. In contrast, the *Chhuhar* variety grafted onto *Ziziphus mauritiana* var. *rotundifolia* showed the lowest performance. These findings underlined the importance of selecting the right root stock and variety to enhance graft success, genetic stability of ber.

Keywords: Callus, Grafting, Scion, Root stock.

INTRODUCTION

Ber or Indian jujube (*Ziziphus mauritiana*) is an important minor indigenous fruit tree belonging to family Rhamanaceae. It is called as king of arid fruits, poor man's fruit, Chinese date and Chinese fig *etc.* because of its high nutritive value and comparatively lower market price (Morwal *et al*, 2018). It has recently attained importance as an arid zone horticulture crop, because of its hardy nature and high yield potential (Nath *et al*, 2000). The fruits are rich in minerals like phosphorus, calcium, iron, vitamin C, A and B complex, the composition varies with varieties. The fruit is the most well-known used product from the tree. Its leaves contain 5.6 percent digestible crude protein and 49.70 percent total digestible nutrients, making it a nutritive fodder for animals (Sharif *et al*, 2015). Though the fruit crop is having vast scope, the expansion of area under cultivation is limited due to the non-availability of sufficient genuine planting material.

Ber is propagated both by seeds and vegetative methods. The most common and simplest method of raising the ber tree is from seed (Singh, 2022). As the tree do not bear true to type fruits it leads to immense variation in fruit and yield characters. In this regard importance of vegetative propagation in ensuring genetic uniformity and preserving the identity of clones or cultivars is well established in horticultural crops. Hence, identifying an efficient method for the rapid multiplication of superior ber plants is essential. Hence, vegetative methods like grafting, budding are adopted in this crop. The important budding methods followed are approach and softwood grafting. The rootstock generally used for grafting is *Ziziphus mauritiana* var. *rotundifolia* which can withstand long periods of drought, salt and water logging and can therefore be grown on degraded or marginal lands (Verma *et al*, 2000). Hence, the present study aimed to evaluate and identify the most effective vegetative propagation method and suitable ber (*Ziziphus*

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mauritiana) variety under in situ conditions to enhance establishment, growth performance, and overall propagation success.

MATERIALS AND METHODS

The present investigation was carried out at Department of Fruit Science, Kittur Rani Channamma College of Horticulture, Arabhavi to study the grafting and budding success under *in-situ* condition using six varieties of ber as scion on local rootstock (*Z. rotundifolia*). Softwood grafting was carried out using rootstocks that were five months old. The terminal portion of the rootstock was removed using a sharp knife and secateurs. A vertical slit, approximately 5 cm in length, was then made on the cut surface of the rootstock. A scion of similar diameter was selected, and its basal end was trimmed with two gentle, slanting cuts on opposite sides to form a wedge by removing both bark and a small portion of wood. This wedge-shaped scion was carefully inserted into the slit on the rootstock, ensuring proper alignment. It was then tightly secured using a 150-gauge transparent white polythene strip, measuring 1.5 cm in width and 30 to 45 cm in length, to maintain close contact between scion and stock. Finally, the grafted scions were enclosed in small transparent plastic tubes for protection. In chip budding the first step is to make a cut about 2-2.5 cm long with a depth of 25 percent of the stock diameter with a horizontal cut made at the bottom of first cut and remove the cut portion from the stock. Then prepare a scion of same size containing active bud such that it exactly fits the cut portion made in the stock portion. After fitting the scion bud into the rootstock hold the bud tightly to stock and wrap the graft tape such (leaving bud to sprout) that there should not be any space for movement of air and water at the union portion.

RESULTS AND DISCUSSION

Graft height

In the present investigation, softwood wedge grafting showed significantly highest graft height (22.27 cm) at 30 DAG, compared to chip budding while at 60 and 90 DAG chip budding showed significantly highest graft height (29.33 and 40.27 cm), respectively (Table 1). While comparing various methods of grafting and budding Kim *et al* (1988) and Chandel *et al* (1998) also obtained the maximum growth of plants with chip budding because formation of quick and strong union, higher uptake of water and nutrients and longer growing period may account for the higher growth of chip-budded plants. Dandan variety showed

highest graft height (23.83 and 31.08 cm) at 30 and 60 DAG respectively, which was on par with Sannaur-2 and Meharun (22.00 and 21.43 cm) at 30 DAG respectively, Sannaur-2 and Gola (30.83 and 29.66 cm) at 60 DAG respectively, while at 90 DAG Gola showed highest graft height (39.16 cm) followed by Dandan (38.83 cm) and Sannaur-2 (38.50 cm). Significantly minimum graft height was found in Chhuhara at different stages of growth (19.83, 25.33 and 31.78 cm) at 30, 60 and 90 DAG respectively. This increase in graft height was mainly because of better graft success of improved varieties with the local rootstock. The reports were similar to findings of Patil *et al* (2008). The interaction of propagation and varieties showed non-significant difference with respect to graft height at 30 and 60 DAG, while at 90 DAG chip budding of Dandan showed the highest graft height (45.66 cm), followed by chip budding of Gola and Sannaur-2 (43.00 and 42.33 cm) at 90 DAG, respectively. Significantly minimum graft height was in softwood wedge grafting of Meharun variety (29.00 cm) at 90 DAG. This difference in height may be due to the better nutrient uptake by grafts at different stages of their growth. This might be also due to the vigour and genetic makeup of individual varieties.

Graft girth

The softwood wedge grafting showed significantly high graft girth (0.64 cm) at 30 DAG, while at 60 and 90 DAG the highest graft height was noticed in chip budding 0.92 and 1.36 cm, respectively. Initially the minimum graft girth was observed in chip budding (0.55 cm) at 30 DAG, while at 60 and 90 DAG minimum graft girth was seen in softwood wedge grafting (0.78 and 0.87 cm, respectively). This was mainly due less damage to the stock which get fast recovery compared to grafting methods and they form strong union formation in short period of time, higher uptake of water and nutrients and longer growing period may account for the higher growth of chip-budded plants (Kim *et al*, 1988; Chandel *et al*, 1998). Meharun variety showed highest graft girth (0.80, 0.99 cm) at 30 and 60 DAG respectively, which was on par with Dandan (0.98 cm) at 60 DAG, while at 90 DAG, Dandan showed high graft girth (1.28 cm), followed by Meharun (1.16 cm). Significantly minimum graft girth was found in Chhuhara (0.44, 0.66 and 1.00 cm) at 30, 60 and 90 DAG respectively. The increase in graft girth is mainly because of better compatibility of local rootstock and better uptake of nutrients and water from deep layers of soil. The interaction of propagation and varieties also showed highest graft girth in softwood wedge grafting of Meharun (0.86 cm) at 30 DAG

Assessment of Grafting and Budding Success in Different Varieties

followed by softwood wedge grafting of Dandan (0.80 cm) and chip budding of Meharun (0.73 cm) however, at 90 DAG highest graft girth was observed in chip budding of Dandan (1.60 cm), which was on par with chip budding of Meharun, Sannaur-2 (1.22 and 1.26 cm) at 90 DAG respectively. Minimum graft girth was observed in chip budding of Chhuhara (0.40 cm) at 30 DAG, while at 90 DAG minimum graft girth was observed in softwood wedge grafting of Chhuhara (0.70 cm). The reason is early healing of graft union due to presence of congenial climate for graft union and growth under *in-situ* conditions as reported by Sharif *et al* (2015).

Number of leaves

The chip budding showed significantly highest number of leaves at different stages of growth (13.30, 30.50 and 41.50) at 30, 60 and 90 DAG respectively, compared to soft wood wedge grafting (11.26, 13.63 and 20.33) at 30, 60 and 90 DAG respectively, which showed minimum number of leaves/graft (Table 3). Ghosh (2009) reported that budding of plants in open sunlight condition showed maximum leaf number. The reason might be explained from the fact that *in-situ* grown-seedlings have good tap root system that help to supply better nutrients and moisture to the stock plant and thereby improve physiological condition of the plants. Better physiological status of stock plants of *in situ* grown-seedlings, would result better cambium activity and help to show good success and survival after budding (Nath *et al*, 2000). Dandan variety showed significantly higher number of leaves/grafts at all stages of growth (14.33, 24.25 and 33.83) at 30, 60 and 90 DAG, respectively, which was on par with Meharun (12.95) at 30 DAG, Meharun and Sannaur-2 (23.66 and 22.83) at 60 DAG respectively and Meharun (31.66) at 90 DAG. Significantly the minimum number of leaves/grafts was found in Chhuhara (10.83, 20.25 and 29.66) at 30, 60 and 90 DAG respectively. The difference in number of leaves/grafts might be because of variation in the formation of callus and the vascular connectivity at the graft union. The higher number of leaves in chip budding of Dandan variety (16.33) at 30 DAG, which was on par with chip budding of Sannaur-2 (14.66) and at 60 DAG highest number of leaves were noticed in chip budding of Sannaur-2 (33.50) at 60 DAG, which was on par with chip budding of Meharun and Dandan (32.33 and 31.33) at 60 DAG respectively. Significantly minimum number of leaves was observed in softwood wedge grafting of Chhuhara (9.66) at 30 DAG, while at 60 DAG least number of leaves were observed in soft wood wedge grafting of

Sannaur-2 (12.16) at 60 DAG. This increase in number of leaves is mainly due to better compatibility of rootstock with the improved varieties which was reported by Singh and Srivastava (1980).

Graft success

The softwood wedge grafting showed significantly highest graft success percent (87.05 and 85.55 %) at 30 and 60 DAG respectively. The minimum success percent was found with chip budding method (78.16 and 75.88 %) at 30 and 60 DAG respectively. These findings are in line with Reddy and Melenta (1988) who reported successful *in situ* soft wood grafting on seven- and eight-month-old rootstocks and the highest graft- take under Bangalore conditions was 90 percent. Dandan variety showed significantly highest percent graft success, at all stages of growth (91.1 and 88.83 %) at 30 and 60 DAG respectively. While the minimum percent graft success was found in Gola (75.50 and 73.33 %) at 30 and 60 DAG respectively. Differential budding success of ber cultivars on rootstock/rootstocks was also observed by Verma *et al* 2000. According to them different budding success of ber cultivars on various rootstocks was due to incompatible graft combination and explained that this graft incompatibility was either due to cellular disturbances at the bud junction or lack of callus formation which resulted no vascular connection between stock and scion. They also opined that failure of success might have been due to excessive callus formation at the budded portion which inhibits the movement of water from stock to scion. The interaction of propagation and varieties was also showed high percent graft success in softwood wedge grafting of Umran variety at all stages of growth (100 and 98.33 %) at 30 and 60 DAG respectively, which was on par with chip budding of Dandan (89.00 and 86.00 %) at 30 and 60 DAG respectively, softwood wedge grafting of Sannaur-2 (96.66 and 95.00 %) at 30 and 60 DAG respectively, softwood wedge grafting of Dandan (93.33 and 91.66 %) at 30 and 60 DAG respectively. Minimum percent graft success was observed in softwood grafting of Gola (74.00 and 72.00 %) at 30 and 60 DAG respectively. This variation might be due to the compatibility of the different varieties with the rootstocks that is affected by the grafting method. The histological studies by Abd El-Zaher 2008 illustrated that graft anatomical features of jackfruit were correlates the grafting success percentage.

The graft survival over a period of time showed that softwood wedge grafting showed significantly high percent graft survival (85.05 %) at

Table 1: Effect of propagation methods on graft height of ber varieties under *in-situ* condition.

Variety	Graft height (cm)								
	30 DAG			60 DAG			90 DAG		
	Grafting	Budding	Mean	Grafting	Budding	Mean	Grafting	Budding	Mean
Chhuhura	20.66	19.00	19.83	24.33	26.33	25.33	29.23	34.33	31.78
Dandan	24.66	23.00	23.83	28.16	34.00	31.08	32.00	45.66	38.83
Gola	22.30	20.33	21.31	30.33	29.00	29.66	35.33	43.00	39.16
Meharun	22.87	20.00	21.43	24.66	29.33	27.00	29.00	41.00	35.00
Sannaur-2	22.00	22.00	22.00	29.66	32.00	30.83	34.33	42.66	38.50
Umran	21.16	18.66	19.91	26.00	25.33	25.66	30.33	35.00	32.66
Mean	22.27	20.50		27.19	29.33		31.70	40.27	
	P	V	P*V	P	V	P*V	P	V	P*V
S.Em±	0.47	0.83	1.17	0.71	1.24	1.76	0.54	0.95	1.34
C.D. at 5%	1.40	2.43	NS	2.11	3.65	NS	1.61	2.79	3.94

Table 2: Effect of propagation methods on graft girth of ber varieties under *in-situ* condition.

Variety	Graft girth (cm)								
	30 DAG			60 DAG			90 DAG		
	Grafting	Budding	Mean	Grafting	Budding	Mean	Grafting	Budding	Mean
Chhuhura	0.48	0.40	0.44	0.60	0.73	0.66	0.70	1.30	1.00
Dandan	0.80	0.51	0.65	0.90	1.06	0.98	0.96	1.60	1.28
Gola	0.61	0.48	0.55	0.83	0.80	0.81	0.90	1.20	1.05
Meharun	0.86	0.73	0.80	1.03	0.96	0.99	1.10	1.22	1.16
Sannaur-2	0.59	0.66	0.63	0.73	0.93	0.83	0.80	1.26	1.03
Umran	0.53	0.53	0.53	0.63	0.83	0.83	0.76	1.30	1.03
Mean	0.64	0.55		0.78	0.88		0.87	1.31	
	P	V	P*V	P	V	P*V	P	V	P*V
S.Em±	0.02	0.03	0.05	0.02	0.04	0.05	0.03	0.06	0.08
C.D. at 5%	0.06	0.11	0.15	0.07	0.12	NS	0.10	0.17	0.25

90 DAG compared to chip budding (81.33 %) at 90 DAG. This difference in propagation methods under *in-situ* conditions may be due to better union in grafts, because of large surface of cambium cells come in contact with stock and scion in grafting method compare to other method. Dandan variety showed significantly highest percent graft survival (87.83 %), which was on par with Umran (87.16 %), Sannaur-2 (84.83 %) and Meharun (81.83 %) at 90 DAG respectively. Significantly the minimum percent graft survival was found in Chhuhura (76.50 %) at 90 DAG. The difference in percent survival may be due the varietal response to different propagation methods under different environmental conditions. The interaction of propagation and varieties also showed highest percent graft survival in softwood wedge grafting of Umran (93.66 %), which was on par with

softwood wedge grafting of Dandan (89.00 %), Sannaur-2 (88.66 %), softwood wedge grafting of Meharun (85.00 %) and chip budding of Dandan (88.66 %) at 90 DAG, respectively, Chhuhura (71.66 %) at 90 DAG. This high percent graft survival may be due to the varietal character in response to congenial environment favoring high graft survival. Similar reports were observed in survival of softwood grafts was minimum in 'Local-3' with 61.18 percent and maximum for 'Kesar' with 76.29 percent (Prajapati *et al*, 2014).

CONCLUSION

In-situ chip budding of Dandan variety grafted onto *Ziziphus mauritiana* var. *rotundifolia* gives highest graft height, graft girth, number of leaves and

Assessment of Grafting and Budding Success in Different Varieties

Table 3: Effect of propagation methods on number of leaves/graft of ber varieties under *in-situ* condition

Variety	Number of leaves								
	30 DAG			60 DAG			90 DAG		
	Grafting	Budding	Mean	Grafting	Budding	Mean	Grafting	Budding	Mean
Chhuhura	09.66	12.00	10.83	14.00	26.50	20.25	19.00	40.33	29.66
Dandan	12.33	16.33	14.33	17.16	31.33	24.25	23.00	44.66	33.83
Gola	10.33	12.50	11.41	14.16	30.00	22.08	18.33	40.00	29.16
Meharun	12.90	13.00	12.95	15.00	32.33	23.66	22.33	41.00	31.66
Sannaur-2	10.26	14.66	12.46	12.16	33.50	22.83	18.00	43.33	30.66
Umran	11.00	11.33	11.16	13.50	29.33	21.41	21.33	39.66	30.50
Mean	11.26	13.30		13.63	30.50		20.33	41.50	
	P	V	P*V	P	V	P*V	P	V	P*V
S.Em±	0.31	0.55	0.77	0.30	0.52	0.73	0.470	0.81	1.15
C.D. at 5%	0.93	1.61	2.28	0.88	1.53	2.16	1.37	2.38	NS

Table 4: Effect of propagation methods on percent graft success and percent survival of ber varieties under *in-situ* condition.

Variety	Percent graft success						Percent graft survival		
	30 DAG			60 DAG			90 DAG		
	Grafting	Budding	Mean	Grafting	Budding	Mean	Grafting	Budding	Mean
Chhuhura	80.00 (63.47)	77.00 (61.35)	78.50 (62.41)	78.00 (62.06)	74.66 (59.78)	76.33 (60.92)	71.66 (57.98)	81.33 (64.54)	76.50 (61.26)
Dandan	93.33 (77.61)	89.00 (70.64)	91.16 (74.12)	91.66 (73.40)	86.00 (68.05)	88.83 (70.72)	89.00 (71.67)	86.66 (69.21)	87.83 (70.44)
Gola	74.00 (59.34)	77.00 (61.57)	75.50 (60.45)	72.00 (58.05)	74.66 (60.05)	73.33 (59.05)	82.33 (65.26)	79.66 (63.37)	81.00 (64.31)
Meharun	78.33 (66.74)	75.00 (60.02)	76.66 (63.38)	78.33 (66.74)	72.33 (58.28)	75.33 (62.51)	85.00 (67.46)	78.66 (62.72)	81.83 (65.09)
Sannaur-2	96.66 (83.66)	76.66 (61.33)	86.66 (72.49)	95.00 (79.45)	75.00 (60.26)	85.00 (69.85)	88.66 (70.34)	81.00 (64.43)	84.83 (67.38)
Umran	100 (89.71)	74.33 (59.95)	87.16 (74.83)	98.33 (85.50)	72.66 (58.80)	85.50 (72.15)	93.66 (75.56)	80.66 (63.94)	87.16 (69.75)
Mean	87.05 (73.42)	78.16 (62.48)		85.55 (70.86)	75.88 (60.87)		85.05 (68.04)	81.33 (64.70)	
	P	V	P*V	P	V	P*V	P	V	P*V
S.Em±	1.70	2.95	04.18	1.78	3.09	04.37	1.23	2.14	3.03
C.D. at 5%	5.01	8.67	12.27	5.23	9.06	12.82	3.63	6.29	8.90

percent graft success. Hence, in-situ establishment of orchards using Dandan variety can be followed under North Dry Zone of Karnataka for successful production of ber plants. This method not only ensured better field establishment and uniform plant growth but also reduced the cost and effort involved in nursery raising and transplanting. The findings can be effectively utilized by farmers and horticulturists aiming for large-scale ber cultivation in arid and semi-arid regions.

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Assessment of *per se* Performance of Gomphrena (*Gomphrena globosa* L.) Genotypes for Productivity and Quality traits

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ABSTRACT

An experiment was conducted to evaluate 13 Gomphrena genotypes for qualitative and quantitative traits at College of Horticulture, Bagalkot in a randomized block design with three replications during 2022. Observations were recorded from each genotype for both qualitative and quantitative traits. The results revealed that maximum plant height, plant spread in N-S and E-W direction, stem girth, days from bud to bloom, duration of flowering, , individual flower weight, number of flowers per plant and yield per plant was observed in genotype AGS-4. More number of primary branches were noticed in AGS-7, secondary branches in AGS-10, maximum leaves count in AGS-5. The genotype AGS-9 took minimum number of days to bud initiation, while AGS-8 took least number of days to 50 percent flowering. The quality traits like stalk length and inflorescence length were best in genotype AGS-1. The highest shelf life and display life was observed in genotype AGS-3 and AGS-6. Based on the qualitative results, genotype AGS-8, 9 and 10 exhibited upright growth habit and remaining other genotypes belonged to spreading type. RHS colour chart grouped all genotypes into four major flower colour groups *i.e.* pink, white, purple and red flower colour, leaf blade as reddish purple group, genotype AGS-1, 2, 4, 5 8 and 9 belonged to short acuminate blade shape, whereas other genotypes showed acute leaf blade shape.

Keywords: AGS-genotype, Flower, Gomphrena, Growth, Parameters, Yield,

INTRODUCTION

Bachelor's button (*Gomphrena globosa* L.) is a popular everlasting flower crop commercially cultivated in India. It signifies special importance due to its vibrant bright inflorescence, hardiness and ease in cultivation, marketability, short duration and easy transportation (Esmat and Mittapally, 2020). The Globe Amaranth (*Gomphrena globosa* L.) is native to North America, South America, Myanmar and India (Ashwini *et al.*, 2019), known by different names; makhmali' in Nepal, Raktamallika in Sanskrit, Adikehuvvu/rudrakshihuvvu in Kannada and 'Gul-e-makhmal in Hindi and Gundi in Kashmir. Genus belongs to the family Amaranthaceae with chromosome number 2n=38 consists of about 100 species of half-hardy annual, biennial and herbaceous perennial plants, but only one species *Gomphrena globosa* is in general cultivation. In India, around 18 genera and 50 species have been recorded (Jiang *et al.*, 2011). The flower has amazing ability to last for years when dried. In India, it is majorly grown in Karnataka, Tamil Nadu, Kerala and in Andhra Pradesh. In Karnataka, commercially grown in Dharwad, Belagavi, Raichur and Bellary Districts (Anonymous, 2020).

Commercially it is used for making garlands, pomanders, bouquets, flower balls, wreath, greeting cards, pot pourris, flower arrangements, stage decorations during marriages, indoor decoration and widely used during Onam, the famous Kerala festival to decorate Pookolam and Bathukamma festival in Telangana (Rathava *et al.*, 2021). The flowers are rich in antioxidants, which possess many health benefits like antibacterial, antifungal, detoxifying and purifying properties and for treating high blood pressure and diabetes. The flowers are rich in betacyanin used as additives and supplements in the food industry, cosmetics and livestock feed. Because of its hardy nature, used in landscaping as flower bed, hedge and edge plant (Ehsanullah *et al.*, 2021). Even though crop is gaining economic significance, but improved varieties not available to farmers for cultivation. There is an urgent need to develop high-yielding *Gomphrena* genotypes with improved quality traits. With this, the present study was conducted to evaluate *Gomphrena* genotypes for their productivity and quality characteristics.

MATERIALS AND METHODS

The present study was carried out during 2022–23 at the experimental block of the College of

Table 1: *Per se* performance of Gomphrena (*Gomphrena globosa* L.) genotypes for growth and flowering parameters.

Genotype	Plant height (cm)	Number of leaves per plant	Stem girth (mm)	Plant spread N-S direction	Plant spread E-W direction	Primary branches	Secondary branches	Days to bud initiation	Days to 50 per cent flowering	Duration of flowering (days)
AGS-1	61.40	398.00	9.97	52.07	43.27	6.60	23.47	10.00	37.00	65.33
AGS-2	59.07	412.53	9.14	52.93	45.27	8.00	25.00	11.00	35.00	66.33
AGS-3	55.00	397.87	8.69	45.67	44.80	8.50	24.40	9.33	31.67	66.00
AGS-4	65.80	454.53	11.31	56.13	53.53	9.17	28.20	11.00	36.00	67.00
AGS-5	60.33	564.47	9.36	54.93	48.60	8.53	25.67	10.33	35.00	66.17
AGS-6	60.33	519.40	9.31	43.93	42.67	8.13	26.07	10.00	37.33	62.00
AGS-7	62.33	520.53	8.97	47.40	45.67	8.67	24.07	11.00	36.67	65.00
AGS-8	54.40	414.53	8.66	44.87	37.00	8.87	25.53	10.00	31.67	62.33
AGS-9	62.87	436.40	8.47	48.20	44.60	9.27	27.87	9.00	33.67	61.00
AGS-10	56.47	381.60	8.62	46.20	40.87	8.33	28.40	10.00	32.00	61.00
AGS-14	23.73	214.67	4.52	42.27	43.33	6.63	15.20	15.00	41.00	62.67
AGS-16	59.93	366.40	8.67	50.87	47.67	7.67	25.67	10.00	35.00	64.67
AGS-17	60.13	336.40	8.49	51.93	46.80	8.17	25.07	9.67	34.67	64.33
S. Em $\pm$	0.53	0.58	0.29	0.58	0.51	0.33	0.66	0.59	0.59	0.51
C.D at 5%	1.54	1.70	0.84	1.70	1.50	0.95	1.92	1.73	1.72	1.50

Horticulture, Bagalkot. Located in Karnataka's Northern Dry Zone, Bagalkot falls under Zone 3, Region 2 of the state's agro-climatic classification. It is situated at an altitude of 542 m above mean sea level, with coordinates of 16.18° N latitude and 75.70° E longitude. Thirteen Gomphrena genotypes collected from previous experiment at College of Horticulture, Bagalkot were used in the present study to evaluate *per se* performance of Gomphrena genotypes for productivity and quality traits in a randomized block design with three replications and the thirteen genotypes were presented in plate-1

The experimental field was prepared to a fine tilth by thoroughly plowing the soil to a depth of 30 cm. Well-decomposed farmyard manure @ 25 t/ha was evenly incorporated into the soil. The field was measured and divided into three replications of homogenous blocks of equal area and then the blocks were subdivided into plots of RCBD design. Ridges and furrows were prepared and 30 days old seedlings were planted at 30x30cm spacing. After 20 days of transplanting pinching operation was done to encourage the lateral branches. The recommended fertilizer dosage of NPK was applied at a rate of 180:60:60 kg/ha using urea, single super phosphate, and muriate of potash, respectively (Anonymous, 2020). Five plants were randomly selected from each genotype to record the observations on various growth, flowering, yield and quality parameters. Genotypes were characterized for various qualitative traits like leaf blade shape, leaf blade colour, leaf blade undulations at margin as per the Celosia UPOVA DUS

guidelines (Celosia, 2002). Observations were also recorded on different growth, earliness, yield and quality traits, then the mean data was subjected to statistical analysis (INDOSTAT software).

RESULTS AND DISCUSSION

Evaluating Gomphrena genotypes is crucial to identify high-yielding genotypes, understand genetic traits for breeding programs and conserve genetic diversity of best genotypes for further research purposes. Selecting superior genotypes through evaluation helps to improve traits like flower color, size and shelf life through breeding strategies. The analysis of variance indicated highly significant differences among the genotypes for all the traits studied, primarily attributed to the genetic composition of each genotype.

Growth parameters

The *per se* performance of Gomphrena genotypes across various growth parameters is presented in Table 1. Among the genotypes plant height varied from 23.73 to 65.80cm.

The genotype AGS-4 had maximum plant height (65.80cm) followed by genotype AGS-9 (62.87cm) and the minimum plant height (23.73cm) was observed in AGS-14. The number of leaves per plant varies from 214.67 to 564.47. Highest leaf count was observed in genotype AGS-5 (564.47) followed by AGS-7 (520.53), while, AGS- 14 has recorded lowest number of leaves (214.67). Mean range of plant spread

Assessment of per se Performance of *Gomphrena* (*Gomphrena globosa* L.) Genotypes

Table 2. *Per se* performance of *Gomphrena* (*Gomphrena globosa* L.) genotypes for yield and flower quality parameters.

Genotype	Number of flowers/plant	Yield per plant (g)	Inflorescence length (cm)	Diameter of flower (cm)	Individual flower weight (g)	Shelf life (days)	Display life (days)
AGS-1	275.73	597.60	4.74	1.86	2.68	5.50	36.00
AGS-2	244.80	674.70	4.01	1.93	3.18	5.00	34.33
AGS-3	244.63	724.54	3.78	1.82	3.05	7.00	30.00
AGS-4	279.53	763.57	3.85	1.97	3.19	5.00	32.00
AGS-5	255.47	617.58	4.03	1.77	2.37	6.00	36.33
AGS-6	244.23	564.60	3.79	1.82	2.47	7.00	37.00
AGS-7	253.93	534.37	2.99	1.91	2.13	5.00	30.00
AGS-8	231.47	588.27	2.53	1.98	2.73	7.00	32.33
AGS-9	255.40	397.77	2.79	1.75	1.79	6.00	32.67
AGS-10	244.67	633.57	3.40	1.75	2.84	6.00	27.00
AGS-14	167.00	357.70	3.68	1.45	2.31	5.00	27.00
AGS-16	264.53	597.93	3.57	2.01	3.17	6.00	32.33
AGS-17	238.73	554.67	2.71	2.16	2.36	6.00	32.67
S. Em $\pm$	0.53	0.52	0.16	0.04	0.08	0.39	0.56
C.D at 5%	1.55	1.52	0.46	0.13	0.25	1.12	1.65

was 42.27 to 56.13cm in N-S and 37.00 to 53.53cm in E-W direction. The genotype AGS-4 had maximum plant spread (56.13cm) in North-South direction followed by AGS-5 (54.93cm), whereas AGS-14 showed minimum plant spread (42.27cm). The genotype AGS-4 had maximum spread (53.50cm) in East-West direction and it was minimum in AGS-8 (37.00cm). Number of primary branches ranged from 6.60 to 9.27. The highest number of branches (9.27) was recorded in genotype AGS-9, which was followed by AGS-4 (9.17), lowest in AGS-1 (6.60). The number of secondary branches ranged from 15.20 to 28.40. Highest branches (28.40) was recorded in AGS-10, on par with AGS-9 (27.87) and AGS-4 (28.20), whereas lowest in AGS-14 (15.20). The variation in vegetative parameters among genotypes may be attributed to genetic differences as well as the influence of climatic conditions during the crop period. Similar findings have been reported by Ashwini *et al.* (2019), Tarannum and Naik (2014), and Kumar *et al.* (2021) in *Gomphrena*.

The performance of *Gomphrena* genotypes for flowering parameters is presented in Table 1. The number of days required for flower bud initiation varied among the genotypes, ranging from 9 to 15 d. Genotype AGS-9 took minimum number of days (9d) and was on par with AGS-3 (9.33d) for flower bud

initiation, whereas genotype AGS-14 took maximum number of days (15d). Days to 50 per cent flowering ranged from 31.67 to 41d, genotype AGS-3 and AGS-8 took minimum number of days (31.67d) and was on par with AGS-10 (32d). The genotype AGS-14 took maximum number of days (41 days). Duration of flowering ranged from 61 to 67 d on crop. Maximum duration of flowering (67 d) was noticed in genotype AGS-4 followed by AGS-2 (66.33 d) and AGS-3 (66d), genotype AGS-9 and AGS-10 had minimum of 61d each. Variation of these characters due to inherent character and by the impact of physiological factors by environment condition, as takes earlier time for transition from vegetative to reproductive stage. Similar reports were observed in marigold by Mahantesh *et al* (2018), Lohar *et al* (2018) in African marigold, Singh *et al* (2022) and Sharma *et al* (2019) in *Chrysanthemum* and Rathava *et al* (2021) in *Gomphrena*.

The average number of flowers per plant ranged from 167 to 279.53. The highest flower count per plant (279.53) was recorded in the genotype AGS-4, followed closely by AGS-1 (275.73), whereas minimum number of flowers (167.00) were recorded in AGS-14. The mean yield per plant ranged between 357.70 to 763.57g. The highest flower yield (763.57g) was reported in AGS-4 followed by AGS-3 (724.54g), while lowest (357.70g) in genotype AGS-14 (Table 2). The mean flower length ranged from 2.53cm to

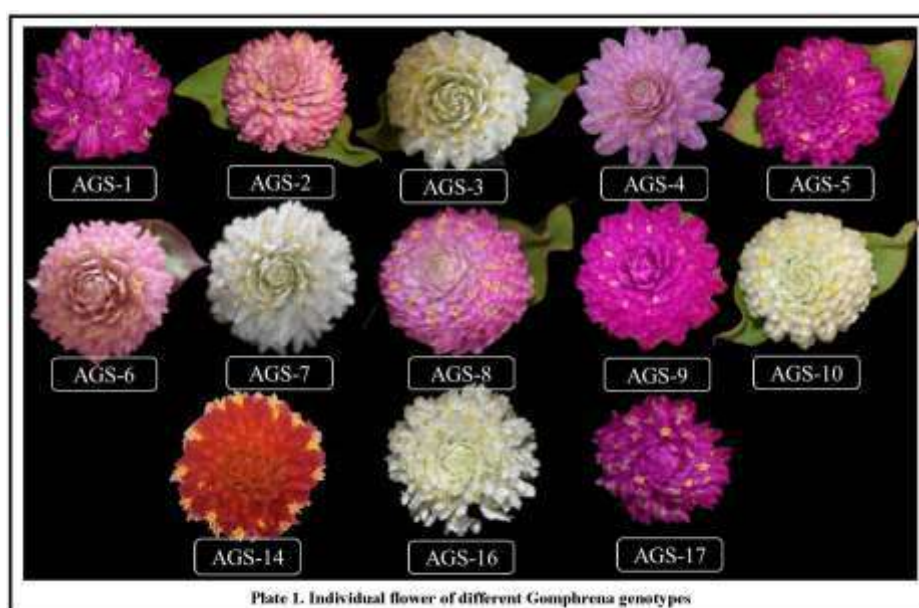


Plate 1. Individual flower of different Gomphrena genotypes

4.74cm, highest inflorescence length (4.74cm) was observed in genotype AGS-1 followed by AGS-5 (4.03cm) and AGS-2 (4.01cm), whereas lowest in case of genotype AGS-8 (2.53cm). The flower diameter had a mean value ranging from 1.45 to 2.16cm. Genotype AGS-17 had recorded maximum flower diameter of 2.16cm followed by AGS-16 (2.01cm) and AGS-4 (1.97cm), minimum in case of AGS-14 (1.45cm). The mean of individual flower weight varied from 1.79 to 3.19g among the genotypes. The genotype AGS-4 had recorded maximum flower weight (3.19g) which was on par with AGS-2 (3.18g) and AGS-16 (3.17g), whereas the genotype AGS-9 had recorded the minimum individual flower weight (1.79g). The mean ranges from 5 to 7 days for shelf life of flower. The flowers of genotype AGS-3, 6 and 8 remained fresh for longer days (7 days), whereas less shelf life (5 days) was recorded in AGS-2, 4, 7 and 14. The mean number of days flower remained fresh in the field on the plant ranged from 27 to 37 days. The genotype AGS-6 had maximum display life of 37 days followed by AGS-5 (36.33 days), whereas AGS-10 and AGS-14 had less display life of 27 days each (Table 2). Similar reports were reported by Mehta (2022) in African marigold, Srinivas and Rajasekharan (2019) in marigold.

Variation observed for various qualitative parameters among the Gomphrena genotype presented in table 3. Based on plant growth habit, Gomphrena genotypes were grouped into 2 groups. The genotypes AGS-1, 2, 3, 4, 5, 6, 8, 9, 10, 17, 14 had shown spreading habit and AGS-8, 9 and 10 exhibited upright nature. The seed colour of all the genotypes shown bluish white colour group with colour code N 155 A. RHS

colour chart was used to differentiate the flower colour of 13 genotypes of Gomphrena, based on the visual observations, genotype AGS-1, AGS-5, AGS-9 and AGS-17 had shown Strong reddish purple group with N 78 A colour code. The genotype AGS-2 belongs to strong purplish pink group with code 63 C. The genotype AGS-4 and AGS-6 belongs to light purplish pink code 63 D. The genotype AGS-3, AGS-7, AGS-10 and AGS-16 had shown pale yellow green colour with code 155 A. The genotype AGS-8 exhibited colour code NN 74 D as strong reddish purple group. The genotype AGS-14 had moderate red with N 45A colour code. The leaf characters like leaf blade shape and colour and leaf blade undulations at margin were examined based on Celosia DUS characterization. The genotypes AGS-1, 2, 4, 5, 8, 9 had shown short acuminate leaf blade shape, while AGS-3, 6, 7, 10, 14, 16 and 17 had shown acute blade shape. For leaf blade colour, all the genotypes shown reddish purple colour with undulations at margins of leaf (Plate 2). The variation w.r.t to flower colour was observed among the Gomphrena genotypes and were majorly grouped into purple, red, white and pink colours. Growth habit has showed that all the Gomphrena genotypes were majorly grouped into upright and spreading types. Similar findings were reported by Kumar *et al.* (2021) in Gomphrena.

CONCLUSION

It can be concluded that analysis of variance revealed presence of significant variation for all traits studied among the Gomphrena genotypes. Genotype

Assessment of per se Performance of *Gomphrena* (*Gomphrena globosa* L.) Genotypes

Table 3. Variability for qualitative parameters in *Gomphrena* (*Gomphrena globosa* L.) genotypes.

Genotype	Growth habit	Flower colour group	Flower colour code	Seed colour group	Seed colour code	Leaf blade shape	Leaf blade colour	Leaf blade undulation at margins
AGS-1	Spreading	Strong reddish purple	N 78 A	Bluish white	N 155 A	Short acuminate	Reddish purple	Present
AGS-2	Spreading	Strong purplish pink	63 C	Bluish white	N 155 A	Short acuminate	Reddish purple	Present
AGS-3	Spreading	Pale yellow green	155 A	Bluish white	N 155 A	Acute	Reddish purple	Present
AGS-4	Spreading	Light purplish pink	63 D	Bluish white	N 155 A	Short acuminate	Reddish purple	Present
AGS-5	Spreading	Strong reddish purple	N 78 A	Bluish white	N 155 A	Short acuminate	Reddish purple	Present
AGS-6	Spreading	Light purplish pink	63 D	Bluish white	N 155 A	Acute	Reddish purple	Present
AGS-7	Spreading	Pale yellow green	155 A	Bluish white	N 155 A	Acute	Reddish purple	Present
AGS-8	Upright	Strong reddish purple	NN 74 D	Bluish white	N 155 A	Short acuminate	Reddish purple	Present
AGS-9	Upright	Strong reddish purple	N 78 A	Bluish white	N 155 A	Short acuminate	Reddish purple	Present
AGS-10	Upright	Pale yellow green	155 A	Bluish white	N 155 A	Acute	Reddish purple	Present
AGS-14	Spreading	Moderate red	N 45 A	Bluish white	N 155 A	Acute	Reddish purple	Present
AGS-16	Spreading	Pale yellow green	155 A	Bluish white	N 155 A	Acute	Reddish purple	Present
AGS-17	Spreading	Strong reddish purple	N 78 A	Bluish white	N 155 A	Acute	Reddish purple	Present

AGS-4 identified as top performing genotype for yield (763.57g) and yield contributing traits, that shows its superiority followed by AGS-3 (724. 54g) and AGS-5 (617.58g), which can be further exploited for crop improvement programme. The genotypes AGS-8, AGS -9 and AGS -10 can be used in landscaping as hedge plant as they exhibited upright growth habit, which is very much useful in creating mobility in garden by attracting pollinators.

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Plate 2. Morphological variation of leaf

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Bioefficacy of chlorantraniliprole (AC 01) 0.4%GR against Early Shoot Borer and Termites in Sugarcane

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ABSTRACT

A field study was conducted using a randomized block design with six treatments, each replicated three times, at the Regional Agricultural Research Station, Anakapalle, Andhra Pradesh to evaluate the efficacy of AC 01 (chlorantraniliprole) 0.4% GR, a formulation developed by NATCO Pharma Limited, Hyderabad against commercially available formulations of chlorantraniliprole 0.4G and fipronil 0.3G for the control of early shoot borer and termites in sugarcane. Treatments were applied at the time of planting and again at 40 days after planting (DAP). Observations on termite damage to sets were recorded at 30 DAP, while early shoot borer infestation was assessed at 30, 60, 90, and 120 DAP on a whole-plot basis. Yield-contributing parameters, juice sucrose content, and cane yield were recorded at harvest. The results demonstrated that soil application of AC 01 (0.4% GR) at 75 g a.i./ha at planting and again at 40 DAP significantly reduced termite damage (4.00%) and early shoot borer incidence (20.58% deadhearts), resulting in a higher cane yield (92.17 t/ha) compared to the untreated control (52.52% deadhearts; 19.91% termite incidence; 69.33 t/ha). The performance of AC 01(0.4%GR) was comparable to that of the market sample of chlorantraniliprole 0.4 GR (COVER) at 75g a.i./ha and fipronil 0.3 GR at 100g a.i./ha. No phytotoxic effects were observed, even at four times the recommended dosage.

Keywords : Chlorantraniliprole, Early Shoot Borer, Fipronil, Sugarcane, Termites.

INTRODUCTION

In Andhra Pradesh, the early shoot borer (*Chilo infuscatellus* Snellen) is a major pest that affects the sugarcane crop during its initial growth stages. Initially acting as a shoot borer and later transitions into an internode borer once internode formation begins. The larvae penetrate the shoots and feed on the growing points resulting in the formation of a characteristic symptom known as a dead heart. This pest poses a major threat, particularly under stress conditions, where it can cause the complete death of seedlings. Infestation rates have been observed to range from 15.5% to 60.5% of emerging shoots, with up to 90% of clumps affected in the North Coastal Zone, leading to yield losses of approximately 22–23% (Bhavani *et al*, 2016; Anonymous, 2024). In subtropical regions of India, damage caused by the early shoot borer during the early crop stages (May–June) has been reported to range from 30% to 75% (Balasubramaniyan *et al*, 2020). If left unmanaged, this pest can result in substantial reductions in sugarcane tonnage.

Chlorantraniliprole, an anthranilic diamide insecticide, effectively controls lepidopteran pests as

well as coleopteran, dipteran and hemipteran pests (Sharma *et al*, 2013) through ryanodine receptor activation, leading to muscle paralysis and insect death (Cordova *et al*, 2006). It has low toxicity to mammals, strong ovicidal and larvicidal properties, long lasting residual effect, and minimal impact on beneficial organisms (Dinter *et al*, 2008) making it suitable for Integrated Pest Management (IPM). With this background, a study has been carried out to evaluate the efficacy of AC 01 (0.4%GR) against early shoot borer and termites in sugarcane.

MATERIALS AND METHODS

A field experiment was conducted during the year 2019-2020 at Regional Agricultural Research Station, Anakapalle, Andhra Pradesh in a Randomised Block design (RBD) with three replications using a sugarcane variety, Co A 99082. The plot size was 28.8 m² (6 M X 0.8 M X 6 R). The insecticide granules viz., AC01-0.4% GR (chlorantraniliprole), a product of M/s NATCO Pharma Limited, Hyderabad, chlorantraniliprole 0.4GR (COVER) and fipronil 0.3GR at two dosages were applied in the soil at the time of planting and at 40 days after planting in

Table 1. Detail of the treatments

Sr. No	Treatment	Dose/hectare		Remarks
		g a.i./ha	Formulation (in kg/ha)	
1	Untreated control	-	-	Bioefficacy + Phytotoxicity studies
2	AC01(0.4GR)	60	15.00	Bioefficacy + Phytotoxicity studies
3	AC 01 (0.4GR)	75	18.75	Bioefficacy + Phytotoxicity studies
4	Chlorantraniliprole 0.4GR	75	18.75	Bioefficacy + Phytotoxicity studies
5	Fipronil 0.3GR	75	25.00	Bioefficacy + Phytotoxicity studies
6	Fipronil 0.3GR	100	33.33	Bioefficacy + Phytotoxicity studies
7	AC 01 (0.4GR)	150	37.50	Phytotoxicity studies
8	AC 01 (0.4GR)	300	75.00	Phytotoxicity studies

Grade	Phytotoxicity symptom%
0	No phytotoxicity
1	1-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	81-90
10	91-100

furrows. The required dose was mixed in sand (1:2) and applied in the furrows to spread the insecticide thoroughly around the planting zone. The treatment details were furnished in Table 1.

Observations on the number of shoots germinated in each treatment were recorded 30 days after planting, excluding two border rows. The number of shoots were counted on a whole-plot basis for each treatment, and the percentage germination was calculated accordingly. Data on termite damage to setts and early shoot borer infestation in shoots were collected on a whole-plot basis for each treatment. The total number of shoots and the number of damaged shoots (dead hearts) were recorded at 30, 60, 90, and 120 days after planting. These counts were then used to calculate the percentage incidence of dead hearts (% DH). Observations on juice sucrose (%), cane height(m), cane weight (kg), cane girth (cm) were recorded from 10 randomly selected plants per plot. The number of millable canes and cane yield per plot were recorded at harvest and expressed as the number of millable canes per hectare (NMC/ha) and cane yield in tonnes per hectare (t/ha), respectively. All collected

data were subjected to statistical analysis using analysis of variance (ANOVA) to determine the significance of treatment effects.

To assess the phytotoxicity of AC 01 (chlorantraniliprole 0.4%GR) at 60g a.i. ha⁻¹, 75g a.i. ha⁻¹ (recommended dose, X), 150g a.i. ha⁻¹ (2X), and 300g a.i. ha⁻¹ (4X), treatments were applied at the time of planting and at 40 days after planting in sugarcane. Phytotoxicity symptoms *viz.*, chlorosis, epinasty, hyponasty, and necrosis were recorded at 30, 60, 90, and 120 days after planting. Observations were made using a 0–100% scale, where 0 indicated no phytotoxicity and 100 indicated complete plant death, in accordance with the Central Insecticide Board and Registration Committee (CIBRC) protocol.

RESULTS AND DISCUSSION

Germination

The data at 35 days after planting (Table 3) revealed that, per cent germination ranged between 67.22 and 74.13. However, among six treatments, the highest per cent germination recorded in AC01(0.4GR) @ 75 g a.i. ha⁻¹ (74.13 %) was

Bioefficacy of chlorantraniliprole (AC 01) 0.4%GR against Early Shoot Borer and Termites

Table 2. Bioefficacy of AC01 0.4%GR (chlorantraniliprole) against termites, early shoot borer in sugarcane

Sr. No	Treatment	Dose/ha		Germination (%)	Incidence of termite at 30 DAP (%)	Reduction over control (%)	Incidence of early shoot borer (%DH)					Reduction over control (%)
		g a.i. ha ⁻¹	Formulation (Kg/Ha)				30 DAP	60 DAP	90 DAP	120 DAP	Cumulative up to 120 DAP	
1	Untreated control	-	-	55.08 ^b (67.22)	26.48 ^d (19.91)	-	30.79 ^c (26.26)	41.06 ^d (30.04)	33.22 ^c (43.17)	19.05 ^d (10.72)	52.23 ^d (62.52)	--
2	AC01(0.4GR)	60	15.00	56.12 ^b (68.96)	17.57 ^c (9.17)	53.94	15.86 ^b (7.51)	24.99 ^b (15.17)	22.91 ^b (17.87)	15.55 ^c (7.20)	38.03 ^b (38.01)	39.21
3	AC 01 (0.4GR)	75	18.75	59.41 ^a (74.13)	11.45 ^a (4.00)	80.0	12.98 ^a (5.08)	11.54 ^a (10.97)	19.31 ^a (4.04)	3.78 ^a (0.50)	26.93 ^a (20.58)	67.08
4	Chlorantraniliprole 0.4GR (Market sample; Cover)	75	18.75	58.96 ^a (73.43)	11.94 ^a (4.30)	78.40	13.20 ^a (5.22)	11.82 ^a (11.05)	19.38 ^a (4.22)	6.60 ^b (1.33)	28.51 ^a (22.80)	63.53
5	Fipronil 0.3GR	75	25.00	58.57 ^a (72.84)	13.27 ^b (5.29)	73.43	15.45 ^b (7.14)	32.22 ^c (18.72)	25.61 ^d (28.49)	15.98 ^c (7.61)	44.81 ^c (49.70)	20.50
6	Fipronil 0.3GR	100	33.33	59.98 ^a (75.00)	11.66 ^a (4.13)	79.26	12.82 ^a (4.96)	26.92 ^b (15.08)	22.83 ^b (20.54)	8.56 ^b (2.23)	28.75 ^a (23.20)	64.60
	'F' test	-	-	Sig.	Sig.		Sig.	Sig.	Sig.	Sig.	Sig.	
	CD (p=0.05)	-	-	2.50	2.43		2.46	2.43	2.10	2.38	2.61	
	CV %	-	-	2.34	8.57		7.91	5.32	5.63	11.16	3.88	

DAP - Days after planting; Figures in parenthesis are original values

Table 3. Impact of AC01 (0.4GR) on juice sucrose, yield attributing characters and marketable cane yield (t/ha)

Sr. No	Treatment	Dose/ha		Juice Sucrose (%)	Yield attributing characters			Cane yield (t/ha)	Increase in cane yield over control (%)
		g a.i./ha	Formulation (kg/ha)		Cane height (m)	Cane girth (cm)	NMC (000'/ha)		
1	Untreated control	-	-	19.25	1.67	1.47	60.78	69.33	-
2	AC01(0.4GR)	60	15.00	19.49	2.04	1.49	62.22	80.08	17.91
3	AC 01 (0.4GR)	75	18.75	20.07	2.27	1.50	73.11	92.17	32.94
4	Chlorantraniliprole 0.4GR (Market sample; Cover)	75	18.75	20.03	2.28	1.51	72.97	91.33	32.88
5	Fipronil 0.3GR	75	25.00	19.29	2.12	1.50	71.24	80.50	16.11
6	Fipronil 0.3GR	100	33.33	19.69	2.24	1.51	72.78	90.50	30.53
	'F' test			NS	Sig.	NS	Sig.	Sig.	
	CD (p-0.05)			-	0.16	-	10.72	8.31	
	CV%			4.08	4.26	1.20	9.04	4.86	

DAP - Days after planting; Figures in parenthesis are original values

statistically at par with chlorantraniliprole 0.4GR (market sample) @ 75 g a.i./ha (73.83%), fipronil 0.3GR @ 75 g a.i./ha (72.84%) and fipronil 0.3GR @ 100 g a.i./ha (75.00%) but differed from untreated control.

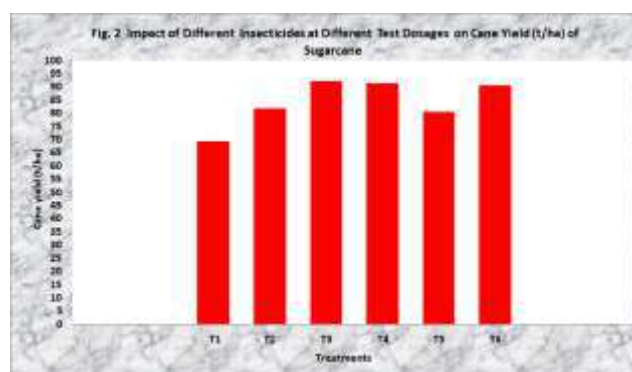
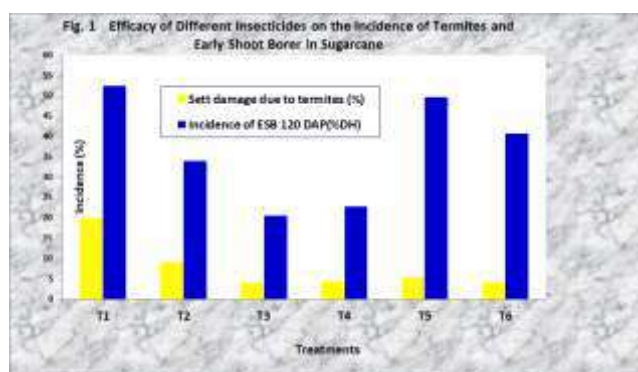
Termites

Based on the data recorded 30 days after planting (Table 2), the percentage of sett damage caused by termites ranged from 4.00% to 19.91%. Among the six treatments, AC 01 (0.4GR) 75 g a.i./ha (4.00%) was found effective against termites as compared to untreated control (19.91%) and it was at par with fipronil 0.3GR 100 g a.i./ha (4.13%) and chlorantraniliprole 0.4GR (Market sample) @ 75 g

a.i./ha (4.30%). However, all the insecticidal treatments except AC 01(0.4%GR) 60 g a.i./ha (9.17%) were found effective in reducing the sett damage by termites and recorded good per cent germination over untreated control. The findings regarding fipronil agree with those of Alam *et al* (2001), who reported that soil application of fipronil 0.3G at 100 g a.i./ha was effective in managing white grubs and termites in sugarcane. Similarly, studies by Gold (2014) and Jones *et al* (2017) demonstrated the high efficacy of chlorantraniliprole when applied to soil, noting its ability to provide structural protection and induce rapid termite mortality upon contact. Chlorantraniliprole is particularly valued for its prolonged residual activity and its capacity to quickly suppress termite activity following application

Table 4. Evaluation of AC01 (0.4GR) for phytotoxicity on sugarcane

S. No.	Treatment	Dose/ha		Phytotoxicity scoring							
		g a.i. ha ⁻¹	Formulation (kg/ha)	Epinasty	Hypo nasty	Yellowing	Necrosis	Leaf injury	Vein clearing	Wilting	Stunting
1	Untreated control	-	-	0	0	0	0	0	0	0	0
2	AC01(0.4GR)	60	15.00	0	0	0	0	0	0	0	0
3	AC 01 (0.4GR)	75	18.75	0	0	0	0	0	0	0	0
4	Chlorantraniliprole 0.4GR (Market sample)	75	18.75	0	0	0	0	0	0	0	0
5	Fipronil 0.3GR	75	25.00	0	0	0	0	0	0	0	0
6	Fipronil 0.3GR	100	33.33	0	0	0	0	0	0	0	0
7	AC 01 (0.4GR)	150	37.50	0	0	0	0	0	0	0	0
8	AC 01(0.4GR)	300	75.00	0	0	0	0	0	0	0	0



Early shoot borer

The data on the incidence of early shoot borer recorded at 30 days after planting (Table 2) revealed that among six treatments, least incidence of early shoot borer was recorded in crop treated with fipronil 0.3GR @ 100 g a.i./ha (4.96% DH) followed by AC01 (0.4 GR) @ 75 g a.i./ha (5.08 % DH) and chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i./ha (5.22 % DH). These treatments were statistically at par but superior over control (26.26 % DH). The incidence of early shoot borer recorded at 60 days after planting revealed that among six treatments, less incidence of early shoot borer was recorded in AC 01 (0.4GR) @ 75 g a.i./ha (4.04 % DH) and chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i./ha (4.22 %DH) as compared to untreated control (43.17% DH) and these treatments were statistically at par with each other. The incidence of early shoot borer recorded at 90 days after planting revealed that among six treatments, less incidence of early shoot borer was recorded in crop treated with AC01 (0.4GR) @ 75 g a.i./ha (10.97 % DH) and chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i./ha (11.05 %DH) compared to untreated control (30.04% DH) and these two treatments were statistically at par with each other. Data on incidence of early shoot borer was also

recorded at 120 DAP (Table 2). Among six treatments, lowest incidence of early shoot borer was recorded in crop treated with AC 01 (0.4%GR) @ 75 g a.i./ha (0.50 %DH) and in chlorantraniliprole 0.4GR @ 75 g a.i./ha (1.33% DH) which were statistically at par with each other and were significantly superior over untreated control (10.72%DH). The data on cumulative incidence of early shoot borer (% DH) revealed that among six treatments, AC 01 (0.4GR) @ 75 g a.i./ha (20.58%DH) and chlorantraniliprole 0.4GR @ 75 g a.i./ha⁻¹ (22.80 %DH) were found significantly most effective against early shoot borer as compared to other treatments and untreated control (52.52%DH) and were statistically at par with each other (Table 2 & Fig.1).

The results of the study revealed that soil application of AC01 (0.4 GR) at 75 g a.i./ha, applied at planting and 40 days after planting, effectively reduced the incidence of termites and early shoot borer up to 120 DAP. Its performance was comparable to that of chlorantraniliprole 0.4 GR (Market sample; COVER) and fipronil 0.3 GR, with no observed phytotoxic effects even at 4X the recommended dosage. These findings align with Bhavani *et al* (2016) and Choudhary *et al* (2018) reported its effectiveness when applied at planting and again at 60 days after

Bioefficacy of chlorantraniliprole (AC 01) 0.4%GR against Early Shoot Borer and Termites

planting (DAP). Similarly, studies by Pandey (2014) and Shobharani *et al* (2018) found chlorantraniliprole 0.4 GR to be effective and comparable to the 20 SC formulation in managing early shoot borer infestations. Umashankar *et al* (2018) also reported that both chlorantraniliprole 0.4 GR and fipronil 0.3 GR effectively reduced the cumulative incidence of *Chilo infuscatellus*, resulting in significantly higher cane yields compared to untreated control. Likewise, Bhawar *et al* (2015) found that treatment with Ferterra 0.4 GR at 75 g a.i.ha⁻¹, along with cartap hydrochloride 4G, effectively reduced dead heart incidence. In the studies conducted by Penn *et al* (2023), Chlorantraniliprole recorded least damage of 0.9 per cent compared to other chemicals and untreated check. Similarly, earlier research supports the effectiveness of fipronil in managing shoot borer and termite infestations. Halimie *et al* (1989), Patil *et al* (1993), Nagalakshmi *et al* (1999), and Dheer Singh and Tomar (2003) reported that the application of fipronil 0.3G significantly reduced the incidence of shoot borer.

Juice sucrose

The data on the percentage juice sucrose ranged between 19.25 in untreated control and 20.07 in AC 01 (0.4GR) @ 75 g a.i.ha⁻¹. However, there was no significant difference between the treatments (Table 3).

Cane height

The data on cane height (Table3) revealed that among six treatments, maximum cane height was recorded in plots treated with chlorantraniliprole 0.4GR @ 75 g a.i.ha⁻¹ (2.28 m) followed by AC01 (0.4 GR) @ 75 g a.i.ha⁻¹ (2.27 m), fipronil 0.3GR @ 75g a.i.ha⁻¹ (2.12 m) and @ 100g a.i.ha⁻¹ (2.24 m). All these treatments resulted in significantly greater cane height compared to the untreated control (1.67 m).

Cane girth

The data recorded on cane girth at harvest showed that all the treatments recorded significantly more cane girth (1.49 to 1.51 cm) as compared to untreated control (1.47 cm). However, statistically there was no significant difference among the treatments (Table 3).

Number of millable canes (NMC/Ha)

The data presented in Table 3 indicated that the number of millable canes (000'NMC/ha) recorded at harvest ranged between 60.78 to 73.11. Among the six treatments, more number of millable canes per hectare were recorded in plots treated with AC 01 (0.4GR) @ 75 g a.i.ha⁻¹ (73.11 NMC/ha) followed by

chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i.ha⁻¹ (72.97 NMC/ha), fipronil 0.3GR at 100 g a.i.ha⁻¹ (71.78 NMC/ha) and at 75 g a.i.ha⁻¹ (70.44 NMC/ha) and were significantly superior over control (60.78 NMC/ha), though these four chemical treatments were statistically at par with each other.

Marketable cane yield

Data on marketable cane yields at harvest revealed that among six treatment, highest cane yield was recorded in AC01 0.4GR) @ 75 g a.i.ha⁻¹ (92.17 t/ha) with 32.94 percent increase in cane yield followed by chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i.ha⁻¹ (91.33 t/ha) with 32.88 per cent increase in cane yield and fipronil 0.3GR @ 100g a.i.ha⁻¹ (90.50 t/ha) with 30.53 per cent increase in yield (Table 3, Fig.2). These treatments were statistically superior over untreated control (69.33 t/ha).

Phytotoxicity

The results of the field experiment to assess the phytotoxicity of the AC01 (chlorantraniliprole) 0.4%GR at 60g.a.i.ha⁻¹, 75g a.i. ha⁻¹ (X dose), 150g a.i. ha⁻¹ (2X dose) and 300g a.i. ha⁻¹ (4X dose) applied at the time of planting and 40 days after planting in sugarcane did not show any phytotoxic effects like leaf injury, wilting, vein clearing, necrosis, yellowing, stunting, epinasty and hyponasty. Phytotoxicity rating of 0 was observed at all the days of observation (Table 4).

CONCLUSION

The study confirms that soil application of chlorantraniliprole (AC 01) 0.4% GR at 75g a.i./ha or fipronil 0.3G at 100g a.i./ha, administered at the time of planting and again 40 days after planting, is an effective strategy for managing early shoot borer and termite infestations in sugarcane.

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Communication Skills and Knowledge Transfer among Livestock Farmers through WhatsApp

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ABSTRACT

This study examined the role of WhatsApp as a communication tool among livestock farmers in Dharmapuri focusing on its effectiveness in enhancing information sharing and decision-making. A total of 1,546 farmers participated in 12 dedicated WhatsApp groups with 100 farmers selected for detailed analysis over six months, resulting in 40 queries primarily concerning large ruminant health, disease management, and reproduction. WhatsApp emerged as the preferred method for information gathering, facilitating timely responses from agricultural experts and fostering a sense of community among farmers. The Krishi Vigyan Kendra, Dharmapuri established these groups to provide expert advice and technological insights, particularly during adverse weather conditions when in-person visits were impractical. Most queries were related to crossbred cattle management with significant interest in low-cost feed options for goats. Farmers utilized various communication methods including text voice messages and images to effectively convey their issues. Overall, WhatsApp has proven invaluable for knowledge exchange and the development of sustainable livestock management practices, bridging information gaps and promoting agricultural innovation, thereby enhancing farmer engagement and enabling efficient data generation for agricultural scientists.

Keywords: Engagement, Farmer, Information Sharing, Livestock, Management, WhatsApp.

INTRODUCTION

WhatsApp one of the most popular social media tools is offered with numerous unique advantages that make it a potent agricultural extension tool. After the COVID-19 outbreak, livestock farmers began utilizing social media to gather information through various queries. KVK Dharmapuri conducted many online training programs for knowledge sharing and problem-solving, motivating the farming community in Dharmapuri to use WhatsApp for immediate responses to their questions. This allowed farmers to gain technological insights from home, even during heavy rain and hot summer days when they could not visit KVK Dharmapuri in person. Senior citizens found it particularly easy to obtain information through the KVK WhatsApp group.

Traditionally, agricultural information was disseminated through mainstream media such as newspapers, television, and radio. Nowadays, farmers are increasingly using smartphones to access social media platforms like Facebook, Twitter, YouTube, and blogs for sharing both personal and agricultural information. The benefits of social media for farmers

include coverage of large geographical areas in a short time, reduction of social isolation, increased networking opportunities, mobilization of farmers, keeping them updated, and facilitating the marketing of agricultural goods with ease. (Ramavhale *et al*, 2024). Social media boosted youth participation in agriculture boosted livestock production and as a result reduced unemployment rates (Tijani, 2023). Research has shown that mobile messaging platforms can enhance the effectiveness of agricultural extension services by providing timely information and fostering collaboration among stakeholders (Choudhary *et al*, 2021). WhatsApp allows for the rapid exchange of information, enabling farmers to address urgent issues such as animal health concerns and management practices more efficiently. This immediacy is crucial in rural areas where access to veterinary services and expert advice may be limited (Patil and Reddy, 2020). Moreover, the use of WhatsApp can lead to increased farmer engagement, as it provides a platform for interactive discussions, enabling farmers to share experiences and best practices (Thakur and Chander, 2017) This community-driven approach not only

empowers individuals but also builds a network of knowledge that can enhance overall agricultural productivity (Mehta *et al*, 2022). Therefore, the current study was conducted to examine the impact of WhatsApp on livestock advisory services examining its role in facilitating communication, disseminating knowledge, and improving farmer participation.

MATERIALS AND METHODS

The Krishi Vigyan Kendra (KVK) in Dharmapuri has established 12 dedicated WhatsApp groups for sharing information and transferring technology with 1,546 farmers joining these groups. These farmers were added as part of their participation in various KVK programs, including Frontline Demonstrations (FLD), On-Farm Trials (OFT), training sessions, and Integrated Farming System (IFS) programs. Additionally, farmers could join voluntarily through referrals from their peers. For this research study, 100 livestock farmers who frequently asked animal husbandry queries were randomly selected. The primary objective was to assess the impact of WhatsApp as a cost-free communication tool for addressing queries and providing updates on KVK programs. Field visits were conducted over two years during KVK's diagnostic assessments, FLD, and OFT activities. Each participating farmer owned at least one type of livestock. During these visits, interviews were held to explain how WhatsApp could be used in animal husbandry, emphasizing that even illiterate farmers could utilize the platform for effective communication through photos, videos, text messages, and voice notes.

Each WhatsApp group included KVK scientists and officials from relevant line departments, ensuring that the advice provided to livestock and poultry farmers was of high quality. When farmers raised queries, these were promptly addressed by the animal scientists in clear and easily understandable language, facilitating comprehension among other farmers in the group and enabling them to implement precautionary measures as needed. Literate farmers used WhatsApp to send text messages in local Tamil, while illiterate farmers asked questions through photos, videos, and voice messages in Tamil, often with help from literate family members or neighbors. Following this initial phase, farmers with relevant expertise also contributed by sharing their own

experiences. In a six-month period, sums of 40 queries were gathered from January to June 2024. After six months, post-intervention evaluation regarding the utilization of the information was collected through semi-structured interviews conducted via telephone and during KVK visits for various programs. Participants were encouraged to expand on their preferred sources of data for specific queries. This approach provided valuable insights into the effectiveness of WhatsApp as a communication tool in the context of livestock management.

RESULTS AND DISCUSSION

The results (Table 1) indicate that most farmers own crossbred cattle followed by goats, indigenous backyard poultry, improved backyard poultry, sheep, indigenous cattle, and buffalo. A very small proportion of farmers have buffalo, indigenous cattle, and sheep. The presence of cattle farmers highlighted their resourcefulness, which requires greater investments in capital feed and forage (Turner and Leonard, 2004). In contrast, sheep and goat owners are often resource limited farmers in India. This suggests that the significant portion of sheep and goat farmers in households may be due to limited access to social media in the Dharmapuri district during the research study.

Queries received in the WhatsApp group

The results (Table 2) express in larger ruminants, the most frequent queries addressed immediate threats to production and reproduction, such as issues related to Ethno Veterinary Medicine, mastitis, and infertility. These findings were consistent with results from the Kisan Call Centre (Tiwari *et al*, 2010). In the present study, majority of inquiries pertained to large ruminant wellbeing, disease management, and reproduction. Following this, inquiries about small ruminants focused on the care and management of newborn kids, disease management, and low-cost feed supplements, such as Azolla production technologies. Queries about backyard poultry included breed selection, feed management, and disease prevention, while very few inquiries were related to buffalo. Additional inquiries regarding cattle covered topics such as vaccination, deworming, communicable viral diseases, and fodder crops.

Communication Skills and Knowledge Transfer among Livestock Farmers through WhatsApp

Table 1. Households raising various livestock and backyard breeds.

Sr. No.	Species	Numbers of households animals
1.	Cattle local	18
2.	Cattle cross bred	65
3.	Buffaloe	8
4.	Goat	64
5.	Sheep	26
6.	Backyard poultry-Natty	56
7.	Backyard poultry- Improved	32

**Since responded had diverse livestock, the overall value may exceed to 100*

Table 2. Queries received in the KVK Dharmapuri WhatsApp groups.

Sr. No.	Parameter	Voice message	Message	Video	Images	Responded by animal scientist	Addressed by other farmers
Queries on cattle and buffaloes							
1	Suggest best fodder for higher milk production	Yes	No	No	No	Yes	No
2	How to increase milk fat percentage?	Yes	No	No	Yes	Yes	Yes
3	What is the use of mineral mixture for improving health?	No	No	No	Yes	Yes	No
4	How to mangat milk seepage from teat?	Yes	No	No	No	Yes	No
5	How to control thelitis in buffaloe?	No	Yes	No	Yes	Yes	Yes
6	How to manage infertility in buffaloes?	Yes	No	No	No	Yes	No
7	What should be done to cure bloat in heifer?	No	No	No	No	No	No
8	Suggest vaccination schedule for cow and buffaloe.	No	No	No	No	No	No
9	What should be done if cow not shed placenta?	No	No	No	No	No	No
10	How to care new born calf ?	No	No	No	No	No	No
11	How to control enteritis in calf ?	No	No	No	No	No	No
12	How to control mastitis through EVM practices?	No	No	No	No	No	No
13	Suggest deworming schedule of pregnant cow .	No	No	No	No	No	No
14	Where to get fodder seeds?	No	Yes	No	No	Yes	No
15	What is the line of treatment for hyper salivation?	No	Yes	No	No	Yes	No
16	What is an EVM for infertility management?	No	No	No	No	Yes	No
17	How to dry off the pregnant cow?	Yes	No	No	No	Yes	No
18	How to identify the LSD in cow ?	Yes	No	No	No	Yes	No
19	Weather LSD can spread to buffaloes?	Yes	No	No	No	Yes	Yes
20	How to control tick on cow ?	No	No	Yes	No	Yes	No
Queries on sheep and goat							
21	What is a best meat type of goat in Dharmapuri district?	No	No	No	Yes	Yes	No
22	How to manage kid mortality?	No	No	Yes	No	Yes	No
23	What should I do for increase kid birth weight?	No	No	Yes	No	Yes	No
24	What should I do for control goat enteritis?	No	No	Yes	No	Yes	No
25	What is difference between sheep and goat in terms of profit ?	Yes	No	No	No	Yes	No
26	What is an quantity of mineral for sheep and goat?	Yes	No	No	Yes	Yes	No
27	What is estrous synchronization of sheep and goat ?	Yes	No	No	Yes	Yes	No
28	What is the best tree fodder for higher weight gain?	No	Yes	No	No	Yes	No
29	What is an quantity of azolla supplement for sheep?	No	Yes	No	Yes	Yes	No
30	Suggest azolla production technology.	No	Yes	No	No	Yes	No
31	How to manage neck abscess in goat ?	No	Yes	No	No	Yes	No
32	How to control bloat in goat ?	Yes	No	No	No	Yes	No
Queries on backyard poultry							
33	What is best varieties of poultry for higher income ?	Yes	No	No	Yes	Yes	No
34	Suggest suitable dual purpose backyard poultry.	Yes	No	No	No	Yes	No
35	How to prevent chick mortality?	No	Yes	No	Yes	Yes	No
36	How to control RD in poultry?	No	Yes	No	No	Yes	No
37	How to prepare concentrate feed at home ?	No	Yes	Yes	Yes	Yes	No
38	How to increase numbers of egg in poultry?	No	No	No	Yes	Yes	No
39	How to prevent pecking behavior in poultry?	No	No	No	Yes	Yes	Yes
40	Suggest brooding management of poultry .	Yes	No	No	No	Yes	No

Table. 3 Preferred approach for gathering to address inquiry.

Sr. No.	Parameter	First	Second	Third
1.	Whatsapp	28	9	0
2.	Internet	1	0	0
3.	Veterinary Dispensary personal (VAS)	4	13	0
4.	Veterinary Training centre	4	14	0
5.	Pharmacy	1	0	1
6.	Progressive farmers	0	0	2
7.	Telephone conversion and message	1	0	0
8.	ATMA personal	0	0	1
9.	NGOs	0	0	1
10.	Dairy cooperative personal	1	0	2
11.	Total	40	36	6

Species wise Enquiries

Species-wise inquiries indicate that many queries regarding cattle focused on production, reproduction, and disease prevention. This suggests that most farmers in the Dharmapuri district rear crossbred cows for milk production and are eager to address any drastic reductions in milk yield. In contrast, there were very few queries related to buffalo, indicating a small buffalo population in the district. Regarding small ruminants, queries about the care of newborn lambs were minimal, suggesting that sheep-rearing farmers rely on open grazing and may lack knowledge about using WhatsApp for information gathering. Conversely, most farmers inquired about the care of newborn kids, feed management, disease management, and low-cost feed for goats. This interest likely stems from the profitable nature of goat rearing in the Dharmapuri district, and these farmers appear to be more familiar with using WhatsApp for information which concurred with the findings of Thakur *et al* (2017).

Queries from Voice message, text message, pictures, video

Queries received in the form of voice messages, text messages, videos, and pictures from farmers are shown in Table 2. Among these, many queries included pictures of the livestock, which provided better insight into the nature and severity of the problems. This was followed by voice messages, text messages, and videos. Consequently the quality of advice enhanced, the quality of advice improved,

leading to an increased level of satisfaction among farmers. In livestock and poultry, visuals assist in concentrating on the material and retaining on the information in long term memory (Thakur, 2017 and Heffernan and Nielsen, 2007). In the present study, picture messages were the most common followed by voice messages, text messages, and videos. This preference may be attributed to the convenience for farmers and their ability to convey problems effectively. Pictures are easy to share, while voice messages can clearly communicate issues.

Discussion with WhatsApp

All queries were responded to by the scientist in charge of animal sciences, while very few queries were addressed by other farmers (7 out of 40). This indicates that farmers were largely unfamiliar with the topics of the queries and had limited knowledge. They also learned from the queries instead of asking other farmers, who were well-versed in the 40 queries. According to Thakur *et al* (2017), WhatsApp has a strong ability to facilitate discussion and build networks among farmers. As a result, farmers' family members and neighbors can quickly learn about all the queries, showcasing WhatsApp's strength in providing timely and cost-free access to technology and information.

Preferred method of obtaining information for addressing the inquiry

The results in Table 3 show that the majority of queries (28 out of 40) indicated that WhatsApp was the

Communication Skills and Knowledge Transfer among Livestock Farmers through WhatsApp

first choice for gathering information, followed by Veterinary Dispensaries (13 out of 36) as the preferred second choice, and queries from progressive farmers as the third choice. Farmers also used WhatsApp after obtaining information from other sources, such as Veterinary Dispensaries, VUTRC professionals, and progressive farmers. There was only one query from a pharmacy and one telephonic conversation. This indicates that after one farmer's query, subsequent farmers quickly followed up for responses, demonstrating the effectiveness of WhatsApp. The high number of queries suggests that farmers trust animal scientists and value the immediate responses facilitated by WhatsApp. This reflects the success of WhatsApp in fostering farmer involvement and engagement, allowing them to gather valuable information in a short amount of time, which aligns with previous findings. (Thakur *et al*, 2017).

CONCLUSION

The study highlights that WhatsApp has become an essential tool for farmers in Dharmapuri, enhancing their ability to gather and share information on livestock management. In today's digital world, personal contact with every farmer for queries is impractical, leading some to remain hesitant about seeking help. WhatsApp enables even the most reluctant farmers to request assistance, while also facilitating efficient data generation for scientists. This platform fosters community connections and supports agricultural innovation. Overall, WhatsApp is invaluable for knowledge exchange, promoting sustainable farming practices in the region.

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Comparative Economics of Groundnut Cultivation under Sprinkler and Conventional Irrigation Methods

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ABSTRACT

The research explores the economic and resource use patterns of groundnut cultivation among farmers adopting and not adopting sprinkler irrigation in Gujarat's Sabarkantha, Mehsana, and Patan districts. A total of 99 adopters and 105 non-adopters were selected through a multistage sampling method, wherein blocks and villages were chosen based on the concentration of adopters, and within the villages farmers were randomly sampled. The study revealed that farmers who adopted sprinkler irrigation incurred lower labour costs and achieved higher yields compared to non-adopters. The resource use pattern revealed that seed, machinery cost and labour cost were major contributors to total cost across both the categories. The returns over variable cost (ROVC) were ₹77,681.83 per hectare for adopter and ₹69415.26 per hectare for non-adopter for all three districts. The benefit-cost ratios were 1.85 for adopter and 1.73 for non-adopter for all three districts. These findings display that adopter achieved higher profitability in groundnut cultivation. The payback period for investment in sprinkler irrigation ranged from 2 to 3 years, compared to its 10-year operational lifespan across all districts. Regression analysis using the power function showed that seed, fertilizer, pesticide, and machinery costs significantly influenced output for adopters, while fertilizer, machinery, and labour costs were key factors for non-adopters. This suggests underutilization of these inputs, indicating potential for increased usage to enhance returns. The study concludes that adopting sprinkler irrigation improves yield and boosts profitability in groundnut cultivation. It recommends strengthening efforts to promote micro-irrigation through training, subsidy awareness, and demonstrations.

Key Words: ROVC, Resource use, Benefit-cost ratio, sprinkler irrigation

INTRODUCTION

Oilseed production has long been a crucial part of Indian agriculture, with oilseed crops covering 16.76% of the total cultivated agricultural land (GoI, 2024). The emphasis on the oilseed production in India is expected to gain momentum with launch of National Mission on Edible Oils – Oilseeds (NMEO-Oilseeds) which aims to reduce the dependency on imports for domestic consumption.

In India, Groundnut holds a significant position among oilseed crops, accounting for 15.59% of the total oilseed area and contributing 25.67% to total oilseed production in 2023-24 (GoI, 2024).

Gujarat leads the country in groundnut cultivation, holding the top position in both area and production. At the all-India level, Gujarat contributes 45.62% to the total groundnut production and covers 36.06% of the

total area under groundnut cultivation. The significance of groundnut in Gujarat is evident from its share in the state's total oilseed area and production. According to the final advance estimates for 2023-24, groundnut accounted for 54.02% of the total oilseed area and 61.42% of the total oilseed production (GoG, 2024).

These figures highlight the need to examine the economics and resource utilization of groundnut cultivation and explore potential improvements in resource use at the farm level. With this aim, a study was carried out in Northern Gujarat to analyse the economics and resource utilization of groundnut cultivation among farmers adopting sprinkler irrigation and those relying on conventional flood irrigation.

The comparison between these two categories of farmers was conducted to highlight the need for more efficient use of water in Northern Gujarat, a region experiencing a declining water table for the past few

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Table 1: Overview of Groundnut Cultivators by District, Block, Village, and Adoption Category.

Sr. No.	District	Block	Village	Adopters	Non- Adopters
1)	Sabarkantha	Idar	Kukadiya, Umedgarh	32	41
		Vijayanagar	Kundla Kampa, Andropa		
2)	Mehsana	Satlasana	Vaghar, Isakpura	35	44
		Kheralu	Moti Hiravani, Gajipur		
3)	Patan	Siddhpur	Nagvasan, Lukhasan	32	20
		Patan	Sariyad, Sampra		
Total Farmers				99	105

decades. The study emphasizes that adopting this water-saving technology can help farmers reduce cultivation costs, enhance crop yields, improve the marginal productivity of water, and increase profitability (Kumar and Palanisami, 2010; Chandrakanth *et al* 2013; Singh and Singh, 2021).

In this context, this paper seeks to achieve two main objectives: a) To analyse the cost and returns of groundnut cultivation among adopters and non-adopters of water-saving technology ; and b) To assess resource utilization and returns to scale using the power production function.

MATERIALS AND METHODS

This study is part of broader research on estimating water productivity in crops and livestock by comparing water-saving technologies with conventional irrigation methods. The proposed study is based on a sample of 240 farmers, with this paper specifically utilizing data from those cultivating groundnut in the study area. The data for this paper was collected from farmers for Kharif season of 2024.

The survey was carried out in three districts- Sabarkantha, Mehsana, and Patan- using a multistage sampling approach, two blocks were selected from each district and two villages from each block were chosen based on data from the Gujarat Green Revolution Company (GGRC) on water-saving technology adopters at the block and village levels.

a) Cost and Returns Analysis:

Profit analysis is essential for determining the viability of any agricultural activity. The profitability was computed using variable cost which includes, expenses on farmyard manure, seeds, seed treatment, human labour, machinery for tillage, intercultural and threshing operations, as well as pesticide (herbicide, fungicide, and insecticide) and fertilizer.

Per hectare returns over variable costs, gross returns, and the benefit-cost ratio were calculated using the following formulas:

$$GR = (Quantity\ of\ main\ product \times Value\ of\ main\ product) + (Quantity\ of\ by- product \times Value\ of\ by- product)$$

$$ROVC = GR - TVC$$

$$B-C\ Ratio = GR / TVC$$

Where,

GR= Gross revenue

ROVC= Return over variable cost

TVC= Total variable cost

B-C ratio= Benefit – cost ratio

b) Payback- Period:

To determine the time required to recover the investment in sprinkler irrigation, the widely recognized payback period method was utilized (Ali *et al*, 2019, Gautam and Singh, 2020). It is calculated by dividing the total cost of installing sprinkler irrigation (₹/ha) by the incremental benefits gained from this investment in groundnut cultivation (₹/ha).

$$Payback\ Period\ (years) = \frac{Total\ Cost\ of\ Sprinkler\ Irrigation\ Installation}{Incremental\ Benefits\ in\ Groundnut\ Cultivation}$$

c) Power function or Cobb- Douglas production function:

The power function is commonly used in agriculture to assess the extent to which changes in input levels impact output levels. It also helps identify the inputs that significantly influence on production and is widely utilized to evaluate the returns to scale of a production activity (Singh and Singh, 2023. Singh and Thakur, 2023, Borisagar *et al*, 2024, Singh *et al*, 2024).

Comparative Economics of Groundnut Cultivation under Sprinkler

Table 2: Cost and return estimation of groundnut cultivation in Patan District (₹/ha)

Sr. No.	Particular	Adopter		Non- Adopter	
1)	Seed	16877.12	(18.54)	16760.64	(17.79)
2)	Seed Treatment	678.08	(0.75)	657.28	(0.70)
3)	FYM	6464.64	(7.10)	6061.12	(6.43)
4)	Pesticides	4516.00	(4.96)	4764.00	(5.06)
5)	Fertilizers	11489.92	(12.62)	10512.32	(11.16)
a)	Urea	819.52		1015.04	
b)	DAP	4476.16		4043.52	
c)	Ammonium Sulphate	1726.40		1385.28	
d)	12:32:16	4467.84		4068.48	
6)	Labour cost	17975.36	(19.75)	19651.84	(20.86)
7)	Machinery cost	21261.76	(23.36)	21632.00	(22.97)
8)	Electricity Cost	9676.78	(10.63)	12007.51	(12.75)
9)	Sub total	88939.66		92046.71	
10)	Interest on Working Capital	2075.26	(2.28)	2147.76	(2.28)
11)	TVC (9+10)	91014.92	(100.00)	94194.46	(100.00)
12)	Gross Returns	167941.96		163755.50	
13)	ROVC (12-11)	76900.06		69561.00	
14)	BC over VC (12/11)	1.84		1.74	
15)	Price (Rs. / Quintal)	6521.90		6526.25	
16)	Yield (Quintals/ ha)	23.59		22.92	

The general form of the production function is as follow:

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} e^{u_i}$$

After applying the log transformation, the

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + u_i$$

Where,

Y = Total returns from groundnut production (Rs/ha)

X₁ = Total seed cost (Rs/ha)

X₂ = Total fertilizer Cost (Rs/ha)

X₃ = Total pesticide cost (Herbicides, Insecticides and fungicides) (Rs/ha)

X₄ = Total labour cost (Rs/ha)

X₅ = Total Machinery cost (Rs/ha)

β₀ = Constant term

β₁-β₅ = Regression coefficients

X₁-X₅ = Independent variables

u_i = Stochastic error term

Returns to scale refer to the change in output when all inputs are varied simultaneously. If output increases more than proportionally to the change in inputs, it indicates increasing returns to scale. If the increase in output is less than proportional, it reflects decreasing returns to scale. When output changes in the same proportion as inputs, it is termed constant returns to scale. For a power function, which is a homogeneous production function, the sum of its coefficients indicates the returns to scale.

$$RTS = \sum_{i=1}^j \beta_i$$

Here, β_i is the production or regression coefficients of variable X₁ to X_j

Consequently, if the returns to scale (RTS) > 1, it indicates increasing returns to scale; if <1, it signifies decreasing returns to scale; and if equal to 1, it represents constant returns to scale.

RESULTS AND DISCUSSION

Groundnut is a major Kharif crop in the state. This section examines the cost and return structure of groundnut cultivation among adopters and non-adopters of the sprinkler irrigation system across three districts.

Table 3: Cost and Return estimation of groundnut cultivation in Mehsana District. (₹/ha)

Sr. No.	Particular	Adopters		Non- Adopters	
1)	Seed	16971.90	(19.15)	15875.19	(17.82)
2)	Seed Treatment	629.67	(0.71)	575.46	(0.65)
3)	FYM	6613.62	(7.46)	6217.47	(6.98)
4)	Pesticides	4856.00	(5.48)	4517.00	(5.07)
5)	Fertilizers	11721.87	(13.23)	12430.77	(13.95)
a)	Urea	917.40		950.76	
b)	DAP	4357.65		4391.01	
c)	Ammonium Sulphate	1367.76		1309.38	
d)	12:32:16	5079.06		5779.62	
6)	Labour cost	22451.28	(25.34)	23702.28	(26.60)
7)	Machinery cost	20116.08	(22.70)	19961.79	(22.40)
8)	Electricity Cost	3229.90	(3.65)	3787.65	(4.25)
9)	Sub total	86590.32		87067.61	
10)	Interest on Working Capital	2020.44	(2.28)	2031.58	(2.28)
11)	TVC (9+10)	88610.76	(100.00)	89099.18	(100.00)
12)	Gross Returns	166197.92		157678.43	
13)	ROVC (12-11)	77587.16		68579.25	
14)	BC over VC (12/11)	1.88		1.77	
15)	Price (Rs. / Quintal)	6059.30		5995	
16)	Yield (Quintals/ ha)	24.69		23.59	

Cost and Return analysis

a) Patan District

Table 2 presents the cost and return structure of groundnut cultivation in Patan district. The gross returns per hectare were higher for adopters of sprinkler irrigation (₹1,67,941.96) compared to non-adopters (₹1,63,755.49), primarily due to the higher yield achieved under sprinkler irrigation (23.59 q/ha) versus the flooding method (22.92 q/ha). Additionally, the variable cost was lower for adopters (₹ 91,014.92/ha) than for non-adopters (₹ 94,194.46/ha). This difference can be attributed to lower labour costs in sprinkler irrigation, as no labour is required for irrigation in sprinkler system.

Machinery, seed, and labour were the major cost affecting factors for both adopter and non-adopter farmers. Among adopters, these inputs contributed 23.36%, 19.75%, and 18.54% of the total variable cost, respectively, while for non-adopters, the shares were 22.97%, 20.86%, and 17.79%, respectively. Due to lower costs and higher gross returns, the return over variable cost (ROVC) was higher for adopters at ₹76,900.06/ha, compared to ₹69,561.00/ha for non-

adopters. The benefit-cost ratio over variable cost was 1.84 for adopters and 1.74 for non-adopters, indicating greater profitability for those using sprinkler irrigation.

b) Mehsana District

Table 3 outlines the cost and return structure of groundnut cultivators in Mehsana district. Adopters of sprinkler irrigation achieved higher gross returns per hectare (₹1,66,197.92) compared to non-adopters (₹1,57,678.43), primarily due to the increased yield under sprinkler irrigation (24.69 q/ha) compared to the flooding method (23.59 q/ha). Additionally, the variable cost was slightly lower for adopters at ₹88,610.76/ha, compared to ₹89,099.18/ha for non-adopters.

Labor, machinery, and seed were the key cost components for both adopter and non-adopter farmers. Among adopters, these inputs constituted 25.34%, 22.70%, and 19.15% of the total variable cost, respectively, while for non-adopters, the proportions were 26.60%, 22.40%, and 17.82%, respectively. Due to lower costs and higher gross returns, adopters achieved a higher return over variable cost (ROVC) of ₹77,587.16/ha, compared to ₹ 68,579.25/ha for non-adopters. The benefit-cost ratio over variable cost was 1.88 for adopters and 1.77 for non-adopters.

Comparative Economics of Groundnut Cultivation under Sprinkler

Table 4: Cost and Return estimation of groundnut cultivation in Sabarkantha District (₹/ha)

Sr. No.	Particular	Adopters		Non- Adopters	
1)	Seed	14361.48	(15.04)	13802.70	(13.59)
2)	Seed Treatment	562.95	(0.59)	546.27	(0.54)
3)	FYM	11346.57	(11.88)	11154.75	(10.98)
4)	Pesticides	5264.00	(5.51)	5490.00	(5.40)
5)	Fertilizers	7593.57	(7.95)	8252.43	(8.12)
a)	Urea	771.45		846.51	
b)	DAP	3657.09		4032.39	
c)	Ammonium Sulphate	1463.67		1676.34	
d)	12:32:16	1701.36		1697.19	
6)	Labour cost	27576.21	(28.87)	32634.42	(32.14)
7)	Machinery cost	25236.84	(26.42)	25145.10	(24.76)
8)	Electricity Charges	1389.11	(1.45)	2205.51	(2.17)
9)	Sub total	93343.24		99264.54	
10)	Interest on Working Capital	2177.72	(2.28)	2315.39	(2.28)
11)	TVC (9+10)	95508.45	(100.00)	101546.58	(100.00)
12)	Gross Returns	158660.04		156615.66	
13)	ROVC (12-11)	63151.59		55069.08	
14)	BC over VC (12/11)	1.66		1.54	
15)	Price (Rs. / Quintal)	26.69		26.10	
16)	Yield (Quintals/ ha)	5944.55		6000.6	

c) Sabarkantha District

Table 4 details the cost and return structure of groundnut cultivators in Sabarkantha district. Sprinkler irrigation adopters achieved higher gross returns per hectare (₹1,74,039.74) compared to non-adopters (₹1,71,652.08), primarily due to their higher yield (26.69 q/ha) versus the flooding method (23.59 q/ha). Additionally, adopters incurred a lower variable cost of ₹95,508.45/ha, whereas non-adopters had a higher variable cost of ₹1,01,546.58/ha.

Labor, machinery, and seed were the major cost components for both adopter and non-adopter farmers. Among adopters, these inputs contributed 28.87%, 26.42%, and 15.04% of the total variable cost, respectively, while for non-adopters, the shares were 32.14%, 24.76%, and 13.59%, respectively. Notably, labour costs in this district were the highest among the three studied. With lower costs and higher gross returns, adopters achieved a higher return over variable cost (ROVC) of ₹78,531.29/ha, compared to ₹70105.50/ha for non-adopters. The benefit-cost ratio over variable cost was 1.82 for adopters and 1.69 for non-adopters.

d) All three districts

Table 5 summarizes the cost and return structure of

groundnut cultivators across all three districts. Farmers adopting sprinkler irrigation achieved higher gross returns per hectare (₹ 1,69,393.21) compared to non-adopters (₹1,64,362), primarily due to their higher yield (24.69 q/ha) versus the flooding method (23.59 q/ha). Additionally, adopters had a lower variable cost of ₹91,711.38/ha, whereas non-adopters incurred a higher variable cost of ₹94,946.74/ha.

Labor, machinery, and seed were the key cost components for both adopter and non-adopter farmers. Among adopters, these inputs accounted for 24.72%, 24.21%, and 17.52% of the total variable cost, respectively, while for non-adopters, the shares were 26.68%, 23.43%, and 16.30%. Adopters benefited from reduced costs and increased revenue, resulting in a return over variable cost (ROVC) of ₹77681.83/ha, surpassing the ₹69415.26/ha recorded for non-adopters. The profitability advantage of sprinkler irrigation was further evident in the benefit-cost ratio, which stood at 1.85 for adopters compared to 1.73 for non-adopters.

Ramoliya and Prajapati (2022) has also found that Seed, machinery and labours were highest contributing inputs to the cost. Hiren and Ramchandra (2023) found the benefit-cost ratio in Jamnagar's groundnut farms at 1.53 (marginal), 1.68 (small), and 1.85 (semi-

Table 5: Cost and Return estimation of groundnut cultivation in all three districts (₹/ha)

Sr. No.	Particulars	Adopters		Non- Adopters	
1)	Seed	16070.17	(17.52)	15479.51	(16.30)
2)	Seed Treatment	623.57	(0.68)	593.00	(0.62)
3)	FYM	8141.61	(8.88)	7811.11	(8.23)
4)	Pesticides	4878.67	(5.32)	4923.67	(5.19)
5)	Fertilizers	10268.45	(11.20)	10398.51	(10.95)
a)	Urea	836.12		937.44	
b)	DAP	4163.63		4155.64	
c)	Ammonium Sulphate	1519.28		1457.00	
d)	12:32:16	3749.42		3848.43	
6)	Labour cost	22667.62	(24.72)	25329.51	(26.68)
7)	Machinery cost	22204.89	(24.21)	22246.30	(23.43)
8)	Electricity Charges	4765.26	(5.20)	6000.22	(6.32)
9)	Sub total	89620.24		92781.83	
10)	Interest on Working Capital	2091.14	(2.28)	2164.91	(2.28)
11)	TVC (9+10)	91711.38	(100.00)	94946.74	(100.00)
12)	Gross Returns	164283.28		159358.78	
13)	ROVC (12-11)	72571.90		64412.04	
14)	BC over VC (12/11)	1.79		1.68	
15)	Price (Rs. / Quintal)	24.99		24.20	
16)	Yield (Quintals/ ha)	6175.25		6173.95	

Table 6 : Evaluation of the Payback Period for Sprinkler Investment in Groundnut Cultivation

Sr. No.	District	Cost of Sprinkler (₹/ha)	Incremental Benefit (₹/ha)	Payback Period (in yrs)
1)	Sabarkantha	24863.50	8082.51	3.08
2)	Patan	23925.62	7418.76	3.23
3)	Mehsana	25264.30	8978.33	2.81

medium). According to Narayanmoorthy *et al* (2020), groundnut farmers who adopted drip irrigation earned ₹25,911 more per acre than those using the furrow method, right due to a yield improvement of 10 quintals per acre.

Payback Period

Table 6 presents the number of years required to recover the investment in the sprinkler irrigation system across three districts. The cost of the sprinkler system was calculated after deducting subsidies. Mehsana recorded the shortest payback period of 2.80 years to recover the investment of ₹25,264.30 per hectare in sprinkler irrigation, followed by Sabarkantha, where the payback period was 2.95 years for a cost of ₹24,863.50 per hectare. Patan required the longest duration, with a payback period of 3.26 years to recover ₹23,925.62 per hectare from groundnut cultivation. The incremental benefits from adopting

sprinkler irrigation were ₹9007.91, ₹8425.79, and ₹7339.06 per hectare for Mehsana, Sabarkantha, and Patan, respectively.

Power Production Function

The power function or Cobb- Douglas production function was employed to identify the resource use pattern.

a) Adopters of sprinkler irrigation system

Table 7 presents the regression results for adopter categories across all three districts. In Sabarkantha, seed and fertilizer were found significant at the 5% and 1% level of significance, respectively. This indicates that a 1% increase in seed and fertilizer usage would result in a 0.26% and 0.23% rise in gross returns per hectare. The model's R² value was 75.6%, with an adjusted R² of 70.9%, suggesting that 75.6% of the variability in gross returns could be explained by the

Comparative Economics of Groundnut Cultivation under Sprinkler

Table 7: Power Production Function for adopters of sprinkler irrigation system.

Independent Variable	Sabarkantha		Patan		Mehsana	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant (β_0)	9.0193**	2.019	8.9457	29.472	4.4526**	1.026
Seed (β_1)	0.2608*	0.051	-0.0321	3.854	0.1129	0.106
Fertilizer (β_2)	0.2303**	0.029	-5.2321	4.925	0.5752**	0.073
Pesticides (β_3)	-0.0049	0.022	0.5812**	0.178	0.0012	0.044
Labour Cost (β_4)	0.053	0.039	4.7621	5.201	-0.0266	0.119
Machinery Cost (β_5)	-0.1184	0.203	0.7234**	0.173	0.0252	0.159
R ²	75.6		80.5		70	
Adjusted R ²	70.9		77.3		64.8	
RTS= $\sum \beta_{1-5}$	0.67		0.80		0.69	
No. of Observations	32		32		35	

**, * indicate significance at 1 and 5 % level of significance, respectively.

Table 8: Power Production Function for non- adopters of sprinkler irrigation system

Independent Variables	Sabarkantha		Patan		Mehsana	
	Coefficients	Standard Error	Coefficients	Standard Error	Coefficients	Standard Error
Constant (β_0)	8.0472**	1.0341	3.3211	4.939	6.9124**	2.542
Seed (β_1)	0.0459	0.0625	0.2933	0.589	0.0347	0.098
Fertilizer (β_2)	0.0935*	0.037	0.0786	0.124	0.3894**	0.068
Pesticides (β_3)	0.0005	0.0275	-0.1263	0.1	-0.0523	0.087
Labour Cost (β_4)	0.0435	0.0476	0.1559	0.305	0.6853**	0.159
Machinery Cost (β_5)	0.2784*	0.0571	0.9947*	0.427	-0.4231	0.451
R ²	57.5		51.4		77.3	
Adjusted R ²	49.3		44.3		74.6	
RTS= $\sum \beta_{1-5}$	0.46		1.39		0.63	
No. of Observations	41		20		44	

**, * indicate significance at 1 and 5 % level of significance, respectively.

included variables.

In Patan, pesticide and machinery cost were found significant at 1% level. This indicates that a 1% increase in pesticide and machinery cost would result in a 0.58% and 0.72% rise in gross returns per hectare. The model's R² value was 80.6%, with an adjusted R² of 77.3%, suggesting that 80.6% of the variability in gross returns (dependent variable) could be explained by the independent variables.

In Mehsana, fertilizer was found significant input at 1% level. This indicates that a 1% increase in fertilizer levels would result in a 0.57 % increase in gross returns per hectare. The observed R² value was 70%, with an adjusted R² of 64.8%, suggesting that 70 % of the variability in gross returns could be explained by the included variables.

Regression analysis showed returns to scale of 0.67 in Sabarkantha, 0.80 in Patan, and 0.69 in Mehsana, implying that a 1% increase in all the inputs included in model will raise gross returns by 0.67%, 0.80%, and 0.69%, respectively.

b) Non-adopters of sprinkler irrigation system

Table 8 presents the regression results for non-adopters

of the sprinkler irrigation system. In Sabarkantha, machinery and fertilizer were found significant at 5% level of significance, indicating that a 1% increase in their usage would result in 0.28% and 0.09% increase in gross returns per hectare, respectively. The model exhibited an R² value of 57.5% and an adjusted R² of 49.3%, suggesting that the included variables explained 57.5% of the variation in gross returns.

In Patan, machinery was found significant at the 5% level, indicating that a 1% increase in machinery usage would result in 0.99% increase in gross returns per hectare. The observed R² value of model was 51.4% and an adjusted R² of 44.3%, suggesting that the included variables explained 51.4% of the variation in gross returns.

In Mehsana, fertilizer and machinery were found significant at 1% level, indicating that a 1% increase in their usage would result in 0.39% and 0.68% increase in gross returns per hectare, respectively. The model shown an R² value of 77.3% and an adjusted R² of 74.6%, suggesting that the included variables explained 77.3% of the variation in gross returns.

Regression analysis revealed returns to scale of 0.46 in Sabarkantha, 1.39 in Patan, and 0.63 in Mehsana,

indicating that a 1% rise in all inputs considered in the model would increase gross returns by 0.46%, 1.39%, and 0.63%, respectively. Singh *et al* (2014) and Devi *et al* (2020), through their regression analysis, also identified seed, fertilizer, human labour, and machine labour as key factors influencing groundnut output.

CONCLUSION

The groundnut farmers using sprinkler micro-irrigation earned higher returns than those practicing conventional open flooding method. Yield under sprinkler irrigation was 2–4% higher across the three districts compared to the conventional method. A detailed analysis of the cost composition in groundnut cultivation for adopters and non-adopters revealed that machinery, labour, and seed were the major cost-contributing inputs across all districts. Adopters had lower labour costs than those using the conventional method, as micro-irrigation eliminates the need for labour for irrigation. The payback period was shorter than the warranty provided by suppliers for sprinkler irrigation equipment across all three districts, highlighting its profitability as an investment. Regression analysis of groundnut farmers revealed that for sprinkler irrigation adopters, seed, fertilizer, and pesticides significantly impacted returns, whereas for non-adopters, fertilizer, machinery, and labour were the key contributing factors.

The findings of this research suggest that farmers adopting sprinkler irrigation not only enhance their profitability but also improve the efficiency of scarce resources like water. In regions where livestock farming has thrived, there is a need to transition towards technologies that can increase the marginal productivity of water, electricity, and farm inputs. Policymakers and state governments should remain committed to initiatives such as "More Crop per Drop," ensuring that awareness about the benefits of these schemes, along with the subsidy structure, effectively reaches farmers at the grassroots level.

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Constraints Perceived by Rainbow Trout (*Oncorhynchus mykiss*) Fish Farmers in Adoption of Fish Farming Practices in Jammu and Kashmir

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ABSTRACT

The study was conducted in the Srinagar district of Jammu and Kashmir (UT) to assess the constraints faced by rainbow trout fish farmers in the adoption of improved fish farming practices. The data were collected from randomly selected 53 fish farmers with the help of pre-tested interview schedule. The collected data were classified, tabulated and statistically analyzed. The findings revealed that majority of the fish farmers were under the middle age group (47.17%), educated up to a higher secondary level (41.51%), male (83.02%), married (83.02%), fish farming experience as medium (49.06%) and under high income group (60.38%). Further, results revealed that constraints like lack of quality fish seed availability was (technological constraints) perceived by 81.13 per cent fish farmers, poor transport facility was (infrastructural constraints) perceived by 77.36 per cent fish farmers and *high price of trout seed and feed* was (economic constraints) perceived by 92.45 per cent fish farmers which were indicating the major barriers in adoption of improved fish farming practices by the farmers in study area.

Keywords: Rainbow trout, socio-economic characteristics, constraints, fish farmers.

INTRODUCTION

The fisheries sector has an enormous potential to provide nutritional security as well as employment opportunities to millions of people. In this sector, about 28 million people are engaged directly or indirectly. India is the third largest fish-producing country in the world and accounts for 8.92% of the global production and second largest aquaculture nation in the world followed by China. The total fish production during 2022-23 was 17.54 MMT (million metric tonnes) with a contribution of 13.11 MMT from inland sector and 4.43 MMT from marine sector (Anonymous, 2023). Fish production in J&K union territory reached 28 thousand Mt in 2023-24. With the increase in the number of trout hatcheries 51 and 1368 trout units, the trout production biomass total of 2380 Mt in 2023-24. Rainbow trout holds significant value for anglers; the valley of Kashmir is renowned as Angler's Paradise due to its abundance of clear, cold-water turbulent streams, powerful springs, and high-altitude lakes (DoF, J&K).

The Kashmir region contributes significantly to trout production. The Kashmir province is composed of 486 km of rivers, 447 km of streams, and 157 square

km of lakes (Sodhi *et al*, 2013). Trout is a cold-water fish that prefers clear, torrential streams and transparent, high-altitude lakes. These streams have a high oxygen level, little vegetation, and trout survive in water between 0°C and 20°C, with an ideal range of 5°C to 15°C. Furthermore, there is a sizable population of insects in these water bodies that serve as food for trout. Brown trout (*Salmo truttafario*) and rainbow trout (*Oncorhynchus mykiss*) are both popular in J&K (Singh *et al*, 2017). The first trout farm was established at Harwan, which is a suburb area of district Srinagar, in 1901 and Achhabal, rural area of district Anantnag in 1908 (Sehgal, 2012).

The demand for trout seed is expected to increase, but till now there has been a huge gap between production and demand due to a lot of hindrances. It was essential to find out the main causes that were responsible for its less adoption by the farmers whereby suitable measures may be suggested to the fish farmers to minimizing the constraints and ultimately increased the fish production in UT of Jammu and Kashmir. Therefore, the present investigation was carried out to assess constraints perceived by rainbow trout (*Oncorhynchus mykiss*) fish farmers in adoption of improved fish farming practices.

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Table 1: Socio-economic characteristics of fish farmers. (*n=53)

Sr. No.	Characteristic	Category	Frequency	Percentage
1	Age (Yr)	Young (18 to 35)	17	32.08
		Middle (36 to 50)	25	47.17
		Old (above 50)	11	20.75
2	Education	Illiterate	3	5.66
		Primary	7	13.21
		Secondary	12	22.64
		Higher secondary	22	41.51
		Graduate	6	11.32
		Post-graduate	3	5.66
3	Gender	Male	44	83.02
		Female	9	16.98
4	Marital Status	Unmarried	9	16.98
		Married	44	83.02
5	Family size	Small (up to 4 member)	21	39.62
		Medium (5 to7 member)	25	47.17
		Large (more than 7 member)	7	13.21
6	Land holdings	Marginal (less than 1 ha)	47	88.68
		Small (1-2 ha)	6	11.32
		Big (more than 2 ha)	0	0.00
7	Land ownership	Personal	3	5.66
		Lease	12	22.64
		Family	38	71.70
8	Type of house possession	Earthen	1	1.89
		Semi cemented	7	13.21
		Cemented	45	84.90
9	Livestock owned	Cow	28	52.83
		Sheep/Goat	12	22.64
		None	13	24.53
10	Fish farming experience	Low (< 5 years)	19	35.85
		Medium (5-10 years)	26	49.06
		High (>10 years)	8	15.09
11	Annual income	Low (< 4 lakh)	3	5.66
		Medium (4-5 lakh)	18	33.96
		High (> 5 lakh)	32	60.38

*n=number of respondents

MATERIALS AND METHODS

The UT of Jammu and Kashmir consists of 20 districts. Out of which, the Srinagar district was selected purposively for the present investigation due to the district having a good opportunities in terms of fish production and consumption. From the list of total 71 trout fish farmers of Srinagar district, out of which only 53 (75%) respondents were selected through random sampling technique for the study purpose. The secondary data about fish farming activities of the district were collected from the department of fisheries, Srinagar. The primary data were collected from the selected fish farmers by personal interview with the

help of pre-tested structured interview schedule during the year 2023. The collected data were classified, tabulated and analyzed by using the appropriate statistical tools like frequency, percentage, mean and standard deviation *etc.*

RESULTS AND DISCUSSION

Socio-economic characteristics of fish farmers

The data (Table 1) indicated that the majority of respondents (47.17%) belonged to the middle age group followed by 32.08 per cent in the young age group and 20.75 per cent in the old age group. Regarding education levels, 41.51 per cent fish farmers

Constraints Perceived by Rainbow Trout (*Oncorhynchus mykiss*) Fish Farmers

had completed higher secondary education, followed by secondary (22.64%), primary (13.21%), graduate (11.32%), and post-graduate (5.66%) qualifications. Only 5.66 per cent respondents were in illiterate category. The gender ratio showed a significant disparity; with 83.02 per cent of respondents being male and 16.98 per cent female were involved in fish farming activities. In terms of marital status, data revealed that 83.02 per cent of fish farmers were married, while 16.98 per cent were unmarried. Family size distribution indicated that 47.17 per cent of respondents belonged to medium-sized families, followed by small (39.62%) and large (13.21%) families. Landholding patterns highlighted that 88.68 per cent fish farmers were having marginal land holdings, 11.32 per cent were having small land holdings, whereas, none of the fish farmers were having big land holdings. In terms of land ownership, 71.70 per cent practiced fish farming on family-owned land, 22.64 per cent on leased land, and 5.66 per cent on personal land. Housing types showed that 84.90 per cent of respondents lived in cemented houses, 13.21 per cent in semi-cemented houses, and 1.89 per cent in earthen houses. Livestock ownership data revealed that 52.83 per cent of fish farmers owned cows, 22.64 per cent owned sheep or goats, and 24.53 per cent had no livestock owner. Fish farming experience varied, with 49.06 per cent were having medium experience followed by 35.85 per cent low experience and 15.09 per cent were having high experience, respectively. Annual income distribution indicated that 60.38 per cent respondents fell into the high-income category, followed by medium (33.96%) income, and only 5.66 per cent respondents were fell into low income group. These economic disparities highlight the importance of equitable income distribution for fostering social cohesion and harmony within the community.

The data indicated that near about fifty per cent of respondents belonged to the 36–50 age groups. It means middle age group fish farmers were actively engaged in fish farming activities due to their personal experience and having good earning from the fish farming. The findings of Kumar *et al* (2015), Salam *et al* (2020), and Surendran and Alex (2023) highlighted that middle-aged individuals were actively engaged in aquaculture and agricultural activities due to their experience, economic responsibilities, and willingness to adopt the improved fish farming practices. Education plays a vital role in encouraging farmers to adopt the fish farming. The majority of fish farmers had attained education up to the higher secondary level, indicating that good access to school education and higher studies. This finding aligns with the studies of

Kumar *et al* (2015), Salam *et al* (2020), and Surendran and Alex (2023) who reported that educated farmers were more likely to adopt improved agricultural methods. Majority of fish farmers were married and also, they have medium family size which facilitated the operation of fish farming through the collective efforts of their family members. The results were in line with the findings of Kumar *et al* (2015), Salam *et al* (2020) and Wake (2021). Maximum number of fish farmers were having marginal land holdings *i.e.* less than one hectare due to the division of land among family members from generation to generation. The findings supported with the findings of Kumar *et al* (2015), Salam *et al* (2020), and Wake (2021). Further the majority of respondents had owned livestock, with cattle and goats being the most common. These research findings were aligned with Wake (2021) who reported that livestock and aquaculture function as integrated farming systems within rural economic activities. A significant portion of fish farmers earning more than ₹5 lakh annually which indicating as fish farming is economically profitable. The findings were supported with the findings of Kumar *et al* (2015), Salam *et al* (2020) and Surendran and Alex (2023).

Constraints faced by the trout fish farmers in adoption of fish farming practices

Technological constraints

The data (Table 2) revealed that lack of quality fish seed availability was most perceived under technological constraints by 81.13 per cent trout fish farmers and occupied ranked as first. Whereas, difficulty to identify the quality fish seed was second most important technological constraints, which were perceived by 67.92 per cent fish farmers. Likewise, unavailability of skilled labour (26.42%) was perceived next important technological constraints. Further, the data revealed that lack of knowledge about scientific fish farming were perceived by 18.87 per cent fish farmers and occupied ranked as fourth among the technological constraints.

Infrastructural constraints

Poor transport facility was the most perceived under infrastructural constraints by 77.36 per cent of trout fish farmers and occupied ranked as first and *timely unavailability of quality seed and other inputs* was second important infrastructural constraints perceived by 39.62 per cent fish farmers. Further the data reported that *lack of access to water quality* (30.19%) was next important constraints and occupied ranked as third. Similarly, the inadequate *supply of medicines* were reported by 24.53 per cent fish farmers

Table 2: Constraints faced by the trout fish farmers in adoption of fish farming practices.
(n= 53 Multiple response)

Sr. No.	Constraint	Frequency	Percentage	Rank
A	Technological constraints			
1	Lack of quality seed availability	43	81.13	I
2	Difficulty to identify the quality fish seed	36	67.92	II
3	Unavailability of skilled labour	14	26.42	III
4	Lack of knowledge about scientific fish farming	10	18.87	IV
B	Infrastructural constraints			
1	Poor transport facility	41	77.36	I
2	Timely unavailability of quality seed and other inputs	21	39.62	II
3	Lack of access to water quality	16	30.19	III
4	Inadequate supply of medicines	13	24.53	IV
C	Economic constraints			
1	High price of trout seed and feed	49	92.45	I
2	Inaccessibility of marketing facility	32	60.38	II
3	Losses due to disease outbreaks	17	32.08	III
4	Low demand in local market	15	28.30	IV
5	Unawareness about government schemes	4	7.55	V
D	Culture constraints			
1	Water pollution	51	96.23	I
2	Less availability of fish feed in local market	44	83.02	II
3	Slow growth rate of fish	14	26.42	III
4	Insufficient availability of modern farm implements	8	15.09	IV
E	Social constraints			
1	Lack of financial support	22	41.51	I
2	Inadequate family encouragement	8	15.09	II
3	Illiteracy	3	5.66	III
F	Extension constraints			
1	Lack of farm publication	39	73.58	I
2	Lack of mass media exposure	28	52.83	II
3	Insufficient farm sites visit by the extension personnel's	19	35.85	III
4	Lack of need-based training program	13	24.53	IV

and occupied ranked as fourth under the infrastructural constraints.

Economic constraints

It was found that the *high price of trout seed and feed* was most perceived economic constraints by 92.45 per cent trout fish farmers and occupied ranked as first. Similarly, *inaccessibility of marketing facility* (60.38%) was perceived next important economic constraints and occupied ranked as second. Further the data revealed that *losses due to disease outbreaks* was

perceived by 32.08 per cent fish farmers and ranked as third, while *low demand in local market* (28.30%) and *unawareness about government schemes* (7.55%) were perceived ranked as fourth and fifth respectively, by the fish farmers among the infrastructural constraints.

Cultural constraints

Water pollution was most perceived by 96.23 per cent fish farmers under the cultural constraints and occupied ranked as first, whereas the less availability of fish feed in local market was perceived by 83.02 per

Constraints Perceived by Rainbow Trout (*Oncorhynchus mykiss*) Fish Farmers

Table 3: Category-wise overall position of constraints as perceived by the trout fish farmers. (n= 53)

Sr. No.	Category	Number of Statements	MPS	Rank
1	Cultural constraints	4	55.19	I
2	Technological constraints	4	48.58	II
3	Extension constraints	4	46.70	III
4	Economic constraints	5	44.15	IV
5	Infrastructural constraints	4	42.92	V
6	Social constraints	3	20.75	VI

MPS=Mean Per cent Score

cent fish farmers and occupied ranked as second among the culture constraints. Further the data revealed that slow growth rate of fish and insufficient availability of modern farm implements were perceived by 26.42 and 15.09 per cent fish farmers and occupied ranked as third and fourth respectively, under the culture constraints.

Social constraints

The (Table 2) revealed that lack of financial support was most perceived by the 41.51 per cent fish farmers among the social constraints and occupied ranked as first, whereas the inadequate family encouragement (15.09%) were perceived next important social constraints by the fish farmers and occupied ranked as second. Further the data revealed that illiteracy were perceived only by 5.66 per cent fish farmers and occupied ranked as last under the social constraints.

Extension constraints

The data presented in Table 2 showed that lack of farm publication was most perceived by 73.58 per cent fish farmers and occupied ranked as first under the extension constraints. Whereas, the lack of mass media exposure was second most important extension constraints which were reported by 52.83 per cent fish farmers. Likewise, the insufficient farm sites visits by the extension personnels' and lack of need-based training program were the next important extension constraints perceived by 35.85 per cent and 24.53 per cent fish farmers and occupied the ranked as third and fourth, respectively.

Categories-wise overall ranking of constraints

The overall ranking of constraints as perceived by the trout fish farmers in adoption of fish farming practices as presented in Table 3.

The data depicted in Table 3 revealed that cultural constraints (55.19 MPS) ranked first in adoption of fish farming practices. Technological constraints (48.58 MPS), extension constraints (46.70

MPS) and economic constraints (44.15 MPS) were ranked second, third and fourth, respectively. Furthermore, the constraints like infrastructural constraints (42.92 MPS) was recorded ranked as fifth, while social constraints (20.75 MPS) was recorded as last position (20.75 MPS) among the category of overall ranking of constraints as perceived by the trout fish farmer in the study area.

The findings indicated that culture constraints was one of the important constraints among all these constraints, under this head major issues as reported by fish farmers were water contamination due to the pesticides and fertilizers residues from the agriculture fields specially from orchards, sewage flow and anthropogenic garbage. Similarly, the lack of quality seed availability was reported as a technological constraint due to the limited availability of trout hatcheries and inadequate transport facilities for fish and fisheries products. Further the extension constraints highlights outreach and communication barriers, including the limited availability of farm publications, insufficient need-based training and awareness programs conducted for the fish farmers.

Economical constraints and infrastructural constraints which were indicating that financial barriers and deficiencies in physical infrastructure pose moderate but significant challenges to implementation of sustainable fish farming practices. These findings align with findings of Salam *et al* (2020), Chettri (2021) and Surendran and Alex (2023).

CONCLUSION

From the above findings, it can be concluded that majority of the trout fish farmers were under middle age group, educated up to a higher secondary level, possess medium family size, marginal land holding, good numbers of house possessions, medium fish farming experience, and having high annual income. The various constraints like lack of quality seed availability, poor transport facility, high price of

trout seed and feed, water pollution, lack of financial support and lack of farm publications were the important constraints in adoption of improved fish farming practices. From the overall ranking of constraints, cultural constraints was observed as the most important constraint whereas, social constraints were found as least important constraint in the adoption of trout fish farming practices by the fish farmers. It is suggested that government agencies should be provide affordable transportation facility for the fish farmers, concerned agencies and subject experts should be given more focus on reducing the seed and feed cost by using available low-cost ingredients. Furthermore, marketing infrastructure should be strengthened to ensure better market access as well as extension agencies should be given more emphasis to create mass awareness among fish farming community to maintaining pollutant-free of water resources.

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Determination of Alcohol in Botanical Extracts Using a Simple and Cost-Effective Oven-Based Assay

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ABSTRACT

A simple assay for the estimation of ethanol concentration is essential during the extraction of bioactive compounds in botanical research. This study presents an assay developed to measure ethanol levels in different extracted samples. Utilizing the boiling point properties of ethanol in conjunction with a hot air oven, the method is capable of determining a minimum standard alcohol content of 2% by volume, with a precision of $\pm 0.5\%$. This technique proves particularly advantageous for identifying ethanol that may have been inadvertently collected alongside the target compounds during the extraction process. Furthermore, this assay has been demonstrated to be a cost-effective, simple and accurate means of determining ethanol concentration in unknown solutions.

Keywords: Bioactive Compounds, Boiling Point, Ethanol, Plant Extract, Simple Method.

INTRODUCTION

Plant-derived bioactive compounds have attracted substantial interest in recent decades due to their promising applications in pharmaceuticals, nutraceuticals, and cosmetics (Sasidharan *et al.*, 2011; Kinghorn and Falk, 2002; Harborne, 1998; Dai and Mumper, 2010; Rostagno *et al.*, 2003). The extraction of these compounds typically involves the use of solvents, with ethanol being a widely preferred option due to its low toxicity, environmental compatibility, and efficiency in extracting a broad range of polar and semi-polar compounds (Harris, 2015). However, residual ethanol in the final extract can present several challenges. Accurate quantification of ethanol content is essential for ensuring the safety and consistency of plant extracts across different applications, monitoring the efficiency of extraction and purification processes, and complying with regulatory limits on residual solvents in food and pharmaceutical products. Moreover, the presence of ethanol may interfere with bioactivity assays, making its precise measurement even more critical. Ethanol's effectiveness as a solvent is largely attributed to its capacity to dissolve a wide spectrum of phytochemicals (Dai and Mumper, 2010). Additionally, the concentration of ethanol used during extraction can significantly affect the yield and composition of the extract (Rostagno *et al.*, 2003), further emphasizing the need for accurate

determination of any residual ethanol. Several factors can complicate the accurate determination of ethanol in plant extracts, including: The complex matrix of plant extracts, which may contain interfering compounds (Dai and Mumper, 2010; Rostagno *et al.*, 2003). The volatility of ethanol, which can lead to losses during sample preparation (Dean, 1998; Miller and Miller, 2018). The wide range of ethanol concentrations that may be encountered.

Various analytical techniques are employed to quantify ethanol in plant extracts, including: Gas Chromatography (GC) (Caputi *et al.*, 1968; Williams and Rosser, 1981; Holmberg and Sievänen, 1980; Skoog *et al.*, 2007). This is a widely used method due to its high sensitivity and selectivity. GC allows for the separation and quantification of ethanol from other volatile compounds in the extract. High-Performance Liquid Chromatography (HPLC) (Skoog *et al.*, 2007; Harris, 2015). HPLC offers an alternative method, particularly for non-volatile or thermally labile compounds. This method is also very useful for the determination of many of the bioactive compounds themselves, therefore can be used in conjunction with the bioactive compound analysis. Enzymatic Methods (Marazuela, 1996). These methods utilize enzymes that specifically react with ethanol, providing a rapid and accurate determination. Spectroscopic Methods (Vidal *et al.*, 2003). Methods like Near-infrared spectroscopy can be used for rapid determination of ethanol. This

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research article aimed to provide an overview of the importance and methodologies employed for the determination of ethanol in bioactive compound extracts derived from plant samples.

MATERIALS AND METHODS

This study developed a simple assay for the estimation of ethanol concentration in botanical extracts, leveraging the boiling point properties of ethanol (Lide, 2004).

Sample preparation

Standard ethanol solutions at concentrations of 2%, 4%, 6%, 8%, and 10% (v/v) were prepared by diluting absolute ethanol (99.9% purity) with sunflower oil, following established methods (Dean, 1998; Miller and Miller, 2018). Botanical extract samples, potentially containing residual ethanol, were collected for analysis. All samples were stored in tightly sealed vials at room temperature ($25 \pm 2^\circ\text{C}$) until further testing.

Assay procedure

Accurately measured 1 ml aliquots of each standard ethanol solution and unknown sample were transferred into pre-weighed, heat-resistant glass vials (Harris, 2015; Skoog *et al*, 2013; Dean, 1998). The initial weight of each vial containing the sample was recorded. The vials were then placed in a preheated hot air oven, maintained at 80°C . This temperature was selected to ensure the evaporation of ethanol (boiling point $\sim 78^\circ\text{C}$) (Lide, 2004). The vials were incubated in the oven for 24 hrs. This duration was empirically determined to ensure complete evaporation of ethanol from solutions with concentrations up to 100% w/v. Following incubation, the vials were removed from the oven and allowed to cool to room temperature. The final weight of each vial was recorded. The difference between the initial and final weights was calculated, representing the weight of evaporated ethanol.

Calculation of alcohol concentration

The percentage of Alcohol (w/v) in each sample was calculated using the following formula: Alcohol Concentration (w/v %) = (Weight of Evaporated Alcohol / Initial Sample Weight of Alcohol with Oil) x 100

Validation and accuracy assessment

The accuracy of the assay was assessed by comparing the measured alcohol concentrations of the standard solutions with their known concentrations

(Harris, 2015; Skoog, 2013; Miller and Miller, 2018). The precision of the assay was evaluated by performing replicate measurements ($n=3$) of each standard and unknown sample (Dean, 1998). The minimum detectable ethanol concentration was determined by analyzing low-concentration standard solutions.

Statistical analysis

The mean and standard deviation of replicate measurements were calculated (Dean, 1998). Linear regression analysis was performed to assess the correlation between known and measured ethanol concentrations (Dean, 1998).

RESULTS AND DISCUSSION

The developed assay demonstrated its ability to accurately estimate ethanol concentrations in both standard solutions and botanical extracts. The weight loss observed after heating the samples in the hot air oven correlated directly with the initial ethanol concentration. The measured ethanol concentrations of the standard solutions closely matched their known concentrations. Linear regression analysis revealed a strong positive correlation ($R^2 > 0.99$) between the known and measured values, indicating high accuracy (Table 1 and Fig 1). Replicate measurements of all samples exhibited a precision of $\pm 0.5\%$ v/v, confirming the reliability and reproducibility of the assay. The assay successfully detected ethanol concentrations as low as 2% v/v, demonstrating its sensitivity for low-level ethanol determination. The assay effectively quantified residual ethanol in various botanical extracts, highlighting its applicability in real-world scenarios.

The utilization of the boiling point differential between ethanol and sunflower oil, facilitated by a hot air oven, provided a simple and effective method for ethanol quantification (Lide, 2004). The 80°C temperature was crucial, ensuring the evaporation of ethanol while minimizing oil loss, thereby maintaining the accuracy of the assay. The assay is simple and required only 24 hours of heating, enabling simple determination of ethanol concentration. The method utilized readily available laboratory equipment and did not require expensive reagents or specialized instrumentation (Harris, 2015; Skoog *et al*, 2013; Smith, 2003). The procedure was straightforward, requiring minimal technical expertise. The assay demonstrated high accuracy and precision, making it a reliable tool for ethanol quantification (Miller and Miller, 2018). Due to the simple nature of the

Determination of Alcohol in Botanical Extracts Using a Simple

Table 1: Standard Calibration Data

Sr. No.	Percent of standard alcohol solution (w/v %)	Loss of alcohol (w/v %)
1	0	0
2	2	0.092
3	4	0.255
4	6	0.402
5	8	0.524
6	10	0.649

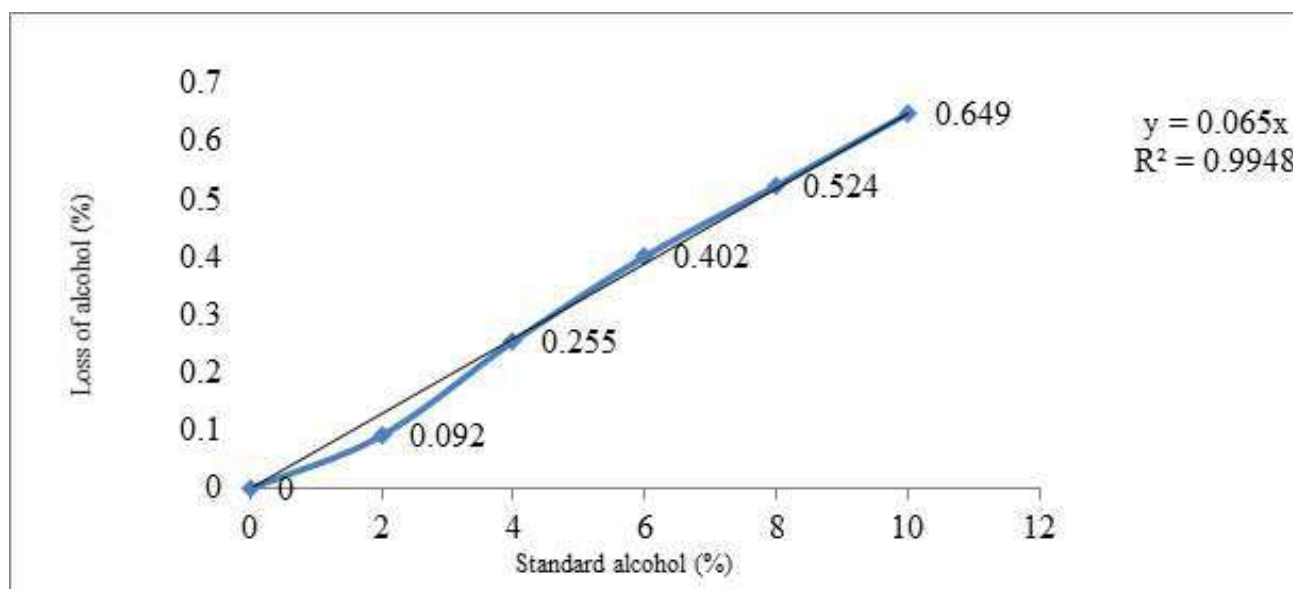


Fig 1: Calibration graph of spiked alcohol

equipment; this method could be very useful. Limitations of this method is the method relies on the assumption that ethanol is the primary volatile component lost during heating. The presence of other volatile compounds with similar boiling points could potentially interfere with the assay. The method is limited to the determination of ethanol in liquid samples. While the method can detect 2% standard ethanol, very low residual amounts of ethanol can be estimated using standard curve. This simple assay offers a valuable tool for researchers and practitioners involved in the extraction and purification of bioactive compounds from plant materials (Holmberg and Sievänen, 1980; Skoog, 2007; Sasidharan *et al*, 2011; Kinghorn and Falk, 2002; Harborne, 1998). It enables efficient monitoring of residual ethanol levels, ensuring product quality and compliance with regulatory standards. The method can be readily implemented in laboratories with limited resources, facilitating ethanol quantification in diverse settings.

CONCLUSION

The developed assay provides a cost-effective, simple, and accurate method for the determination of ethanol concentration in botanical extracts. Its simplicity and reliability make it a valuable tool for quality control and process optimization in botanical research and related industries. Additionally, the method's ability to detect ethanol as low as 2% with $\pm 0.5\%$ precision ensures dependable monitoring during extraction processes. Its adaptability to various extract types and ease of implementation make it particularly useful for both academic and industrial laboratories involved in phytochemical studies.

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Effect of Dietary Xylanase enzyme Supplementation on the Performance of Growing Crossbred Pigs

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ABSTRACT

A study examined whether xylanase enzyme supplementation could improve performance in growing crossbred pigs fed diets with lower energy content. The experiment used eighteen crossbred pigs (Large White Yorkshire × local pig crosses), 4 months old, divided into three equal groups of six animals each based on average body weight. The pigs were fed according to BIS (2023) standards (18% crude protein, 3170 kcal ME/kg), with the following treatment groups: T0: Standard pig grower diet (Control), T1: Control diet with energy reduced by 100 kcal ME/kg (Negative control) and T2: Negative control diet supplemented with xylanase (100 g/t). The feeding trial was conducted for 60 days during which daily dry matter intake, weekly body weight changes and body weight gain were recorded. The results indicated no significant differences in body weight, body weight gain, feed conversion ratio, or dry matter intake among the groups. The initial and final body weights were similar across all groups and the body weight gain remained consistent. Hence, the supplementation of xylanase did not significantly improve the growth performance in growing crossbred pigs.

Keywords: Enzyme supplementation, Feeding, Feed efficiency, Growth, Pig.

INTRODUCTION

Pigs offer exceptional economic potential compared to other livestock species due to their unique biological advantages like high reproduction rates, superior feed conversion efficiency, quick maturation and short generation intervals allow for faster returns on investment. The pig industry constantly seeks ways to improve feed efficiency while reducing production costs. One key approach involves lowering the energy or nutrient content in diets without compromising performance. The use of exogenous enzymes in these energy-reduced diets represents a promising strategy for maintaining productivity while decreasing feed costs. By supplementing lower-energy diets with specific enzymes, producers may potentially maintain growth performance while using less expensive feed formulations, creating an opportunity to enhance profitability in pig farming operations.

Corn and soybeans are an important feedstuff in pig feeding. Studies indicated that non-starch polysaccharide (NSP) in corn and soybean meal has negative effects on nutrient digestibility (Van Kempen *et al*, 2006). Whole corn grain contains 27–32 g of xylose/kg (Knudsen, 1997) as arabinoxylans in the pericarp and aleurone (Doner *et al*, 2001) which results in decreasing nutritional value of corn. The

supplementation of xylanase has been evaluated to improve growth performance and nutrient digestibility in pigs (Cheng *et al*, 2022). Xylanase enzyme supplementation in pig diets has shown promising results in improving feed efficiency and nutrient utilization. This exogenous enzyme specifically targets non-starch polysaccharides like xylans, which are abundant in cereal grains commonly used in pig feed but cannot be effectively broken down by the animal's endogenous enzymes. By hydrolyzing these complex carbohydrates, xylanase reduces intestinal viscosity and enhances the release of nutrients that would otherwise remain trapped within plant cell walls. Research indicates that xylanase supplementation can improve digestibility of energy, protein, and minerals, particularly phosphorus, while potentially reducing environmental pollution through decreased nutrient excretion. So far various research has been conducted to see the effect of supplementation of multi-carbohydrases (Yin and Kim, 2019) in all phases of pig production (Aranda-Aguirre *et al*, 2021), while scientific work addressing supplementation of the xylanase enzymes alone or in combination in the diet of growing pigs fed metabolizable energy-reduced diets are scarce and their mechanisms of action have not been yet established. Hence, the hypothesis in this study was that the supplementation of xylanase

Table 1: Ingredient composition (% DM basis) of experimental diets

Sr. No.	Ingredient	T0	T1	T2
1	Maize	51.1	54.0	54.0
2	Soybean	20.0	20.5	20.5
3	Rice polish	13.6	14.5	14.5
4	GNC	7.0	5.0	5.0
5	Vegetable oil	4.4	2.1	2.1
6	Trace Mineral/Premix	2.0	2.0	2.0
7	Salt	1.0	1.0	1.0
8	Lysine	0.6	0.6	0.6
9	Methionine	0.3	0.3	0.3
10	Vitamins/Premix	+	+	+
	Total	100	100	100

T0: No supplementation (Basal or Positive control diet), T1: T0 with reduced energy by 100 kcal ME/kg diet (Negative control diet), T2: T1 + xylanase enzyme supplementation @ 100 g/t.

Table 2: Effect of xylanase in low energy density diets on weekly body weight change (kg/pig) in growing crossbred pigs.

Age (Weeks)	Control	T1	T2	SEM	P Value
Initial BW	30.60	30.97	29.57	1.32	0.984
1	34.94	35.14	33.79	1.43	0.984
2	39.46	39.01	38.28	1.49	0.99
3	43.53	43.13	42.27	1.59	0.994
4	46.02	45.52	45.10	1.57	0.998
5	49.63	49.32	48.90	1.57	0.999
6	54.15	54.20	54.17	1.65	0.998
7	56.73	56.73	57.20	1.70	0.999
8	59.96	59.50	61.50	1.76	0.984

T0: No supplementation (Basal or Positive control diet), T1: T0 with reduced energy by 100 kcal ME/kg diet (Negative control diet), T2: T1 + xylanase enzyme supplementation @ 100 g/t.

Table 3: Effect of xylanase supplementation in low energy density diets on weekly body weight gain (kg/pig) in growing crossbred pigs.

Age (Weeks)	Control	T1	T2	SEM	P Value
1	4.34	4.17	4.22	0.22	0.979
2	4.52	3.86	4.49	0.14	0.368
3	4.07	4.13	3.99	0.17	0.732
4	2.48	2.38	2.83	0.12	0.505
5	3.62	3.8	3.8	0.14	0.951
6	4.52	4.89	5.26	0.25	0.576
7	2.58	2.52	3.03	0.13	0.422
8	3.23	2.77	4.3	0.21	0.350
Overall	3.67	3.56	3.99	0.08	0.323

T0: No supplementation (Basal or Positive control diet), T1: T0 with reduced energy by 100 kcal ME/kg diet (Negative control diet), T2: T1 + xylanase enzyme supplementation @ 100 g/t.

Effect of Dietary Xylanase enzyme Supplementation on the Performance

Table 4: Effect of xylanase supplementation in low energy density diets on dry matter intake (kg/pig) in growing crossbred pigs.

Age (Weeks)	Control	T1	T2	SEM	P Value
1	1.17	1.23	1.17	0.02	0.699
2	1.26	1.31	1.23	0.02	0.586
3	1.20	1.40	1.22	0.04	0.451
4	1.34	1.16	1.31	0.03	0.115
5	1.76	1.76	1.74	0.02	0.107
6	1.67	1.82	1.77	0.03	0.246
7	1.33	1.35	1.70	0.05	0.179
8	1.57	1.40	1.72	0.04	0.270
Overall	1.41	1.42	1.48	0.01	0.281

T0: No supplementation (Basal or Positive control diet), T1: T0 with reduced energy by 100 kcal ME/kg diet (Negative control diet), T2: T1 + xylanase enzyme supplementation @ 100 g/t,

Table 5: Effect of xylanase supplementation in low energy density diets on average daily feed intake (kg/pig) in growing crossbred pigs

Age (Weeks)	Control	T1	T2	SEM	P Value
1	1.31	1.38	1.31	0.02	0.697
2	1.43	1.48	1.39	0.02	0.609
3	1.35	1.57	1.38	0.04	0.444
4	1.51	1.31	1.48	0.03	0.204
5	1.98	1.98	1.96	0.02	0.206
6	1.89	2.05	2	0.03	0.255
7	1.5	1.52	1.91	0.05	0.214
8	1.76	1.58	1.94	0.04	0.261
Overall	1.58	1.60	1.66	0.02	0.255

T0: No supplementation (Basal or Positive control diet), T1: T0 with reduced energy by 100 kcal ME/kg diet (Negative control diet), T2: T1 + xylanase enzyme supplementation @ 100 g/t,

Table 6: Effect of xylanase supplementation in low energy density diets on feed conversion ratio in growing crossbred pigs.

Age (Weeks)	Control	T1	T2	SEM	P Value
1	2.33	2.44	2.21	0.13	0.952
2	2.27	2.71	2.19	0.08	0.123
3	2.41	2.73	2.42	0.08	0.528
4	4.36	4.02	3.9	0.17	0.442
5	3.87	3.73	3.8	0.14	0.753
6	3.01	3.06	2.73	0.14	0.852
7	4.67	4.25	4.43	0.25	0.941
8	3.95	4.31	3.28	0.21	0.268
Overall	3.36	3.40	3.12	0.07	0.600

T0: No supplementation (Basal or Positive control diet), T1: T0 with reduced energy by 100 kcal ME/kg diet (Negative control diet), T2: T1 + xylanase enzyme supplementation @ 100 g/t,

enzymes would allow the reduction of ME in diets, by increasing the use of energy and nutrients and consequently, would support pig performance.

MATERIALS AND METHODS

Selection of experimental animals, dietary treatment, and experimental design

Eighteen growing crossbred pigs (irrespective of sex) about 4 months of age pertaining to large white yorkshire crossed with desi pigs, were selected from AICRP on pig unit, Adhartal, College of Veterinary Science and A.H., N.D.V.S.U., Jabalpur (M.P) for the study. The growing crossbred pigs were randomly allotted to three dietary (6 animals each) treatments. The control group (T0) was standard pig grower diet as per BIS (2023) feeding standard (18% CP and 3170 kcal ME/kg diet) (Basal or Positive control diet) with no supplementation. Group T1 was T0 with reduced energy by 100 kcal ME/kg diet (Negative control diet). Group T2 diet included T1 + xylanase enzyme supplementation at a dosage rate of 100 g/t of feed (cost of 1 kg xylanase enzyme: ₹550). The ingredient composition of experimental diets is given in Table 1. The experiment was conducted for 8 weeks where all the pigs was managed under similar conditions.

The growth and feed utilization of experimental crossbred pigs were closely monitored throughout the trial. Daily dry matter intake (DMI) was tracked by recording the difference between feed offered and leftover feed on a weekly basis. This allowed to calculate precise consumption levels for each treatment group. Body weights were recorded weekly from the beginning to the end of the experiment using an electrical weighing balance. To ensure accuracy, weight measurements were taken in the morning before feeding. A 5-day adjustment period preceded the actual experiment to allow animals to acclimate to the experimental conditions. The pigs were housed and fed in groups, receiving measured quantities of feed twice daily—at 9:00 A.M. and 3:00 P.M. Clean drinking water was provided freely around the clock. Individual average feed consumption was determined by dividing the total group feed intake by the number of animals in each group. Feed conversion ratio, a key efficiency measure, was calculated by dividing the total feed consumed by the total body weight gained during the experimental period. Statistical analysis of the data was done by using analysis of variance using a completely randomized design as per Snedecor and Cochran (1994). Differences among the treatments will be tested for significance by Duncan's Multiple Range Test (1955)

RESULTS AND DISCUSSION

Growth Performance

The effect of xylanase supplementation on the weekly BW change (Kg) and weekly BW gain (Kg) of growing crossbred pigs is summarized in Table 2 and 3, respectively. The initial BWs in the T0, T1 and T2 groups were 30.60 Kg, 30.97 Kg and 29.57 Kg, respectively. By the end of the study, the BWs in the T0, T1 and T2 groups were 59.96 Kg, 59.50 Kg and 61.50 Kg, respectively. T2 Group crossbred pigs which were fed with marginal deficient in energy diet supplemented with enzyme xylanase their body weight improved and reached better than the positive and negative control pigs' group with normal ME for pigs. The initial weekly BW gain in the T0, T1 and T2 groups were 4.34 Kg, 4.17 Kg and 4.22 Kg, respectively. By the end of the feeding trial, the overall weekly BW gain for the T0, T1 and T2 groups were 3.67 Kg, 3.56 Kg and 3.99 Kg, respectively. Statistical analysis revealed no significant differences in the weekly BW gain among the groups ($P>0.05$).

During the 1st week, the DMI in the T0, T1 and T2 groups was 1.17 Kg/day, 1.23 Kg/day, 1.17 Kg/day, respectively, while, 8th week, T2 had a significantly ($p<0.05$) higher DMI 1.72 kg/day, followed by T0 which 1.56 kg/day while T1 recorded the lowest intake 1.40 kg/day. The overall DMI across the 8 weeks for the T0 (control), T1, and T2 groups was 1.41 kg/day, 1.42 kg/day, and 1.48 kg/day, respectively (Table 4). Overall (8 weeks) results indicated that when growing crossbred pigs were fed with low energy density diet supplemented with xylanase 100g/ t, did not influence the dry matter intake and therefore dry matter intake (kg/ pig) were statistically ($p>0.05$) similar in all the groups.

The effect of xylanase supplementation on the ADFI (Kg) and FCR of growing crossbred pigs is summarized in Table 5 and 6, respectively. During the study, no significant ($P>0.05$) differences were observed in the ADFI among the groups. In the 1st week, T1 exhibited the highest average daily feed intake 1.38 kg, followed by the control group 1.31 and T2 1.31 kg and by the overall, the ADFI for the control, T1 and T2 groups was 1.58 Kg/day, 1.60 Kg/day and 1.66 Kg/day, respectively. Overall (8 weeks) results of study indicated that when growing crossbred pigs were fed with low energy density diet supplemented xylanase 100 g/t did not influence their average daily feed intake and therefore average daily feed intake (kg/pig) were statistically ($p>0.05$) similar in all the groups. The mean FCR across all weeks for the control,

Effect of Dietary Xylanase enzyme Supplementation on the Performance

T1 and T2 was 3.36, 3.40 and 3.12, respectively. The FCR values remained consistent across all dietary treatments, indicating no substantial impact from the supplements. Similarly, results were also reported by Baker *et al* (2024), who found no significant effect of reducing energy by 100 kcal ME/kg or supplementing with β -mannanase in diets containing xylanase-phytase on body weight but highlighted improvements in nutrient digestibility. In the same manner, studies by Barrera *et al* (2004) and Cho *et al* (2013) reported that enzyme supplementation, particularly xylanase, improved body weight, body weight gain and growth performance, mainly by enhancing nutrient utilization. In this study, the trend of higher body weights in enzyme-supplemented groups suggests that xylanase could help support growth performance, especially in pigs on reduced energy diets, by improving nutrient digestibility and absorption. Although the statistical differences were not significant, the observed trends are promising and indicate that enzyme supplementation could be a useful strategy to optimize growth performance in energy-restricted diets.

Agyekum *et al* (2015) and Diebold *et al* (2004) reported by no significant ($p < 0.05$) changes in ADFI were observed across the treatments in several weeks. T2 exhibiting higher ADFI in the 7th and 8th weeks, consistent with Cho *et al*. (2013) and Bharathidhasan *et al* (2010), who noted that enzyme supplementation could enhance feed intake by improving nutrient utilization. The enzyme supplementation did not consistently affect feed intake but showed improvements at specific time points, suggesting that xylanase may enhance nutrient digestion without major alterations in overall feed consumption. McAlpine *et al*. (2012), observed no significant improvements in feed conversion efficiency with enzyme supplementation. T2 showed the most favourable FCR overall, despite the lack of consistent statistical significance, improved FCR was observed in certain weeks in T2 group, supporting the findings of Paterson *et al* (2005), who found that enzyme supplementation helps improve digestion and nutrient availability by reducing intestinal viscosity. Galli *et al* (2024) further emphasized that improvements in nutrient digestibility and metabolizable, which could result from enzyme supplementation, can contribute to better feed conversion.

These results align with the findings of the current study, suggesting that supplementing xylanase had no significant impact on the growth performance of growing crossbred pigs. The lack of notable differences in growth performance parameters may be

attributed to the lower dosage levels of these enzymes, which were likely insufficient to produce a measurable effect. Further research exploring different dosages and enzyme combinations is necessary to gain a clearer understanding of their potential benefits.

CONCLUSION

The dietary supplementation xylanase (@100g/tonn) in low-energy diets can enhance the growth performance and feed efficiency of growing crossbred pigs. Xylanase showed the most improvements in body weight gain, feed conversion ratio. Further research exploring different dosages and enzyme combinations is necessary to gain a clearer understanding of their potential benefits.

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Effect of Different Vase Solutions on Vase Life of Gladiolus (*Gladiolus grandiflorus*)

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ABSTRACT

Gladiolus is a highly popular ornamental bulbous plant, admired for its stunning spikes that bloom sequentially from the base to the top. Despite its vast potential, the crop's contribution to the international market remains limited, possibly due to inadequate post-harvest management. Enhanced vase life can be achieved by using certain vase solutions to improve their spike life. The study was undertaken to evaluate the impact of floral preservative chemicals on the vase life of cut spikes of Gladiolus cv. Arka Amar. A laboratory experiment was carried out at the Department of Floriculture and Landscaping, College of Horticulture, Mysuru during November 2024, in a completely randomized design with two replications using T1-water (control), T2-sucrose 200ppm, T3-sucrose 200ppm+citric acid 200ppm, T4- sucrose 200ppm+citric acid 300ppm, T5-sucrose 200ppm+STS 200ppm, T6-sucrose 200ppm+STS 300ppm, T7-sucrose 200ppm+Al₂So₄ 200ppm, T8-sucrose 200ppm+Al₂So₄ 300ppm, T9- sucrose 200ppm+ GA₃ 25ppm, T10- sucrose 200ppm+GA₃ 35ppm. Results revealed that among the treatments studied, holding solution containing Sucrose 200ppm+ Al₂So₄ 200ppm has improved days for basal floret opening (5d), vase life (11d), longer days for softening of lower floret in a spike (6days), more number of florets opened (10), maximum percentage of florets opening (88.15%), minimum transpiration loss and maximum water uptake followed by sucrose 200ppm with Ga₃ @ 25ppm. Thus, Al₂So₄ inhibit the microbial proliferation in the solution and sucrose in providing energy source for florets opening. Upon visual scoring on appearance (8.5) and freshness (8.0) were observed for same treatment combination.

Keywords: Gladiolus, Longevity, Preservative solution, Vase life.

INTRODUCTION

Gladiolus, commonly known as the Sword Lily is widely grown as a commercial cut flower worldwide. Its popularity stems from its striking spikes, adorned with elegant and delicate florets that bloom sequentially over time, contributing to its excellent keeping quality. However, the typical post-harvest life of gladiolus spikes is limited to just 6–7 d, which is insufficient for long-distance markets. Improper post-harvest handling further contributes to significant losses, with nearly 20–40% of cut flowers being wasted. Arka Amar is a high-yielding gladiolus variety distinguished by its orange-pink florets with a white blotch. It is commercially cultivated for cut flower production and is commonly used in floral arrangements, vase decorations, and bouquets (Bhattacharjee, 1999). The most desirable quality traits

from a market perspective include flower shape, size, color and freshness. As a result, consumers strive to preserve these qualities to keep the flowers fresh for as long as possible.

Flower longevity is affected by both pre-harvest factors and post-harvest care and post-harvest factors (Sowjanya *et al*, 2021). Pre-harvest factors include the genetic makeup and growing conditions of the plant, while post-harvest factors involve various techniques to minimize losses. These techniques involve regulating water relations, respiration, and relative humidity, as well as utilizing growth regulators, preservative solutions, pre-cooling, and storage methods as well as proper packaging and transportation Gupta *et al* (2018). Among preservatives, sugars play crucial role in maintaining the quality of cut flowers by providing the necessary energy source of food to the detached flower and for various

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Table 1: Treatment details for enhancing the vase life of gladiolus var. Arka Amar.

Treatment	Treatment combinations
T1	Control (dd.Water)
T2	Sucrose 200ppm
T3	Sucrose 200ppm + Citric acid 200ppm
T4	Sucrose 200ppm + Citric acid 300ppm
T5	Sucrose 200ppm + STS 200m
T6	Sucrose 200ppm + STS 300ppm
T7	Sucrose 200ppm + Al ₂ SO ₄ 200ppm
T8	Sucrose 200ppm + Al ₂ SO ₄ 300ppm
T9	Sucrose 200ppm + GA ₃ 25ppm
T10	Sucrose 200ppm + GA ₃ 35ppm

biological and physiological process even after separation from the mother plant. It also serve as an energy source for respiration, metabolic process in cut flowers Srinivas and Lakshmi (2019). It involves the breakdown of sugars to produce energy (in the form of ATP) that fuels cellular activities such as, nutrient uptake, synthesis of essential compounds and maintenance of cell integrity. This helps to maintain the turgidity of the flower's tissues, especially the expanding corolla in flower development and opening (Halevy and Mayak, 1981). While the GA₃ gibberellic acid, a plant growth regulator, extend the vase life by promoting their opening and delaying of senescence, keeping them fresh for longer time.

Aluminum sulfate (Al₂SO₄) inhibits the bacterial growth and stabilize petal colour due to antimicrobial properties. It also acts as a biocide in water to prevent the flowers from decaying quickly and prevents plugging of the conducting tissues (Sowjanya *et al*, 2019).

Citric acid maintains the pH level and prevents the bacterial growth. STS (Silver thiosulphate), chemical compound used as preservative to extend vase life by acting as an ethylene antagonist, by inhibiting the ethylene production. Recognizing the critical role of extended vase life in the trade of cut flowers, the present study aims to maximize the longevity of gladiolus flower spikes through preservative vase solutions like Sucrose, citric acid, Al₂SO₄, STS and GA₃.

MATERIALS AND METHODS

A laboratory experiment was conducted in November 2024 at the Department of Floriculture and Landscaping, College of Horticulture, Mysuru, to identify the best preservative combination for extending the vase life of **Gladiolus var. Arka Amar**.

Ten different preservative treatment combinations (Table 1) including water as control used in vase life experiment, performed in Completely Randomized Design with two replications. The spikes were harvested at its colour break stage and were kept in bucket of water immediately after harvesting. The cut flowers were positioned upright in the conical flask ensuring that the stems were dipped in vase solution (Plate 1). Prior to placement, the lower leaves were removed, leaving no leaves immersed in the vase solution. One gladiolus spike was taken for each treatment with two replications immersed in conical flask containing preservative solution of 200ml by giving a slant cut for the better absorption under ambient condition. The mouth of each conical flask was plugged with cotton to minimize evaporation losses during the experiment. Observations on days for basal floret opening, days for softening of first lower floret, initial spike weight (g), spike weight at peak florets bloomed stage (g), number of florets opened in a spike, percentage of florets opened in a spike, vase life (days), water uptake both on weight basis and volume basis, transpiration loss and overall quality of florets and spike by scoring at last day of vase life based on their colour and freshness. The cut spikes were monitored on daily basis until the end of freshness. The flowers along with the preservative solutions were initially weighed on alternate days. By calculating the consecutive difference in weights on each day, the water uptake was determined and expressed in grams per spike along with volume basis (ml). Spike longevity was measured by recording the number of days the florets remained fresh in the vase solution before exhibiting symptoms of bent neck (loss of spike strength) or advanced signs of withering. The vase life data for various parameters were analyzed statistically using sample means. An analysis of variance (ANOVA) table was prepared, and the critical

Effect of Different Vase Solutions on Vase Life of Gladiolus (*Gladiolus grandiflorus*)

Table 2: Effect of different chemical preservatives on post harvest spike quality traits of gladiolus var. Arka Amar.

Treatment	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
T1	4.50	4.00	32.80	38.35	8.00	81.00	31.00	8.00	7.00	7.00
T2	5.00	4.50	35.95	39.70	8.50	85.50	52.50	8.50	8.00	8.00
T3	4.50	5.50	34.50	37.00	9.50	67.80	42.50	9.00	8.00	8.00
T4	4.50	5.50	38.40	41.00	9.00	79.50	65.00	10.00	8.00	7.00
T5	5.00	5.50	31.00	39.00	8.50	73.00	50.00	10.50	7.50	7.50
T6	5.00	5.50	40.50	45.70	9.00	69.00	55.00	10.00	7.00	8.00
T7	5.00	6.00	38.20	42.75	10.00	88.15	75.00	11.00	8.50	8.00
T8	5.50	5.00	35.75	41.60	7.50	73.20	52.50	10.50	8.00	7.00
T9	4.50	5.50	36.30	42.80	9.00	77.00	65.00	8.50	7.50	7.00
T10	5.00	5.00	35.30	40.15	9.00	77.00	55.00	10.50	7.00	8.00
S.E m(±)	0.47	0.47	1.09	1.44	0.63	1.42	3.18	0.59	6.00	8.00
CD@1%	2.13	2.13	4.90	6.45	2.83	6.37	14.24	2.65	7.00	7.50

Traits: X1: Basal floret opened, X2: Days for softening of first lower floret, X3: Initial Spike weight (g), X4: Spike weight at 5th day (g), X5: Number of Florets opened in a spike, X6: Percentage of florets opened in a spike, X7: Amount of water uptake (v/v ml), X8: Vase life (days), X9: Score of Freshness and Strength of Spike, X10: Overall acceptability appearance Score



Plate 1: Gladiolus spikes at 1st day and 5th day of vase life studies

difference at the 1% level was calculated to compare treatment means.

RESULTS AND DISCUSSION

As consumers pay much attention towards quality of gladiolus in the sense of flower colour, freshness, longevity and spike strength that is driving the market competition. Unfortunately, the flowers are losing freshness and quality due to high ethylene synthesis and microbial activity during storage condition, poor post-harvest handling and management practices. This can be overcome by proper use of preservative solutions like sucrose, citric

acid, Al_2SO_4 , STS and GA_3 . The analysis of variance for the observed parameters indicated a significant effect ($CD = 1\%$) of different preservatives on the quality parameters of gladiolus var. Arka Amar. Experimental results showed that all treatments significantly improved vase life compared to the control (Table 2). Early floret opening was observed in treatments T1, T3, T4, and T9 (4.5 days), followed by other treatments, which recorded floret opening at 5 d. Earlier softening of basal floret was observed in T1 (4 d) followed by T2 (4.5 d), T8 and T10 (5d each respectively). The maximum number of florets opened was recorded in treatment T7 (10 florets), followed by

Table 3: Effect of different chemical preservatives on water uptake (weight basis) by the spikes of gladiolus cv. Arka Amar.

Treatment	1 st day	3 rd day	5 th day	7 th day	10 th day
T1	570.65	561.45	559.05	554.50	491.50
T2	503.90	555.30	554.55	550.60	485.85
T3	566.50	591.20	488.45	484.40	480.95
T4	567.90	561.25	559.35	555.80	553.25
T5	554.30	543.45	541.05	520.70	532.85
T6	524.80	497.80	511.75	503.90	551.50
T7	555.60	512.90	509.35	522.00	525.60
T8	561.65	534.55	550.50	542.95	544.25
T9	554.50	549.45	547.00	538.30	542.95
T10	494.85	486.10	479.70	527.20	474.25
S.E m(±)	1.15	2.85	2.57	2.48	2.23
CD@1%	5.14	12.77	11.51	11.09	9.99

Table 4: Effect of different chemical preservatives on transpiration loss by the spikes of gladiolus cv. Arka Amar.

Treatment	1 st day	3 rd day	5 th day	7 th day	10 th day
T1	621.60	609.15	597.55	586.50	584.90
T2	551.15	540.95	529.50	519.90	518.50
T3	559.50	547.01	536.30	562.50	519.80
T4	619.75	610.10	595.35	582.10	585.10
T5	586.55	574.60	571.15	537.50	539.35
T6	577.20	545.30	532.90	548.20	518.10
T7	584.45	531.80	517.85	559.50	556.40
T8	580.65	564.10	553.05	568.15	538.90
T9	609.25	591.75	584.60	576.90	572.05
T10	599.10	559.85	580.60	576.55	547.50
S.E m(±)	2.31	2.35	2.62	2.16	3.07
CD@1%	10.34	10.54	11.75	9.67	13.76

T3 (9.5), T9 and T10 (9 each respectively), whereas the minimum was recorded in control (8). The highest floret opening percentage was observed in treatment T7 (88.15%), followed by T2 (85.50%) and T9 and T10 (77% each). These findings align with the studies of Nasrin *et al* (2008) on gladiolus and Talukdar and Barooah (2010) on tuberose. The effect of Al_2SO_4 in promoting the maximum number of open florets and the highest percentage of floret opening was attributed to its antimicrobial properties, which helped prevent vascular blockage and finally increasing water uptake and more number of florets opening.

Similar results were found by Sharma *et al.* (2017) in gladiolus and by Selvaraj *et al* (2014) in tuberose. Treatment T7, sucrose 200ppm with Al_2SO_4 200 ppm observed maximum vase life (11 days), followed by T8, T10, T5 (10.5d each) as compared to

control (8d). The extended vase life of spike may be probably due to effect of Al_2SO_4 property of inhibiting microbial growth thus enhancing better absorption and longer freshness. The results of this study align with the findings of previous researchers, including Abadi *et al* (2013) in gerbera and Selvaraj *et al* (2014) in tuberose.

From the period of first day to last day of vase life studies, at last day maximum solution uptake (30g and 75ml) was reported in the treatment T7 (Table 3) with sucrose 200ppm + Al_2SO_4 200 ppm (weight basis and volume basis) followed by T4 and T9 (65ml each respectively). Similarly minimum transpiration loss (Table 4) was found in T7 (28.05g) followed by T2 (31.25g) and T4 (37.65g), while high loss in T6 (59.10g). Variation in solution uptake might be due to disturbance in transpiration pool, bacterial and fungal

Effect of Different Vase Solutions on Vase Life of Gladiolus (*Gladiolus grandiflorus*)

growth. The germicidal action of Al_2SO_4 at 200 ppm prevented stem blockage, allowing better water flow through the stems. Sucrose enhanced water uptake, likely due to the accumulation of translocated sugars in the flowers, which increased osmotic potential. This improved the spikes' ability to absorb water while reducing transpiration loss by minimizing stomatal opening, thereby maintaining flower turgidity (Nair *et al*, 2003).

The findings of this study were consistent with those of Kumar and Awasthi (2012), Choudhary *et al* (2011) in gladiolus, and Mishra and Khanal (2019) in gladiolus. The highest score (8.5) for appearance and freshness was recorded in treatment T7 (sucrose 200 ppm + Al_2SO_4 200 ppm) (Table 2). This may be attributed to the combined effect of sucrose and aluminum sulfate, which resulted in a lower percentage of wilting and improved physiological characteristics compared to other treatments (Sarje *et al*, 2024). Both acts as antimicrobial and energy source. Similar results were observed in gladiolus by Verma and Fatmi (2022), Bajwa *et al* (2016) in rose, Mishra and Khanal (2019) in gladiolus.

CONCLUSION

From the present investigation the holding solution containing T7- Sucrose 200ppm + Al_2SO_4 200ppm resulted in extending of gladiolus var. Arka Amar keeping quality in sense of vase life (11d), maximum percentage of florets opening (88.15%), minimum transpiration loss (28.05g) and maximum water uptake (30g and 75ml).

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Effect of Evaporative Cooling on Colour and Quality Changes During Ripening of Grand Naine Banana

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ABSTRACT

The Grand Naine banana comes under *Musa acuminata* (AA) is one of the most commonly cultivated bananas where color development is an important feature during ripening which is used to determine the quality of fruit for marketing. As calcium carbide and direct contact of fruits with ripening agents was banned due to its hazardous health effects by FSSAI, a further method for utilizing ethylene gas to commence ripening is used. Temperature and exposure time of ethrel is essential for the quality and longevity in storage of the fruits. The postharvest study was laid out in a completely randomized design consisting of three treatments viz., T1 – air tight chamber; T2 – zero energy cool chamber; T3 - cold chamber with seven replications. The fruits were exposed to ethrel treatment in three distinct temperature-controlled chambers over 24 hours after which the fruits were stored at the ambient condition to study the ripening behaviour. The various observations on shelf-life parameters and biochemical attributes were taken on alternate days from the 2nd day after treatment to the 8th day of storage. The sensory assessment was conducted on the exact day of complete maturation of fruits. Based on the summary findings of the research, we found that the physiological and shelf-life parameters of fruits placed in zero energy cool chamber were found to be on par with that have been processed in cold chamber on the time of full maturity whereas the quality parameters were found to be preferable in fruits that have been handled in a zero-energy cool chamber in contrast to cold chamber. During banana harvest, zero energy cool chamber might be utilized as an alternative to a cold chamber for ripening operations in addition to the regular use of prolonging the durability of fruits and vegetables.

Keywords: Banana, Colour development, Fruit quality. Ripening, Zero energy cool chamber.

INTRODUCTION

Grand Naine bananas, also known as Cavendish bananas, play a pivotal role in India's banana production. India produces more bananas annually than any other country in the world exceeding 30 million MT cultivated across approximately 800,000 ha (Rajamanickam, 2021; Kumar *et al*, 2024). Among the various banana varieties grown in the country, Grand Naine is increasingly prominent due to its high yield and suitability for commercial markets (Jayavalli, 2024). This cultivar's popularity is attributed to its consistent quality and export potential, which align with the growing demand for Cavendish bananas globally (Alagukannan *et al*, 2015; Patel *et al*, 2024). Among the various banana cultivating states, Tamil Nadu leads due to the significant contribution of Grand Naine bananas to the local banana industry (Badgujar, 2016). The economic impact of Grand Naine bananas in Tamil Nadu extends beyond local markets to international exports such as the Middle East, Europe, and North America.

The temperature has a significant impact on the quality and shelf life of fruits (Othman *et al*, 2021). When fruits are ripened at ambient temperature, they exhibit a sharp rise in respiration rate and ethylene production after 3-4d of harvesting, thereby limiting its popularity among customers and after harvest period (Narayana *et al*, 2005). For the Cavendish group, including Grand Naine, ripening is typically controlled through the application of ethylene, which accelerates these changes by promoting the production of enzymes like amylase and polygalacturonase (Gonge *et al*, 2013). Various ripening chambers have been used to control the ripening environment of banana. Innovations such as zero energy cool chambers and evaporative cooling systems offer more sustainable alternatives by reducing energy consumption while maintaining favorable ripening conditions (Ravikumar *et al*, 2018).

Studies have shown that different ripening conditions can significantly impact the quality attributes of Grand Naine bananas. For instance, higher temperatures and optimal ethylene levels can enhance

sweetness and flavor but may also increase physiological loss in weight (PLW) and reduce longevity (Chiwate *et al*, 2023). Conversely, cooler ripening conditions can help preserve ascorbic acid levels and extend shelf life but may result in slower ripening and delayed color development (Kulkarni *et al*, 2011). Hence, the present study was conducted with the objective to evaluate the effect of ethrel-induced ripening at different temperature-controlled storage conditions on the shelf-life, quality, and sensory attributes of Grand Naine banana, and to assess the potential of a zero-energy cool chamber as an alternative to cold chambers for ripening operations.

MATERIALS AND METHODS

The current study was conducted at Horticultural College and Research Institute (HC&RI), Tamil Nadu Agricultural University, Coimbatore, during the year 2024. This study was carried out to find the best ripening chamber for Grand Naine fruits that results in high quality and shelf life. Three types of chambers having three different temperatures were used for ethrel treatment of banana fruits. The air tight chamber ($33 \pm 1^\circ\text{C}$, 85 % RH) and cold chamber ($22 \pm 1^\circ\text{C}$, 94 % RH) located in the Analytical lab and the zero-energy cool chamber ($26 \pm 1^\circ\text{C}$, 90 % RH) located in the College orchard used for the study (Table 1). The Fruits were harvested from college orchard, washed with clean water and then subjected to 0.1% Bavistin treatment for 10 minutes to decrease the prevalence of postharvest maladies such as anthracnose and stem end rot (Waskar and Gaikwad, 2005). The banana fruits had been exposed to ethylene at 100 ppm for 24 hours in three various storage conditions. Twenty-four hours later, the fruits had been subjected to ambient conditions for studying the maturity behaviour and shelf life.

The number of days taken by fruits to attain ripened stage suitable for consuming in more than 90 % of the fruit in a treatment is considered as days taken for ripening. That's additionally referred to as pre-climacteric life or green life (Peacock, 1972). The fruits were observed for ripening daily in all treatments. The post-harvest life of the fruits was calculated on the harvest time until the fruits remained in a good edible state without any spoilage under ambient storage conditions inferred through visual appearance and expressed in days. The yellow life of the fruits was calculated from the day of ripening until the end of edible life of the fruits (Dadzie and Orchard, 1997). The fruit colour was estimated using the book Horticultural Colour Chart by Royal Horticulture Society. The total

soluble solids (T.S.S.) of the banana pulp was estimated by using a hand refractometer (ERMA[®]) between the scale of 0-32 and values were expressed in °Brix. The amount of Vitamin C is expressed as mg /100g pulp and Titratable acidity was determined (Ranganna, 1986).

A digital pH scale was used to measure the pulp's pH. Sensory evaluations of the fruits ripened in different chambers having different temperatures were evaluated for sensory assessment such as appearance, chroma, flavour, taste and wider preference to identify the best treatment using a 9-point hedonic scale (9 and 1 points indicating extreme like and dislike) (Maduwanthi and Marapana, 2019). The marketability of fruits was calculated on the day of full maturity of fruits and 2nd day after complete ripening and expressed in terms of percentage. A one-way analysis of variance (ANOVA) was used to compare the means by least significant difference (LSD) analysis in the experiment, which was set up using a completely randomized design using R 0.05 software. Data significance was established at $p < 0.05$.

RESULTS AND DISCUSSION

Shelf life parameters

The air tight chamber had the highest mean temperature ($33 \pm 1^\circ\text{C}$), while the cold chamber maintained the lowest ($22 \pm 1^\circ\text{C}$), contributing to slower ripening (Table 2). Bananas ripened faster in the cold chamber (4 d) compared to the zero energy cool chamber (6d), likely due to lower temperatures and higher humidity in the latter. The yellow life was shortest in the air tight chamber (2 d) and similar in the other two chambers (3d). Physiological loss in weight elevated starting on the day of treatment till the ripening of fruits regardless of the chambers used. The highest physiological loss in weight was reported in fruits processed in cold chamber (T3) (9.88%) subsequently by fruits placed in air tight chamber (T2) (9.09%) and the lowest PLW were recorded in fruits handled in zero energy cool chamber (T1) (8.06%). This could indicate higher moisture loss in the cold chamber due to its chilling conditions, which might affect fruit texture and weight retention. In terms of moisture content, the air tight chamber recorded the highest (77.85%), suggesting better moisture retention but also potentially indicating less effective ethylene diffusion.

Biochemical attributes and quality assessment

The total soluble solids (T.S.S.) content,

Effect of Evaporative Cooling on Colour and Quality Changes During Ripening

Table 1: The amount of water (ml), ethrel (ml), and NaOH (g) necessary to discharge 100 ppm of ethylene.

Sr. No.	Chamber	Ethrel (ml)	Water (ml)	NaOH (g)
1.	Zero Energy Cool Chamber	0.9	450	0.18
2.	Air Tight Chamber	0.86	0.43	0.173
3.	Cold Chamber	31.6	15800	6.3

Table 2: Impact of temperature on physiological and shelf-life indicators during ethrel treatment in various chambers.

Treatment	Green Life (Days)	Yellow Life (Days)	Shelf Life (Days)	Physiological Loss in Weight (%)	Fruit Marketability (%)	Moisture content
T1-Zero energy chamber	6	3	10	10.48	89	80.91
T2-Air Tight Chamber	4	3	7	11.39	71.43	86.93
T3-Cold Chamber	4	2	8	11.17	62.14	85.93
SE(d)	0.25	0.154	0.37	3.0312	9.033	0.3108
CD 5%	0.72	0.32	0.77	9.65	18.977	0.6529

Table 3: The temperature's effect upon ethrel treatment in various chambers on biochemical parameters.

Treatment	T.S.S. (%)	Titratable acidity (%)	Ascorbic acid (mg/100g)	pH	Colour values
T1	23	0.26	18	4.6	Sulphur yellow 1/3
T2	23	0.8	16.49	4.85	Chartreuse green 663/2
T3	22.57	0.75	20.75	4.57	Empire yellow 603/2
SE(d)	0.4666	0.0543	1.5880	0.059	-
CD 5%	0.9802	0.1329	5.0537	0.125	-

Table 4: The impact of temperature on ethrel exposure in multiple chambers on quality assessment.

Treatment	Colour and appearance (peel)	Colour and appearance (pulp)	Texture	Taste	Flavour	Overall acceptability
T1	8.6	8.1	8.3	8.3	8.6	8.3
T2	7.0	8.4	7.0	8.6	7.6	7.3
T3	9.0	7.4	8.9	7.6	8.4	8.1
SE(d)	0.24	0.32	0.36	0.33	0.29	0.39
CD 5%	0.51	0.66	0.76	0.69	0.60	0.82

indicative of fruit sweetness was highest in the air tight chamber, likely due to higher temperatures accelerating sugar development. Conversely, the cold chamber showed a delayed increase in T.S.S., suggesting slower ripening. The highest titratable acidity was found in the cold chamber, reflecting a more acidic profile, which might be a result of slower fruit ripening. Ascorbic acid content decreased across all treatments, with the cold chamber maintaining the highest levels (37.44 mg/100g) and the zero-energy cool chamber following (29.86 mg/100g). The cold chamber's ability to delay the decline in ascorbic acid could be due to its lower temperature, which might slow down the oxidation processes. The pH levels were

highest in the air tight chamber, suggesting more acidic conditions compared to other chambers (Table 3). Sensory evaluations indicated that the cold chamber had the highest scores for peel colour and appearance, while the air tight chamber excelled in pulp color and taste. The zero-energy cool chamber achieved high scores in flavor and overall acceptability, which might reflect a balance between quality and sustainability. The air tight chamber, despite its superior taste and pulp appearance, showed lower overall acceptability, possibly due to its impact on shelf life and ripening uniformity (Table 4).

The results underscored the impact of the maturation conditions on Grand Naine bananas. While

the cold chamber offers superior control over temperature and may enhance certain quality aspects like acidity and shelf life, the zero energy cool chamber provides a viable, cost-effective alternative with commendable ripening outcomes and overall acceptability. The air tight chamber, although beneficial for certain quality traits, exhibited limitations in shelf life and overall acceptability. These findings highlight the importance of choosing appropriate ripening conditions to optimize banana quality and align with sustainability goals.

CONCLUSION

This study evaluated the effects of different ethylene treatment environments on the ripening of Grand Naine bananas, focusing on temperature, relative humidity, and fruit quality. Three chambers were compared: a cold chamber, a zero energy cool chamber, and an air tight chamber. The cold chamber maintained the lowest temperature ($22\pm1^{\circ}\text{C}$) and the highest relative humidity (94%), leading to the highest physiological loss in weight (9.88%) and delayed increases in total soluble solids (T.S.S.). The zero energy cool chamber, with a moderate temperature ($26\pm1^{\circ}\text{C}$) and relative humidity (90%), extended the ripening period (6 d) and shelf life (8 d), offering a balance between quality and sustainability. The air tight chamber, which had the highest temperature ($33\pm1^{\circ}\text{C}$) and lower relative humidity (85%), resulted in the shortest ripening time (4 d) and lower shelf life (2 d), but excelled in taste and pulp appearance. Quality assessments revealed that bananas from the cold chamber had the highest acidic profile and Vitamin C content, indicating slower ripening and better retention of certain nutrients. In contrast, the zero energy cool chamber provided high overall acceptability and flavor, while the air tight chamber, despite its advantages in taste and pulp color, showed lower marketability and shelf life. Overall, the study highlights the trade-offs between ripening speed, fruit quality, and sustainability, emphasizing the zero energy cool chamber as a viable, eco-friendly alternative that balances ripening efficiency with fruit quality.

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Effect of Evaporative Cooling on Colour and Quality Changes During Ripening

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Effect of Foliar Application of Micronutrients and Plant Growth Regulators on Quality of Guava (*Psidium Guajava* L.) Cv. Lalit

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ABSTRACT

Lalit guava known for its distinct sweetness and vibrant red color is a favored variety among growers for its exceptional flavor and nutritional qualities. A field experiment was carried out during the year 2020–2021 on seven-year-old red guava trees at a farmer's orchard located in Semmangalam, Anathur, in the Villupuram district. The study aimed to identify the most suitable treatment for improving fruit quality in guava. The trial followed a Randomized Block Design with ten treatment combinations of T₁ (Control), T₂ (Boric acid @ 0.4% + GA₃ @ 150 ppm), T₃ (Chelated Zinc @ 0.5% + GA₃ @ 150 ppm), T₄ (Boric acid @ 0.4% + Chelated Zinc @ 0.5% + GA₃ @ 150 ppm), T₅ (Boric acid @ 0.4% + NAA @ 100 ppm), T₆ (Chelated Zinc @ 0.5% + NAA @ 100 ppm), T₇ (Boric acid @ 0.4% + Chelated Zinc @ 0.5% + NAA @ 100 ppm), T₈ (Boric acid @ 0.4% + SA @ 100 ppm) and T₉ (Chelated Zinc @ 0.5% + SA @ 100 ppm). Each replicated three times. For optimal quality parameters such as total soluble solids, total sugars, reducing and non-reducing sugars, TSS/acid and minimal acidity, T₄ (Boric acid @ 0.4% + Chelated zinc @ 0.5% + GA₃ @ 150 ppm) exhibited superior results compared to the control. In contrast, T₇ (Boric acid @ 0.4% + Chelated Zinc @ 0.5% + NAA @ 100 ppm) was found to be most effective in enhancing the ascorbic acid and pectin content when compared to the untreated control.

Keywords: Fruit quality, Guava, Pectin content, Total sugar.

INTRODUCTION

Guava (*Psidium guajava* L.), a member of the Myrtaceae family, is extensively cultivated across tropical and subtropical regions. In India, it holds significant economic importance and is often dubbed the "Apple of the Tropics." This fruit is highly valued for its abundance of pectin and Vitamin C, and it also provides moderate levels of Vitamin A, calcium, phosphorus, pantothenic acid, riboflavin, thiamine, and niacin. Nutritionally, guava contains about 82.5% moisture, 2.45% acidity, 4.45% reducing sugars, 5.25% non-reducing sugars, 9.73 °Brix total soluble solids (TSS), and approximately 260 mg of Vitamin C per 100 grams of fresh fruit. It is especially suited for jelly production, and its juice is often used in ice cream formulations (Shahroon *et al.*, 2018). In addition to its nutritional profile, guava exhibits strong antioxidant activity due to its high Vitamin C levels and the presence of bioactive compounds such as carotenoids, isoflavonoids, and polyphenols. Although foliar sprays of micronutrients and plant growth regulators have been shown to improve fruit quality individually, there

is limited research on their synergistic effects in guava cultivation.

MATERIALS AND METHODS

The research entitled "Effect of Foliar Application of Micronutrients and Plant Growth Regulators on Quality of Guava (*Psidium guajava* L.) cv. Lalit" was carried out during the year 2020–2021 using seven-year-old red-fleshed guava trees. The study site was a farmer's field located in Semmangalam, Anathur, in the Villupuram district. A Randomized Block Design (RBD) was employed, comprising 10 treatment combinations with three replications each, involving a total of 300 guava plants. The trees were planted at a spacing of 9 × 9 meters to ensure adequate growth and canopy development. The foliar treatments of T₁ (Control), T₂ (Boric acid @ 0.4% + GA₃ @ 150 ppm), T₃ (Chelated Zinc @ 0.5% + GA₃ @ 150 ppm), T₄ (Boric acid @ 0.4% + Chelated Zinc @ 0.5% + GA₃ @ 150 ppm), T₅ (Boric acid @ 0.4% + NAA @ 100 ppm), T₆ (Chelated Zinc @ 0.5% + NAA @ 100 ppm), T₇ (Boric acid @ 0.4% + Chelated Zinc @ 0.5% +

Table 1. Effect of foliar application of micronutrients and plant growth regulators on total sugars, reducing sugar and non-reducing sugar of guava cv. Lalit (*Psidium guajava*).

Treatment	Details	TSS (°Brix)	Total sugars (%)	Reducing sugar (%)	Non-reducing sugar (%)
T ₁	Control	7.89	8.03	4.19	3.84
T ₂	Boric acid @ 0.4 % + GA ₃ @ 150 ppm	9.57	9.17	4.81	4.36
T ₃	Chelated zinc @ 0.5 % + GA ₃ @ 150 ppm	8.53	8.38	4.39	3.99
T ₄	Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + GA ₃ @ 150 ppm	12.23	10.65	5.63	5.02
T ₅	Boric acid @ 0.4 % + NAA @ 100 ppm	11.59	10.31	5.43	4.88
T ₆	Chelated zinc @ 0.5 % + NAA @ 100 ppm	9.17	8.74	4.59	4.15
T ₇	Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + NAA @ 100 ppm	10.95	9.96	5.23	4.73
T ₈	Boric acid @ 0.4 % + SA @ 100 ppm	10.21	9.52	5.01	4.51
T ₉	Chelated zinc @ 0.5 % + SA @ 100 ppm	9.37	9.09	4.79	4.30
T ₁₀	Boric acid@ 0.4 % + Chelated zinc @ 0.5 % + SA @ 100 ppm	10.85	9.87	5.21	4.66
S. ED		0.29	0.27	0.14	0.13
CD (p=0.05)		0.61	0.58	0.31	0.27

NAA @ 100 ppm), T₈ (Boric acid @ 0.4% + SA @ 100 ppm) and T₉ (Chelated Zinc @ 0.5% + SA @ 100 ppm), T₁₀ (Boric acid @ 0.4% + Chelated Zinc @ 0.5% + SA @ 100 ppm). consisting of various micronutrients and plant growth regulators, were administered at three stages: immediately after pruning, 30 days post-pruning, and 60 days after pruning. Data obtained from the experiment were analyzed statistically in accordance with the methodology proposed by Panse and Sukhatme (1961).

RESULTS AND DISCUSSION

The data (Table 1) indicated significant variations among treatments regarding parameters such as total soluble solids, total sugars, reducing and non-reducing sugars. Significantly higher Total Soluble Solids are observed with the treatment (T₄) with 12.23 °B over control (T₁) 7.89°B. The observed increase in Total Soluble Solids (TSS) may be attributed to the application of GA₃, which is known to enhance the accumulation of assimilates in developing fruits. GA₃ likely facilitates the mobilization of carbohydrates, promoting the conversion of complex polysaccharides into simpler sugars. Additionally, the role of boron in improving TSS could be linked to its involvement in transmembrane sugar transport. Boron is essential for several physiological and biochemical processes, including chlorophyll synthesis, enzymatic activities, respiration, and photosynthesis. Since sugars are the primary product of photosynthesis, an increase in photosynthetic activity due to boron application may lead to higher sugar synthesis, thereby contributing to greater TSS content in fruit juice (Ram and Bose, 2000). These results were in conformity with the results

reported by Kale *et al* (1999) in Ber. The increase in TSS has also been recorded by Yadav *et al* (2018), Lal and Das (2017) and Singh *et al* (2020) in guava.

The perusal of data on total sugars showed that the treatment T₄ (Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + GA₃ @ 150 ppm) recorded maximum total sugars of 10.65 % over control (T₁) 8.03 %. This might be due to the fact that GA₃ increases the activity of the enzymes such as amylases, which hydrolyses the complex polysaccharides in to simple sugars.

The data on reducing sugars showed that the treatment T₄ (Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + GA₃@ 150 ppm) recorded that maximum reducing sugar of 5.63 % over control (T₁) 4.19 %. This may be due to the fact that boron promotes cell division and development in the growth regions of the plant near the tips of shoots and roots.

Statistically significant variation was recorded for Non-reducing sugar with the application of Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + GA₃ @ 150 ppm. The data on Non-reducing sugar showed that, the treatment T₄ recorded that maximum non-reducing sugar of 5.02 % over control (T₁) 3.84 %. The increase in sugar content could be attributed to the higher concentration of GA₃, which enhances the hydrolysis of starch into simpler sugars. The elevated levels of total sugars, including both reducing and non-reducing sugars, may result from the efficient translocation of photosynthates to the developing fruits, regulated by the action of GA₃. This hormone likely facilitates the mobilization of carbohydrates, contributing to improved sugar accumulation in the fruit. These findings are supported by the results obtained by

Effect of Foliar Application of Micronutrients and Plant Growth Regulators

Table 2. Effect of foliar application of micronutrients and plant growth regulators on acidity, Total Soluble Solids and TSS/acid ratio of guava cv. Lalit (*Psidium guajava* L.)

Treatment	Detail	Acidity (%)	TSS/ Acid	Ascorbic acid (mg/100 g)	Pectin (%)
T ₁	Control	0.48	16.60	159.85	0.49
T ₂	Boric acid @ 0.4 % + GA ₃ @ 150 ppm	0.39	25.26	177.58	1.08
T ₃	Chelated zinc @ 0.5 % + GA ₃ @ 150 ppm	0.45	19.13	166.05	0.70
T ₄	Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + GA ₃ @ 150 ppm	0.24	50.96	188.99	1.45
T ₅	Boric acid @ 0.4 % + NAA @ 100 ppm	0.27	42.93	194.15	1.66
T ₆	Chelated zinc @ 0.5 % + NAA @ 100 ppm	0.42	22.02	171.21	0.86
T ₇	Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + NAA @ 100 ppm	0.31	35.32	200.35	1.87
T ₈	Boric acid @ 0.4 % + SA @ 100 ppm	0.36	28.36	182.74	1.24
T ₉	Chelated zinc @ 0.5 % + SA @ 100 ppm	0.40	24.13	176.37	1.03
T ₁₀	Boric acid@ 0.4 % + Chelated zinc @ 0.5 % + SA @ 100 ppm	0.32	33.91	187.90	1.41
S. ED		0.29	0.01	0.87	5.27
CD (p=0.05)		0.61	0.02	1.83	11.07

Agrawal and Dikshit (2010) in sapota and Garasiya *et al* (2013) in guava.

The data presented in Table 2 Statistically significant variation was recorded for acidity with the application of micronutrients and plant growth regulators. A closer observation of data on acidity showed that, the treatment T₄ (Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + GA₃150 ppm) recorded as minimum acidity of 0.24 % over control (T₁) 0.45 %. The reduction in acidity content may be attributed to the influence of boron, which becomes neutralized through plant metabolic pathways and is also utilized as a substrate in respiratory processes. The decreased acidity observed in the fruits could also be linked to the advancement of ripening triggered by the application of micronutrients, during which the degradation of organic acids likely takes place. These results are in accordance with the findings of Singh *et al* (2017) and Dutta and Banik (2005) in guava.

The data on ascorbic acid showed that, the treatment T₇ (Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + NAA @ 100 ppm) recorded as maximum ascorbic acid content (200.35 mg) over control T₁ (159.85 mg). An increased in vitamin C content was due to catalytic influence of NAA on bio synthesis of vitamin C.

or both. Similar trend was also observed by Brahmachari *et al* (1997), Dubey *et al* (2002) and

Garasiya *et al* (2013) in guava.

The data on pectin content showed that, the treatment T₇ (Boric acid @ 0.4 % + Chelated zinc @ 0.5 % + NAA @ 100 ppm) recorded that maximum pectin content of 0.24 % over control (T₁) 0.49 %. This effect may be attributed to the application of NAA, which facilitates the solubilization of pectic substances from the middle lamella, thereby contributing to an increase in pectin content. Kumar *et al.* (2010) also observed that the application of NAA in guava proved effective in increasing pectin content. Similar trend was also observed by Suman *et al* (2021) and Kumari *et al* (2021).

CONCLUSION

The study highlighted the significant influence of micronutrients and plant growth regulators on fruit quality parameters. Treatment T₄ (Boric acid @ 0.4% + Chelated zinc @ 0.5% + GA₃ @ 150 ppm) proved most effective in enhancing total soluble solids, total sugars, reducing sugars, and non-reducing sugars while reducing acidity. Meanwhile, T₇ (Boric acid @ 0.4% + Chelated zinc @ 0.5% + NAA @ 100 ppm) significantly increased ascorbic acid and pectin content. These findings suggested that the combined application of micronutrients and PGRs can effectively improve fruit quality, warranting further research for optimized formulations.

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Effect of Foliar Application of Micronutrients on Growth and Yield of Marigold (*Tagetes erecta* L.)

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ABSTRACT

The present study was conducted to investigate the effect of foliar application of micronutrients on growth and yield of marigold cv. Yellow Benz Tall during the year 2022-23 at the experimental farm of Annamalai University, Tamil Nadu to find out effect of various levels of micronutrients on marigold. The experiment included nine combinations of Fe and Zn micronutrient treatments with three replications, designed in Randomized Block Design. The treatments were viz., T₁ [Control (75% N + 100% P + 75% K + Nano N and Nano K)], T₂ [T₁ + 0.5% ZnSO₄], T₃ [T₁ + 0.5% FeSO₄], T₄ [T₁ + 0.5% ZnSO₄ + 0.5% FeSO₄], T₅ [T₁ + 0.25% Chelated Fe], T₆ [T₁ + 0.25% Chelated Fe + 0.5% ZnSO₄], T₇ [T₁ + Nano Zn], T₈ [T₁ + 0.5% FeSO₄ + Nano Zn], T₉ [T₁ + 0.25% Chelated Fe + Nano Zn]. The results revealed that crop responded significantly to micronutrient application like plant height (72.24 cm), number of primary branches (16.09), number of secondary branches (60.36), number of nodes (30.68), internodal length (6.87 cm), stem girth (4.56 cm) and plant spread (63.17 cm²) and flowering parameters like days taken for flowering (27.20) shown earliness, duration of flowering (99.48 days), number of flowers per plant (56.39), single flower weight (14.03 g), flower diameter (10.05 cm) and yield parameter like yield per plant (593.36 g) with T₉ (T₁ + 0.25% Chelated Fe + Nano Zn). Foliar application of Fe and Zn improved growth and photosynthetic characteristics in marigold. It promotes nutrient availability and plant uptake, increase crop growth, yield and physiological characters, reduce dependence on costly chemical fertilizer inputs and minimize environmental risks. It is concluded that foliar application of micronutrients in combination of Fe and Zn enhanced growth, flowering and yield parameters.

Keywords: Chelated iron, Foliar application, Marigold, Micronutrient, Yellow Benz Tall, zinc.

INTRODUCTION

Marigold (*Tagetes erecta* L.) belongs to the family Asteraceae; it is an herbaceous annual. The genus *Tagetes* consists of 55 species, among which the African marigold (*Tagetes erecta* L.) and French marigold (*Tagetes patula* L.) are of commercial importance (Mahdi and Said, 2022), lemon marigold (*Tagetes tenuifolia*) and Mexican mint marigold (*Tagetes lucida*) are other important types (Shalaby *et al*, 2022). It is one of the most important ornamental crops in the world. Indian flower growers highly prefer this crop owing to its short life cycle, excellent adaptability to diverse agro-climatic conditions, better shelf-life, prolonged flowering period, ease in cultivation and varied flower shapes and colours (Mishra *et al*, 2022).

The fertilization is one of the important factors that determine the crop growth, adding chemical

fertilizers in recommended combinations boost soil chemical, physical as well as biological environment (Mahdi *et al*, 2022). In Indian agriculture, the relevance of micronutrients is well understood as their application has greatly enhanced the production of variety of crops. Historically, there was no need to supplement micronutrients in soil because these were found naturally. However, most soils due to intensive farming practices, increased salinity and soil pH, lack availability of required micronutrients to plants (Jena *et al*, 2022). Usually, micronutrients improve chlorophyll pigments, synthesis of protein and nucleic acid, which further improves growth and flowering of floral crops (Mudassir *et al*, 2021). The suitable amounts of required micronutrients, their time and method of application are vital for enhanced growth and flowering. Foliar spray by direct application on aerial plant parts is effective method than root fertilization to rectify deficiency symptoms, maintain nutritional status and improve growth and produce quality in

marginal soils (Niu *et al*, 2020). Foliar application promotes nutrient availability and plant uptake, increase crop growth, yield and physiological characters, reduce inputs of chemical fertilizers and minimize environmental risks (Mohana *et al*, 2021).

It has been shown that micronutrients such as Fe and Zn are necessary for plant intensification than those of primary nutrients (Yadegari, 2022). Among the micronutrients, iron is an important micronutrient for plants and it plays a vital role in various physiological and metabolic processes of plants (Jena *et al*, 2023). Iron is necessary for protein, chlorophyll and thylakoid synthesis, respiratory enzymes, energy transportation and cofactor to active the enzymes (George and Manuel, 2013). On other hand, zinc plays crucial role in several biosynthesis processes in plants, acting as a cofactor for numerous enzymes and influencing diverse biological mechanisms including photosynthesis, nucleic acid metabolism and carbohydrate and protein biosynthesis (Choudhary *et al*, 2016). Assimilation network of Zn comprises the synchronised activities of Zn absorption, translocation, trafficking, chelation and sequestration, providing a sufficient amount of Zn to different types of plant cells, at all stages of growth and under various environments (Sobati-Nasab *et al*, 2021).

Even though, the cultivation of marigold is expanding in India, the farmers are not having complete awareness about micronutrient application viz. Fe and Zn in enhancing the yield and quality of marigold. The aim of this research is to determine the effect of foliar application of Fe and Zn on growth and yield of marigold to introduce the best combination of micronutrients for better yield in marigold.

MATERIALS AND METHODS

The experiment was carried out during 2022-2023 at floriculture yard, Department of Horticulture, Annamalai University, Tamil Nadu. Experimental field was located at 11°24' North latitude and 79°44' East longitude at an altitude of 5.79 m above mean sea level. For the estimation of physical and chemical properties of soil, samples were collected from different spots of experimental sites before and after initiation of the experiment and thoroughly mixed to make a representative soil sample. The experiment was carried out in clay loam soil. A popular, high yielding variety of African marigold hybrid cv. Yellow Benz Tall was chosen for the experiment. This field experiment was laid out in randomized block design with three replications.

Treatment details:

The experiment comprised with following eleven treatments *i.e.* T₁ [Control (75% N + 100% P + 75% K + Nano N and Nano K)], T₂ [T₁ + 0.5% ZnSO₄], T₃ [T₁ + 0.5% FeSO₄], T₄ [T₁ + 0.5% ZnSO₄ + 0.5% FeSO₄], T₅ [T₁ + 0.25% Chelated Fe], T₆ [T₁ + 0.25% Chelated Fe + 0.5% ZnSO₄], T₇ [T₁ + Nano Zn], T₈ [T₁ + 0.5% FeSO₄ + Nano Zn], T₉ [T₁ + 0.25% Chelated Fe + Nano Zn].

Cultivation practices:

Seeds of Yellow Benz Tall were sown uniformly in pro trays filled with organic growing media. The entire field was ploughed three to four times until fine tilth and exposed to the sun for soil solarisation. The plots were laid with a spacing of 2 m x 1.5 m to form a 3 m² area. Twenty-five days old seedlings were transplanted in the main field with a spacing of 45 cm x 30 cm. The crop was irrigated depending on soil moisture status at an interval of 5 days. Earthing up was done at 25th day after transplanting to prevent the crop from lodging. Pinching was done 25th day after transplanting by removing the apical shoots of the plants to promote lateral shoots. Application of nano nutrients such as nano nitrogen and nano potassium were given as foliar application at 20th and 40th DAT (2 sprays each). The foliar application of nano nutrients was given as per the treatments @ 4 ml per liter with power sprayer. Uniform cultural practices were followed for all the treatments.

Observations recorded:

The observations recorded on growth parameters are plant height, primary branches, secondary branches, number of nodes, intermodal length, stem girth, plant spread and flowering yield parameters like days to taken for flowering, duration of flowering in days, number of flowers per plant, single flower weight, flower diameter and yield per plant.

Statistical methods:

The experiment data were statistically analysed using the methods suggested by Panse and Sukhatme (1978). The critical difference was worked out at 5 per cent probability for significance. The analysis was carried out using the personal computer based AGRISTAT package.

Effect of Foliar Application of Micronutrients on Growth and Yield of Marigold



Fig. 1: View of experimental field of marigold (*Tagetes erecta* L.)

RESULTS AND DISCUSSION

Growth parameters

The data on the effect of foliar application of micronutrients on plant height recorded at 30, 60 and 90 DAT are presented in Table 1 and Fig. 1. A progressive increase in plant height was noted in every treatment at regular intervals. Among the various treatments tested T_9 (T_1 + 0.25% Chelated Fe + Nano Zn) recorded the highest plant height of 72.24 cm at 90 DAT and it was followed by T_8 (T_1 + 0.5% $FeSO_4$ + Nano Zn) which recorded 67.53 cm and T_6 (T_1 + 0.25% Chelated Fe + 0.5% $ZnSO_4$) of 62.57 cm at DAT. The least plant height of 45.20 cm at 90 DAT was observed in T_1 (75% N + 100% P + 75% K + Nano N and Nano K). Similarly, maximum number of primary (16.09) and secondary branches (60.36) was observed in treatment T_9 (T_1 + 0.25% Chelated Fe + Nano Zn) followed by treatment T_8 (T_1 + 0.5% $FeSO_4$ + Nano Zn) and T_6 (T_1 + 0.25% Chelated Fe + 0.5% $ZnSO_4$). However, minimum number of primary and secondary branches was recorded 11.90 and 47.60 in treatment T_1 (Control 75% N + 100% P + 75% K + Nano N and Nano K). The treatments T_2 (T_1 + 0.5% $ZnSO_4$), T_3 (T_1 + 0.5% $FeSO_4$), T_4 (T_1 + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$), T_5 (T_1 + 0.25% Chelated Fe) and T_7 (T_1 + Nano Zn). Also, significantly maximum number of nodes (30.68), internodal length (6.87 cm), stem girth (4.56 cm) and plant spread (63.17cm²) was recorded and in T_9 (T_1 + 0.25% Chelated Fe + Nano Zn) followed by T_8 (T_1 + 0.5% $FeSO_4$ + Nano Zn) and T_6 (T_1 + 0.25% Chelated Fe + 0.5% $ZnSO_4$).

The positive effect of Fe and Nano Zn in promoting the plant height was might be due to the role of zinc in active synthesis of tryptophan, an amino acid

which is a precursor of indole acetic acid (IAA) which stimulates the growth of plant. Zinc has harmonious effect on phosphorus absorption which may function as a source of energy for the synthesis of auxin and it could be indorsed as stem elongation. While Fe, involves in the bioassay of chlorophyll, catalytic function, enzymatic activities and other metabolic processes which helps in increasing the growth of the plants. Fe associate with chloroplast and enhances the rate of photosynthesis leading to better vegetative growth. (Raghatate *et al*, 2015) reported that foliar application of $FeSO_4$ 0.5% + $ZnSO_4$ 0.5% recorded the highest plant height and number of primary branches per plant. Plants with a greater number of branches stimulates cell division, which outcomes in increased biomass and vegetative growth (Yadav *et al*, 2024). Treatments with Fe significantly increased node number compared with treatments without foliar spray of Fe (Bestic-Pennings *et al*, 2024).

Flowering and yield parameters

The results presented in Table 2 and Fig. 2 revealed that significant differences were exhibited among the various treatments on days taken for first flowering. The commencement of flowering was early in T_9 (T_1 + 0.25% Chelated Fe + Nano Zn) with 27.20 day and it was followed by T_8 (T_1 + 0.5% $FeSO_4$ + Nano Zn) and T_6 (T_1 + 0.25% Chelated Fe + 0.5% $ZnSO_4$). While, duration of flowering (99.48 days), number of flowers per plant (56.39), single flower weight (14.03 g), flower diameter (10.05 cm) and yield per plant (593.36 g) performed highest in treatment T_9 (T_1 + 0.25% Chelated Fe + Nano Zn), followed by (T_1 + 0.5% $FeSO_4$ + Nano Zn) and T_6 (T_1 + 0.25% Chelated Fe +

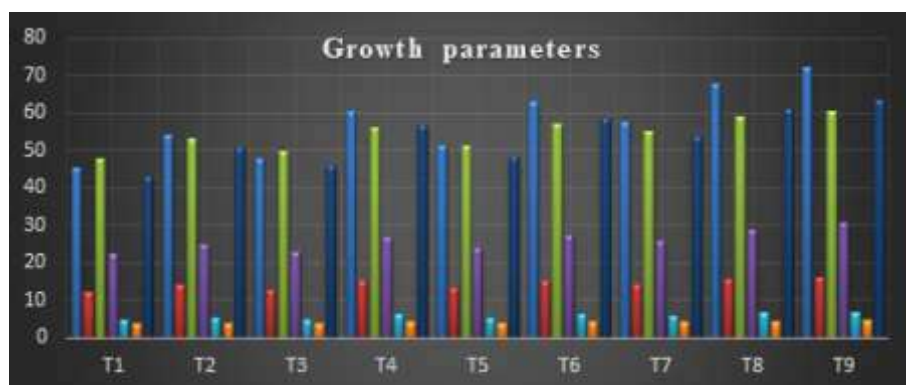


Fig. 1: Effect of treatments on growth parameters of Marigold

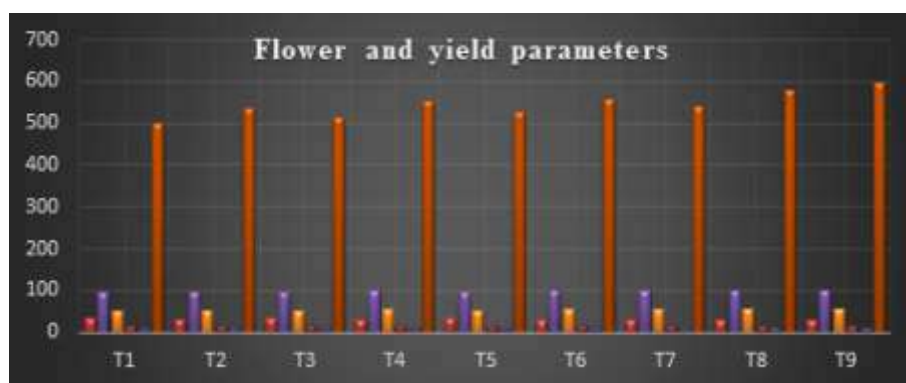


Fig. 2: Effect of treatments on flower and yield parameters of Marigold

Table 1. Effect of foliar application of micronutrients on growth parameters of marigold (*Tagetes erecta* L.) cv. Yellow Benx Tall.

Sr. No	Plant height (cm) at 90 DAT	Number of Primary branches	Number of Secondary branches	Number of nodes	Internodal length (cm)	Stem girth (cm)	Plant spread (cm ²)
T ₁	45.2	11.9	47.6	22.19	4.67	3.74	42.68
T ₂	53.94	13.87	52.96	24.87	5.37	4.03	50.73
T ₃	47.84	12.59	49.56	22.98	4.88	3.82	45.52
T ₄	60.49	14.85	56.13	26.81	6.12	4.25	56.48
T ₅	50.87	13.18	50.95	23.91	5.1	3.94	48.12
T ₆	62.57	15.01	56.98	27.35	6.27	4.31	58.24
T ₇	57.24	14.25	54.82	25.67	5.78	4.11	53.75
T ₈	67.53	15.47	58.76	28.56	6.48	4.43	60.84
T ₉	72.24	16.09	60.36	30.68	6.87	4.56	63.17
S. ED	1.21	0.12	0.55	0.37	0.09	0.03	0.98
CD (p = 0.05)	2.45	0.26	1.11	0.74	0.17	0.06	1.96

0.5% ZnSO₄). Increasing the micronutrient concentration shows a significant effect on flowering characters by increasing the concentration of flowers by plants and due to higher concentration of carbohydrates and their translocation from the leaves to developing flower buds and produces higher number of flowers per plant. The application of zinc with combination of Fe played an important role for

extending the vegetative growth, pollen function and fertilisation (Annasamy and Karuppapiah, 2024). Sha and Karuppaiah (2005) reported that the increasing flowering characters may be due to the beneficial role of micronutrients in enhancing the translocation of carbohydrates, minerals and amino acids from the site of the synthesis to the storage tissues of flowers.

Effect of Foliar Application of Micronutrients on Growth and Yield of Marigold

Table 2. Effect of foliar application of micronutrients on flowering and yield parameters of marigold (*Tagetes erecta* L.) cv. Yellow Benx Tall.

Sr. No	Days taken for flowering	Duration of flowering (days)	Number of flowers/plant	Single flower weight (g)	Flower diameter (cm)	Yield/plant (g)
T ₁	32.52	92.29	48.5	13.63	8.87	496.51
T ₂	30.64	95.82	51.92	13.77	9.28	531.54
T ₃	31.98	93.54	49.66	13.68	8.97	510.48
T ₄	29.21	97.45	53.87	13.84	9.69	550.76
T ₅	31.56	94.35	51.12	13.73	9.15	523.22
T ₆	29	97.86	54.33	13.85	9.76	556.35
T ₇	29.99	96.64	53.09	13.8	9.46	539.81
T ₈	28.57	98.72	55.23	13.95	9.88	576.85
T ₉	27.2	99.48	56.39	14.03	10.05	593.36
S. ED	0.19	0.27	0.33	0.06	0.04	3.86
CD (p = 0.05)	0.39	0.56	0.67	0.02	0.09	7.76

CONCLUSION

It was concluded that the foliar application of Fe and Zn at different concentration combinations had shown a significant effect on growth, flowering and yield parameters of marigold. Among the treatments, T₉ (T₁ + 0.25% Chelated Fe + Nano Zn) had performed as best of all the parameters. Thus, combined application of micronutrients had a more noticeable effect in assessment with the individual use of the micronutrients. Utilizing a combination of micronutrients in cultivation improves the plant health and fostering vigorous crop development. This study delivers valuable information about the foliar application with various treatment combinations of micronutrients where soil have undesirable characteristics and chemical properties in particular.

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Effect of Methyl jasmonate (MeJA) on Biochemical Constituents of Seed Treated Tomato

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ABSTRACT

Tomato (*Solanum lycopersicum*) plant is often attacked by numerous insect pests which lead to severe crop loss. To reduce the crop loss naturally, plants have evolved with variety of defensive hormone namely jasmonic acid (JA) which protect the plants from the insect pests. A study was carried out at Kittur Rani Channamma College of Horticulture, Arabhavi in 2023-24 to investigate the effect of methyl jasmonate (MeJA) on biochemical constituents such as phenol and tannin content in leaves of seed treated tomato. The experiment followed a Completely randomized design included nine treatments and three replications [T₁- MeJA at 0.5 mM, T₂- MeJA at 0.75 mM, T₃- MeJA at 1 mM, T₄- MeJA at 2 mM, T₅- MeJA at 2.5 mM, T₆- MeJA at 3 mM, T₇- Ethyl alcohol, T₈- UHSB - POP and T₉- Untreated control (Water)]. The results revealed that among treatments seeds treated with MeJA at 3 mM recorded highest phenol and tannin content as 4.86 and 2.85 mg/g, respectively which was statistically similar to MeJA at 2.5 mM concentration (4.76 and 2.78 mg/g, respectively) and lowest phenol and tannin content (2.72 and 0.91 mg/g, respectively) was recorded in ethyl alcohol treatment. However, These results highlighted tomato seeds treated with methyl jasmonate has positive effect in increasing phenol and tannin content in leaves and potentially helps in inducing resistance in plants.

Keywords: Methyl jasmonate, Phenol, Tannin, Tomato

INTRODUCTION

Plants have developed a wide range of adaptations over time to protect themselves against herbivores including lowering their overall performance or disrupting the digestive system of the insect pests. One notable defense mechanism is plants have ability to produce secondary metabolites and defense associated proteins that alter the quality of food for herbivores. This, in turn, can decrease the herbivores fitness and fecundity (Kant *et al*, 2015). The association between plants and herbivores involves key molecular processes, particularly the production of Jasmonic acid (JA), which plays a crucial role in plant defense and it also involved in indirect defense mechanism by emitting plant volatiles that attract different parasitoids, which lay eggs inside the herbivore and once the eggs hatch, the herbivore die. This indirectly protects the plant from herbivore

damage. Furthermore, the precursor of JA triggers the activation of defensive genes, which are essential for synthesis of methyl jasmonate (MeJA) through the terpenoid biosynthesis pathway (Wang, 2009; Sripontan and Hwang, 2016). Remarkably, JA can be induced within minutes of herbivore attack, leading to rapid defense responses that either affect early-colonizing herbivores or result in delayed responses that hinder herbivore establishment (Kant *et al*, 2004; Wu and Baldwin, 2009). Therefore, the current investigation was carried out to assess the biochemical constituents in methyl jasmonate (MeJA) treated seeds of tomato.

MATERIALS AND METHODS

The research was conducted at K. R. C. C. H, Arabhavi, Belagavi district, Karnataka, India, during the 2023-24 period. The experiment followed a Completely randomized design included nine

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treatments and three replications [T_1 - MeJA at 0.5 mM, T_2 - MeJA at 0.75 mM, T_3 - MeJA at 1 mM, T_4 - MeJA at 2 mM, T_5 - MeJA at 2.5 mM, T_6 - MeJA at 3 mM, T_7 - Ethyl alcohol, T_8 - UHSB - POP and T_9 - Untreated control (Water)].

Methodology of seed treatment

For the preparation of one millimolar MeJA solution, 229 micro litres of MeJA (95%) was dissolved in five ml of ethyl alcohol and volume was adjusted to one litre by using deionized water (Pushpalatha *et al*, 2021). Here, Ethyl alcohol was used as soluble solvent. A total of 200 hybrid seeds of tomato (Arth - 2075) were soaked in 50 ml of aqueous methyl jasmonate solution in the petri dishes (35 mm diameter) later these were wrapped in aluminium foil and incubated for 24 hr in the dark at 4°C. Prior to sowing, seeds were washed twice with deionized water for ten minutes and later allowed to dry on a paper towel (Worrall *et al*, 2012). Then seeds were sown in portrays containing autoclaved cocopeat mixed with vermicompost as the growing media. For biochemical estimation fourth youngest leaves from the top were taken. The biochemical constituents such as phenol and tannin were assessed twenty days after seed sowing by following below mentioned procedures.

Estimation of total phenols (mg/g)

For the estimation of phenol content Folin Ciocalteu Reagent (FCR) method was followed. One gram dried leaf sample was grinded in ten ml of 80 per cent ethanol with pestle and mortar. The obtained solution was filtered and filtrate was then placed in a test tube and heated at 100 °C until the solution was evaporated. one ml of deionized water was added to the test tube. From that 0.5 millilitre of solution was transferred to another test tube, where 2.5 ml solution of sodium carbonate (Na_2CO_3) was added. The mixture was allowed to cool and absorbance was taken at 650 nm by spectrophotometer. Total phenol level was quantified by using standard graph and represented in milligram of dried leaf (Sadasivam and Manickam, 2008).

Assessment of total tannin content (mg/g)

The leaves from the fourth node was collected randomly from each replication in every treatment. These leaf tissue was subsequently dried in a hot air oven at 70°C temperature for 48 hours. One-gram sample of the dried leaves were weighed and ground using pestle and mortar in 10 ml of 80% ethanol. From each treatment, 0.1 millilitre of the extracted sample was transferred to individual test tubes and added with

7.5 ml of deionized water. The test tubes were then placed in boiling water for 30 minutes to extract tannins later, cooled at room temperature and volume was adjusted to 10 ml after that we obtained tannin extract from the clear solution. One milliliter of this tannin extract was transferred to a test tube containing one ml of (35%) sodium carbonate and 200 µl of FCR (1N) was added and these mixture was kept in the dark for 20 minutes. Absorbance was then measured in spectrophotometer at 700 nm wavelength and instead of tannin extract deionized water is used as blank. A standard graph was drawn using standard tannic acid solution ranging from 0-1000 µl in 200 µl intervals, corresponding to 0-100 µg of tannic acid (Sadasivam and Manickam, 2008).

To interpret the results, comparison between treatment means were made using Duncan's multiple range test (DMRT). The standard error mean (SE. $m \pm$) and critical difference (CD) were calculated at one per cent and five per cent level of significance.

RESULTS AND DISCUSSION

Effect of MeJA on total phenols in leaves

Among treatments, significantly highest (4.86 mg/g) phenol content was recorded in the treatment MeJA at 3 mM (T_6) which was statistically on par with MeJA at 2.5 mM (T_5) (4.76 mg/g). However, significantly lowest (2.72 mg/g) amount of phenol content was recorded in ethyl alcohol (T_7) which was statistically on par with UHSB - POP (T_8) and untreated control (T_9) (2.84 and 2.92 mg/g, respectively). The total phenol content in leaves plays important role in defense mechanism where it will interfere with feeding deterrence and growth of the herbivores also helps the plants from oxidative damage. The presence of higher concentration of phenols had direct toxicity effect on herbivores and the phenol content in leaves is increases with increasing concentration of MeJA this is may be due to JA signalling enhanced phenylpropanoid pathways and cross talks of jasmonic acid with salicylic acid and ethylene will amplifies the phenol production in response to rising MeJA levels.

The present findings were supported by Kim *et al* (2006), Moreira *et al* (2009) and Asghari *et al* (2020) who found MeJA at 0.1 and 0.5 mM concentrations increased phenolic contents in the leaves of sweet basil, pine seedling and pomegranate, respectively. Malekpoor *et al* (2016) reported the foliar application of JA at (200 and 400 µL) had significant effect on total phenol in the sweet basil. Ahmadi *et al* (2018) found exogenous spraying of MeJA in addition to NaCl has

Effect of Methyl jasmonate (MeJA) on Biochemical Constituents of Seed Treated Tomato

Table 1. Impact of MeJA on phenol and tannin content of leaves.

Treatment	Dose/l	Total Phenol (mg/g)	Total Tannin (mg/g)
T ₁ - MeJA	0.5 mM	3.62 ^c	1.90 ^c
T ₂ - MeJA	0.75 mM	3.71 ^c	1.98 ^c
T ₃ - MeJA	1 mM	3.84 ^c	2.01 ^c
T ₄ - MeJA	2 mM	4.55 ^b	2.63 ^b
T ₅ - MeJA	2.5 mM	4.76 ^{ab}	2.78 ^a
T ₆ - MeJA	3 mM	4.86 ^a	2.85 ^a
T ₇ - Ethyl alcohol	5 ml	2.72 ^d	0.88 ^d
T ₈ - UHSB - POP	-	2.84 ^d	0.91 ^d
T ₉ - UTC	-	2.92 ^d	0.96 ^d
S. Em±		0.078	0.04
CD (1%)		0.31	0.16
CV (%)		3.56	3.48

Note: * DAS = Days after sowing. * Values with letters are significant at ($P=0.01$ by DMRT).

significantly increase the phenolic contents in *Brassica* plants. Ehsanpour and Maleki (2018); Miclea *et al* (2020) showed increasing concentration of salicylic acid (SA) has increased the total phenol content in tomato and *Lavandula* plants. Yolanda *et al* (2013) and Pushpalatha (2021) found that external application of methyl jasmonate had significantly highest total phenol level in grapes.

Effect of MeJA on tannin content of leaves

It was evident that a significant difference was found between the treatments with respect to total tannin levels in leaves (Table 1). Significantly highest (2.85 mg/g) tannin content was recorded in MeJA at 3 mM (T₆) which was statistically on par with MeJA at 2.5 mM (T₅) (2.78 mg/g) followed by the treatment MeJA at 2 mM (T₄) (2.63 mg/g). Further, significantly lowest (0.91 mg/g) amount of tannin content was recorded in ethyl alcohol (T₇) which was statistically on par with UHSB - POP (T₈) and untreated control (T₉) (0.91 and 0.96 mg/g, respectively).

Total tannin contents in plant plays key role in the defense mechanism against insect pests. The use of methyl jasmonate increases the tannin content in leaves with increasing concentration of MeJA was possibly due to jasmonic acid activating the genes involved in the production of secondary metabolites like phenols and tannins. This study was in conformity with Arnold *et al* (2004) who reported JA application stimulate the tannin production in poplar seedlings. War *et al* (2015) found spraying of groundnut plants with jasmonic acid and salicylic acid showed significantly high level of tannin in leaves of groundnut plant. Present findings were also in accordance with Thiruvengadam *et al* (2016) who reported increased tannin content in turnip due to application of JA. Also, Yan *et al* (2021) found application of jasmonic acid (JA) recorded higher tannin level in leaves of wild rose.

Hussain *et al* (2023) reported that application of methyl jasmonate showed higher levels of tannin content in grape plant.

CONCLUSION

The current study concluded that treatments exhibited a notable variation in total phenol and tannin levels. Specifically, the highest concentrations of phenol and tannin were observed in the MeJA treatments at 3 mM (T₆), 2.5 mM (T₅) and 2 mM (T₄). In contrast, the lowest levels were found in the ethyl alcohol treatment (T₇), UHSB - POP (T₈) and the untreated control (T₉).

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Effect of Secondary Nutrients and Biofertilizers on Growth, Yield and Quality of Chilli (*Capsicum annuum* L.)

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ABSTRACT

An experiment was conducted at the Department of Vegetable Science, College of Horticulture, Mudigere during the year 2022-23. The experiment was laid out in Randomized Complete Block Design (RCBD) with eleven treatments and three replications to evaluate growth, yield and quality parameters of chilli. Among the treatments, treatment (T₁₁) which received 75 % RDNPK + CaNO₃ @ 0.5 % + MgSO₄ @ 0.4 % + *Azospirillum* + PSB + KSB significantly recorded maximum plant height (84.02 cm), number of leaves per plant (288.58), plant spread (N-S) 61.58 cm, plant spread (E-W) 57.66 cm, number of primary branches per plant (9.37), number of secondary branches per plant (22.54), total number of branches per plant (31.91), leaf area per plant (8085.43 m²), fresh weight (251.08 g), dry weight (185.20 g), dry matter (175.82 g), Absolute growth rate (1.673 g/plant/day), crop growth rate (6.29 g/m²/day), net assimilation rate (0.0817 g/dm²/day), relative growth (0.0309 g/day), quality parameters like highest total chlorophyll content (2.24 mg/g), ascorbic acid content (154.69 mg/100 g) recorded in T₁₁. Significantly recorded maximum fruit length (11.53 cm), fruit diameter (1.82 cm), fruit pericarp thickness (2.49 mm), number of fruits per plant (234.98), average fruit weight (6.42 g), fruit yield per plant (796.1 g), Fruit yield per plot (19.91 kg), Fruit yield (29.50 t/ha) showed the better growth and quality parameters under 75 % RDNPK + CaNO₃ @ 0.5 % + MgSO₄ @ 0.4 % + *Azospirillum* + PSB + KSB.

Keywords: Chilli, Secondary Nutrients, Biofertilizers.

INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important vegetable and spice crop which is commercially cultivated in tropical and sub-tropical regions. It requires a combination of warm and humid weather. A temperature range of 20 - 30 °C is optimum for chilli. The growth and yield of vegetable crops are mainly depending on the quality and quantity of fertilizers used. Secondary nutrients are required by the plant in smaller quantities than macronutrients. Although plants only require relatively small amounts of secondary nutrients but are essential for plant growth. If they are deficient, critical plant functions can be limited resulting in plant abnormalities, reduced growth and yield potential. They helps in absorption and translocation of other nutrients and activates number of plant growth regulating enzymes which are needed for cell wall formation and normal cell division.

Azospirillum can also alter the forms of plant nutrients such as nitrogen and phosphorus to make them more available to plants. *Azospirillum* also make antioxidants that protect the plant roots from stress due to drought and flooding. Plant growth can also be promoted indirectly by *Azospirillum* reducing plant disease (Tikhonova *et al*, 2019). The use of PSB as inoculants increases P uptake by plants. Simple inoculation of seeds with PSB gives crop yield responses equivalent to 30 kg P₂O₅ per ha or 50 per cent of the need for phosphatic fertilizers. Alternatively, PSB can be applied through fertigation or in hydroponic operations (Park *et al*, 2011). Potassium (K) is considered as an essential nutrient and a major constituent within all living cells. Naturally, soils contain K in larger amounts than any other nutrients however, most of the K is unavailable for plant uptake.

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The application of chemical fertilizers has a considerably negative impact on environmental sustainability (Han *et al*, 2006). The present study was conducted to assess the effect of secondary nutrients and biofertilizers on growth, yield and quality of chilli.

MATERIAL AND METHODS

To study the effect of secondary nutrients and biofertilizers on growth, yield and quality of chilli (*Capsicum annuum* L.) under hill zone of Karnataka. The field experiment was conducted at College of Horticulture, Mudigere during Summer season 2022-2023. The experiment was laid out in a Randomized Complete Block Design (RCBD) with eleven treatments and three replications. The seedlings were sown in ridge and furrow method at a distance of 60 cm between row to row and 45 cm between plants. All the recommended cultural operations were followed and observations were recorded in five randomly selected plants per replication of all the treatments.

The treatment details as follows

T₁- RDF

T₂-RDF + CaNO₃@ 0.5 %

T₃-RDF + MgSO₄@ 0.4 %

T₄-RDF + CaNO₃@ 0.5 % + MgSO₄@ 0.4 %

T₅-RDPK + 75 % N + CaNO₃@ 0.5 % + *Azospirillum*

T₆-RDPK + 75 % N + MgSO₄@ 0.4 % + *Azospirillum*

T₇-RDNK + 75 % P + CaNO₃@ 0.5 % + PSB

T₈-RDNK + 75 % P + MgSO₄@ 0.4 % + PSB

T₉-RDNP + 75 % K + CaNO₃@ 0.5 % + KSB

T₁₀- RDNP + 75 % K + MgSO₄@ 0.4 % + KSB

T₁₁-75% RDNPK + CaNO₃@ 0.5 % + MgSO₄@ 0.4 % + *Azospirillum* + PSB + KSB

Well decomposed FYM @ 25 t/ha was applied at the time of land preparation. The recommended dose 150:75:75 kg NPK per ha was applied in the form of urea, single super phosphate and muriate of potash, respectively. One week after transplanting drenching of biofertilizers was done and two weeks after transplanting secondary nutrients were sprayed as first spray, second spray was done at 15 days after the first spray and at the same time observations on growth, yield and quality parameters were recorded.

Leaf area was recorded by taking five leaves evenly from the bottom, middle and top portion of the plant using leaf area meter (LICOR portable leaf area meter). The fresh weight, dry weight, dry matter content of fruits were recorded at 60, 90 and 120 days interval and the growth analysis parameters like AGR, CGR, NAR and RGR at 60-90 and 90-120 DAT were worked, fruit quality parameters like fruit length, diameter, pericarp thickness and quality parameters like chlorophyll and ascorbic acid content were recorded and yield parameters like fruit yield per plant, fruit yield per plot and yield per hectare were worked out.

$$\text{AGR (g/plant/day)} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W₁ – Total dry weight of the plant (g) at time t₁

W₂ – Total dry weight of the plant (g) at time t₂

t₂ – t₁ - Time intervals in days

$$\text{CGR (g/m}^2\text{/day)} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{A}$$

Where,

W₁ – Total dry weight of the plant (g) at time t₁

W₂ – Total dry weight of the plant (g) at time t₂

t₂ – t₁ - Time intervals in days

A – Land area in m²

$$\text{NAR (dm}^2\text{/day)} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\text{Loge } L_2 - \text{Loge } L_1}{L_2 - L_1}$$

Where,

L₁ and W₁ - Leaf area in cm² and dry weight of the plant (g), respectively at time t₁

L₂ and W₂ - Leaf area in cm² and dry weight of the plant (g), respectively at time t₂

Loge – Logarithm to the base e.

t₂ – t₁ - Time intervals in days

$$\text{RGR (g/g/day)} = \frac{\text{Loge } W_2 - \text{Loge } W_1}{t_2 - t_1}$$

Where,

W₁ – Total dry weight of the plant (g) at time t₁

W₂ – Total dry weight of the plant (g) at time t₂

t₂ – t₁ - Time intervals in days

Effect of Secondary Nutrients and Biofertilizers on Growth, Yield and Quality

Table 1. Effect of Secondary nutrients and biofertilizers on Growth, Yield and Quality of chilli.

Treatment	Plant Height (cm)	No. of leaves	Plant spread (N-S)	Pt spread (E-W)	Primary branches	Secondary branches	Total no of branches	Leaf area (cm ²)	Fresh weight (g)	Dry weight (g)	Dry matter (g)	Absolute growth rate (g/plant/ d)	Crop growth rate (g/m ² /day)
T ₁	65.94	225.09	44.74	43.00	6.82	12.24	19.06	6445.93	213.30	156.78	147.57	1.421	5.26
T ₂	68.92	227.60	44.97	43.40	7.31	12.68	19.90	6598.51	216.70	160.63	151.31	1.483	5.49
T ₃	69.66	232.43	46.33	44.18	7.50	16.87	24.37	6761.78	219.54	163.85	154.52	1.502	5.56
T ₄	70.35	238.64	49.60	45.40	7.76	15.37	23.13	6925.26	223.60	166.43	157.99	1.537	5.69
T ₅	72.53	240.92	50.95	46.08	7.87	15.67	23.65	7089.14	226.68	168.98	159.63	1.539	5.70
T ₆	79.40	242.44	53.35	45.86	7.93	14.27	22.20	7252.70	230.58	170.37	161.01	1.541	5.72
T ₇	74.16	253.58	53.09	46.36	8.16	14.98	23.14	7416.15	234.96	172.23	162.95	1.555	5.76
T ₈	75.92	273.78	52.72	47.05	8.43	13.75	22.18	7592.14	238.88	176.00	166.63	1.578	5.84
T ₉	78.45	277.55	53.55	49.77	8.51	15.78	24.18	7756.30	241.85	178.38	169.86	1.606	5.95
T ₁₀	81.06	280.05	58.12	52.36	8.68	17.12	25.80	7921.26	245.81	181.17	171.79	1.627	6.02
T ₁₁	84.02	288.58	61.58	57.66	9.37	22.54	31.91	8085.43	251.08	185.20	175.82	1.673	6.29
S. Em±	0.68	2.58	0.41	0.44	0.07	0.18	1.48	55.51	1.66	1.67	0.67	0.01	0.03
CD @ (5%)	1.99	7.57	1.19	1.27	0.56	0.63	2.76	163.28	4.85	4.00	3.74	0.03	0.24

RESULTS AND DISCUSSION

It was found that 75 % RDNPK + CaNO₃ @ 0.5 % + MgSO₄ @ 0.4 % + *Azospirillum* + PSB + KSB showed significant increase in plant height (84.02 cm), Number of leaves per plant (288.58), plant spread (N-S) 61.58 cm, plant spread (E-W) 57.66 cm, number of primary branches per plant (9.37), number of secondary branches per plant (22.54), total number of branches per plant (31.91), leaf area per plant (8085.43 m²), fresh weight (251.08 g), dry weight (185.20 g), dry matter (175.82 g), absolute growth rate (1.673 g/plant/day), crop growth rate (6.29 g/m²/day), net assimilation rate (0.0817 g/dm²/day), relative growth (0.0309 g/g/day). The increased growth parameters might be due to the presence of macro, secondary nutrients like calcium which is responsible for physiological processes like cell division and cell elongation in a coincident enlargement of protoplast through water uptake and the microbial bioinoculants might have helped in effective utilization of macro nutrients. Biofertilizers like, PSB and KSB helps in converting the unavailable form of P and K respectively into available form in soil condition. Hence better nutrient uptake by the plants which in turn stimulates the vegetative growth and yield attributing traits. Bharathiraj *et al* (2012) observed similar results in tomato crop sprayed with combination of *Azospirillum lipoferum*, *Bacillus megaterium*, *Frateruria aurantia* with inorganic fertilizers to increase the yield both qualitatively and quantitatively. These results were in conformity with the results of Gollagi *et al* (2009), Hao and Papadopoulos (2003) in tomato and Yogaraju *et al* (2017) in chilli

Significantly recorded maximum fruit length (11.53 cm), fruit diameter (1.82 cm), fruit pericarp thickness (2.49 mm), number of fruits per plant (234.98), average fruit weight (6.42 g), fruit yield per plant (796.1 g), Fruit yield per plot (19.91 kg), Fruit yield (29.50 t/ha) which might be due to regulating semi permeability of cell walls, thus mobilizing more water content into fruit and increasing the size of fruits. this might have enabled to accumulate more carbohydrate into the storage organs which might have led to the increased fruit weight and nutrient use efficiency throughout the cropping period which might have enhanced the translocation of photosynthates from source to sink and the major macronutrient such as nitrogen resulted beneficial effects of microflora might have played a role in producing more number of flowers and that helps for production of more number of fruits, which resulted in increased number of fruits per plant and lead to a maximum number of harvest and more number of fruits per square meter and ultimately increases fruits yield. Similar results were reported by Kiran *et al* (2010) in brinjal.

Increase in chlorophyll content (2.24 mg/g), ascorbic acid content (154.69 mg/100 g). This might be due to enhanced availability of major nutrients, secondary nutrients are involved in biochemical and physiological plant processes, including protein synthesis and chlorophyll formation. As magnesium is constituent of chlorophyll, protein and protoplasm resulting in greater photosynthetic activity. Cytokinin produced by microbial inoculants might have greater sink to attract nutrients like Mg, Fe and K. The indirect role of iron is enhancing the functioning of plant system ultimately increased the chlorophyll content in the leaves. These results were in line with the earlier

Table 2. Effect of Secondary nutrients and biofertilizers on Growth, Yield and Quality of chilli.

Treatment	NAR (g/cm ² /day)	RG R (g/day)	Fruit length (cm)	Fruit diameter (cm)	Pericarp thickness (mm)	Number of fruits/ plant	Average fruit weight (g)	Fruit yield d/ plant (g)	Fruit yield d/ plot (kg)	Fruit yield / ha (ton s)	Total chlorophyll	Ascorbic acid content (mg/100 g)
T ₁	0.0656	0.0234	7.50	1.36	1.89	166.12	3.40	572.0	14.31	21.20	1.26	119.18
T ₂	0.0682	0.0246	8.24	1.41	2.02	172.19	3.54	596.0	14.91	22.10	1.65	121.74
T ₃	0.0693	0.0257	8.45	1.43	2.05	178.62	3.63	608.0	15.18	22.50	1.74	122.62
T ₄	0.0734	0.0260	8.89	1.46	2.18	186.63	4.24	626.0	15.66	23.20	1.85	123.15
T ₅	0.0746	0.0264	8.96	1.59	2.21	195.48	4.64	659.1	16.47	24.40	1.87	124.85
T ₆	0.0754	0.0266	9.08	1.64	2.19	201.69	4.89	669.5	16.74	24.80	1.94	126.05
T ₇	0.0766	0.0268	9.35	1.49	2.09	208.93	5.16	678.4	16.94	25.10	1.97	128.09
T ₈	0.0778	0.0272	9.71	1.54	2.22	215.99	5.34	684.8	17.14	25.40	1.96	132.43
T ₉	0.0789	0.0278	9.90	1.68	2.17	221.12	5.56	706.8	17.68	26.20	2.04	137.17
T ₁₀	0.0800	0.0292	10.61	1.76	2.32	227.94	5.86	712.8	17.82	26.40	2.06	141.18
T ₁₁	0.0817	0.0309	11.53	1.82	2.49	234.98	6.42	796.1	19.91	29.50	2.24	154.69
S. Em±	0.0004	0.0005	0.08	0.02	0.05	2.09	0.09	8.82	0.18	0.35	0.02	0.87
CD @ (5%)	0.0013	0.0015	0.22	0.04	0.14	6.00	0.26	25.37	0.51	1.00	0.07	2.52

findings of Alaboz *et al* (2017) in chilli and Bharathiraja *et al* (2012) in tomato and the findings of Yogaraju *et al* (2017) who reported that integrated use of microbial consortia and secondary nutrients had increased fruit quality parameters like chlorophyll content in chilli by the application of *Azospirillum* + PSB + VAM + KSB + 75% RDF + MgSO₄ + Micronutrient mixture.

CONCLUSION

The study concluded that treatment T₁₁ consisting of 75% RDNPK + CaNO₃@ 0.5 % + MgSO₄ @ 0.4 % + *Azospirillum* + PSB + KSB was found to be the most suitable for adoption by the farmers.

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Effect of Secondary Nutrients and Biofertilizers on Growth, Yield and Quality

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Effect of Various Potting Media on Growth Characteristics of Phalsa Cuttings (*Grewia subinaequalis* L.)

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ABSTRACT

Phalsa (*Grewia subinaequalis*), belonging to the Tiliaceae family, is a bushy plant adapted to the arid and semi-arid regions of India. Known for its hardiness, it thrives in diverse soil and climatic conditions where other fruit crops often fail. Phalsa fruits are valued for their exceptional medicinal and nutritional properties. Although traditionally propagated by seeds in India, the rapid loss of seed viability has made vegetative propagation a more reliable method, ensuring true-to-type plants and simplifying cultivation. An experiment conducted by the Department of Horticulture, Faculty of Agriculture, Annamalai University, Cuddalore, Tamil Nadu, evaluated the impact of different potting media on the growth characteristics of phalsa cuttings. The study was arranged in a Completely Randomized Design (CRD) with three replications. Results showed that hardwood cuttings planted in a mixture of Soil + Farmyard Manure (1:1) exhibited superior performance, with the shortest number of days taken for sprouting (10.21), highest number of sprouts per cutting (6.60), number of leaves per cutting (8.74), leaf area per cutting (15.08 cm²), length of longest root per rooted cutting (18.51 cm), survival percentage of rooted cuttings (70.78%), fresh weight of the roots (3.22 g) and dry weight of the roots (0.95 g).

Keywords: Cuttings, Growth characteristics, Phalsa, Potting media, Propagation

INTRODUCTION

Phalsa (*Grewia subinaequalis*), classified under the Tiliaceae family is a bushy plant that thrives in India's dry and semi-arid regions. Native to the Indian subcontinent and Southeast Asia, it is an important minor fruit crop in the northern, northwestern, and southern parts of India, with significant cultivation in states like Gujarat, Maharashtra, Madhya Pradesh, Uttar Pradesh, and Bihar (Joshi *et al*, 2020). This hardy crop is well-suited to diverse soil and climatic conditions where other fruits struggle to grow (Pujari, 2012). Phalsa fruits are renowned for their medicinal and nutritional benefits. Unripe fruits are used to lower fever, treat blood, heart, and respiratory conditions, and diminish inflammation. (Singh *et al*, 2015). Ripe fruits, enjoyed fresh or processed into cooling summer beverages, are valued for their tonic and aphrodisiac properties. Rich in vitamins A and C, as well as vital minerals like iron and phosphorus, they hold significant nutritional value. Additionally, phalsa leaves possess antibiotic

properties and are traditionally used to treat skin eruptions (Singh and Tomar, 2015). In India, phalsa is commonly propagated through seeds, but its seeds lose viability within three months under ambient storage, making fresh seeds from ripe fruits essential. To overcome this limitation, vegetative propagation methods such as rooting hardwood cuttings and layering have gained preference. These methods are more reliable, ensuring true-to-type plants and simplifying the cultivation process. Propagation through cuttings is particularly beneficial due to its ease, effectiveness in root initiation, and minimal precision requirements (Samson, 1986).

MATERIALS AND METHODS

The experiment was carried out at Annamalai University's Department of Horticulture, Faculty of Agriculture, Cuddalore, Tamil Nadu. Seven treatments were included in the completely randomized design experiment namely control – soil (M₁), farmyard manure (M₂), cocopeat (M₃), vermicompost (M₄), soil + farmyard manure (1:1) (M₅), soil + cocopeat (1:1) (M₆),

Table 1. Effect of different potting media on phalsa at 60 days after planting.

Media	Number of days it takes for phalsa to sprout	The count of sprouts per phalsa cutting	Number of leaves per phalsa cutting	Leaf area per phalsa cutting (cm ²)
M ₁	24.08	2.27	4.58	8.92
M ₂	16.52	4.52	6.73	11.71
M ₃	20.63	3.45	5.39	10.28
M ₄	17.91	4.09	6.20	11.04
M ₅	10.21	6.60	8.74	15.08
M ₆	13.04	5.13	7.36	12.59
M ₇	11.77	5.78	7.87	14.14
S. Ed	0.26	0.07	0.11	0.19
CD at 5 % (p = 0.05)	0.57	0.16	0.23	0.41

soil + vermicompost (1:1) (M₇) and which contained three times of replications. Hardwood cuttings prepared from 3 to 4 years old plants and from the hardwood portion of the branches, cuttings measuring 20 cm in length, comprising 4–5 nodes and exhibiting a thickness of 1.0–1.2 cm, were excised for propagation. To reveal the largest absorbing surface area for the best roots following treatment, the basal end of each cutting was sliced in slanting manner. 200 ppm of IBA is applied to the hardwood cuttings for a full day before to planting. Before being planted, the hardwood cuttings are treated with IBA 200 ppm for a whole day. Potting mixtures were prepared and filled in black polythene bags. The treated cuttings were planted at a depth of 4 to 5 cm.

To record the observations, five phalsa cuttings were chosen at random from each treatment per replication, and at 60 days following the planting, the following data were recorded: the number of days it took for the roots to sprout, the number of sprouts per cutting, the number of leaves per cutting, the leaf area per cutting (cm²), the length of the longest root per rooted cutting (cm), the survival percentage of rooted cuttings (%), the fresh weight of the roots (g), and the dry weight of the roots (g). The experimental data for various traits was statistically analysed using Analysis of Variance (ANOVA) under a Completely Randomized Design, adhering to the methodology outlined by Fisher and Yates (1963). One-way ANOVA was performed for each parameter using the software WASP 2.0. The significance of the treatments was evaluated through the “F” test at a 5% level of significance. Additionally, the standard error of difference (S. Ed) and critical difference (CD) at the 5% significance level were included in the summary table to illustrate the nature and extent of the treatment effects.

RESULTS AND DISCUSSION

The data regarding the duration required for sprouting, the count of sprouts per cutting, the number of leaves per cutting, and the leaf area per cutting (cm²) in Phalsa cuttings under various potting media treatments are summarized in Table 1. The least duration required for sprouting was observed in soil + farmyard manure (FYM, 1:1) (M₅), followed by soil + vermicompost (1:1) (M₇), which took 10.21 and 11.77 days, respectively, compared to the Control – soil (M₁) at 24.08 d. These findings indicated that cuttings planted in FYM sprouted earlier than those in other treatments. This might be because, in comparison to alternative potting media, FYM has more porosity and improved moisture and nutrient availability, which encourage physiological activity in the cuttings and cause early leaf emergence (Jamil *et al*, 2016).

Soil + farmyard manure (1:1) (M₅) registered the highest number of sprouts per cutting (6.60) whereas M₁ recorded the lowest number of sprouts per cutting (2.27). FYM significantly improved soil's physical, chemical, and biological properties. It enhances soil structure, nutrient availability, and microbial activity, creating optimal conditions for plant growth. FYM's ability to bind soil aggregates improves water retention and aeration, while gradually releasing essential nutrients. This study showed that soil mixtures with FYM increased the number of sprouts per cutting due to better nutrient availability and moisture retention. Similar findings were observed in mulberry (Sharma, 1993).

Soil + farmyard Manure (1:1) (M₅) recorded the most leaves per cutting followed by soil + vermicompost (1:1) (M₇) which showed 8.74 and 7.87, respectively to control – soil (M₁) (4.58). FYM, a rich

Effect of Various Potting Media on Growth Characteristics of Phalsa Cuttings

Table 2. Effect of different potting media per cutting in Phalsa at 60 days after planting.

Media	Length of the most extended root per rooted cutting (cm)	Survival rate of rooted cuttings (%)	Fresh weight of the phalsa roots (g)	Dry weight of the phalsa roots (g)
M ₁	10.76	60.47	1.07	0.25
M ₂	15.19	68.02	2.18	0.57
M ₃	12.64	67.89	1.53	0.39
M ₄	13.95	67.91	1.86	0.46
M ₅	18.51	70.78	3.22	0.95
M ₆	16.42	68.51	2.50	0.70
M ₇	16.94	69.05	2.82	0.80
S. Ed	0.23	1.01	0.04	0.01
CD at 5 % (p = 0.05)	0.51	2.20	0.08	0.02

organic matter, improves soil structure by binding aggregates, enhances nutrient availability, and boosts microbial activity. These combined effects improve moisture retention and aeration, creating ideal conditions for plant growth. FYM's nutrient supply supports photosynthesis and metabolism, leading to more vigorous shoot development and increased leaf numbers. Findings similar to the present study were reported on pomegranates (Bhagat and Saraswati, 1988) and on mulberries (Sharma, 1993).

At 60 days after planting, the highest leaf area per cutting (15.08 cm²) in M₅ and the minimum leaf area per cutting (8.92 cm²) were observed in M₁. Farmyard manure improves soil structure by binding aggregates, enhances nutrient availability, and boosts microbial activity. These improvements, along with increased moisture availability and nutrient supply, likely contribute to a significant increase in leaf area. Findings similar to the present study were obtained in mulberries (Sharma, 1993), in pomegranates (Bhagat and Saraswati, 1988), and in papaya (Ramteke *et al*, 2013).

The data (Table 2) present values on the Phalsa cuttings under various potting media treatments for length of the longest root per rooted cutting (cm), survival percentage of rooted cuttings (%), fresh weight of the roots (g), and dry weight of the roots (g). The longest root per rooted cutting was recorded by M₅ whereas the lowest recorded length of the longest root per successfully rooted cutting was recorded by M₁ (10.76). The increase in root length was due to the nutrient-rich mixture, which, because of its high porosity and ability to retain water and nutrients, it supports the development of a strong root system. This combination creates ideal conditions for root growth. The organic substances in the rooting media improve soil physical properties, fostering a

better environment for root development (Ramteke *et al*, 2013). Furthermore, organic amendments enhance soil structure by improving water retention, aeration, and drainage, which in turn promotes development of roots and nutrients uptake (Kumar *et al.*, 2009). Findings similar to the present study were reported by Deol and Uppal (1990) in pomegranate, Sharma (1993) in mulberry, Lakra (2004) in passion fruit and Ramteke *et al* (2013) in Papaya.

At 60 days after planting, the highest survival percentage of rooted cuttings (70.78 %) in M₅ and the lowest survival percentage of rooted cuttings (60.47 %) was observed in M₁. The use of FYM in soil improves plant survival by modifying soil physical properties and increasing nutrient availability, which supports healthy growth and development (Singh and Gupta, 2005). Moreover, tree cutting survival depends on potting soil with a high carbohydrate content and low nitrogen levels since these elements promote root formation, bud initiation, and leaf development in shoots, increasing the likelihood of successful sprouting (Jamil *et al*, 2016). These findings were comparable to those of Lakra (2004) in passion fruit, Sharma (1993) in mulberries,

Soil + farmyard manure (1:1) (M₅) has the most leaves per cutting, followed by soil + vermicompost (1:1) (M₇) which showed 8.74 and 7.87 respectively to control – soil (M₁) (4.58). The observed results may be due to the enhanced nutrient availability in the potting media combinations, it encourages the growth of more leaves that are photosynthetically active (Borah *et al*, 2008). The increased number of leaves per cutting could be attributed to the plant allocating more assimilates to the leaf bud, as leaves play a crucial role in natural auxin production and key processes like photosynthesis and respiration. Additionally, the higher organic matter content helped

increase the number of leaves by supplying essential nutrients that fostered early root development (Awan *et al*, 2003). In conclusion, Farmyard manure and other organic soil combinations increased the biomass of leaves produced. Indriyani *et al* (2011) and Ramteke *et al* (2013) reported similar findings in pineapple and papaya, respectively.

At 60 days after planting, soil + farmyard manure (1:1) (M₅) registered the highest fresh and dry weights of the roots (3.22 and 0.95 g), whereas M₁ recorded the lowest fresh and dry weights of the roots (1.07 and 0.25 g). Organic substances in rooting media improve the soil's physical properties, creating an environment that supports better root growth (Ramteke *et al*, 2013), leading to enhanced root development. Additionally, organic amendments in potting mixtures enhance soil structure by increasing water retention, aeration, and drainage, promoting improved development of roots and absorption of nutrients (Kumar *et al*, 2009).

CONCLUSION

The findings from the study indicated that the soil and farmyard manure combination notably enhanced the growth characteristics of phalsa cuttings. This approach can serve as an effective technique for farmers to improve growth outcomes in phalsa propagation.

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Effect of Various Processing Methods on Nutritional and Anti-Nutritional Compositions of Brown Rice

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ABSTRACT

This study was conducted to evaluate the qualitative changes in brown rice (IC-577410) during different processing treatments such as soaking, germination and fermentation. Soaking was carried out for 12, 24 h and germination for 24, 48, 72 h. Natural fermentation was carried out by microorganisms already present in the grain and with baker's yeast (*Saccharomyces cerevisiae*) for 12, 24, and 36 h interval. Dehulled rice that contains the embryo, endosperm and bran is called brown rice. Brown rice can be utilized as a functional meal and is an excellent source of nutrients as compared to the fantastic so white or polished rice. By the use of various processing treatments significant effect ($p \leq 0.05$) observed on the chemical composition and antioxidant activity of brown rice. Germination and fermentation help to enhance the nutritional profile of cereals and legumes by causing significant changes in chemical composition. Crude protein and crude fibre content increased by 11.94 and 17.04%, respectively but the crude fat content decreased by 8.24% after germination treatment. Total polyphenolic content (TPC) and antioxidant activity increased significantly ($p \leq 0.05$) by 58.08 and 77.62%, respectively during germination treatment. After the fermentation treatment, crude protein content increased significantly ($p \leq 0.05$) by 11% but the crude fat and crude fibre decreased by 4.12 and 3.41%, respectively. Bioactive components mainly total phenolic components (TPC) and anti-oxidant activity increased significantly ($p \leq 0.05$) by 33.52 and 48.02%, respectively during the fermentation process. Therefore, it was observed that throughout the germination and fermentation treatments, there was a significant ($P \leq 0.05$) increment observed in protein, total phenolic components, and antioxidant activity of brown rice.

Keywords: Antioxidant, Fermentation, Germination, Physicochemical Properties, Rice, Soaking.

INTRODUCTION

Rice botanically named as *Oryza sativa* has been a staple food in Asian nations for quite a long time. During the milling process, the external bran and germ part of intact rice grains (*i.e.* brown rice) are eliminated to produce white rice that fundamentally comprises starchy endosperm. Higher dietary glycemic index (GI) has been reliably connected with an eminent risk of type 2 diabetes (T2D). Brown rice consumption may confer beneficial impacts on T2D hazards due to the presence of nutrients like fiber, and minerals, most of which are lost during refining and processing treatments (Sun *et al*, 2010). Cereals are major sources of carbohydrates and provide the majority of the energy in the human diet, particularly in underdeveloped countries. Both whole brown rice (BR) and polished white rice are made up of carbohydrates mainly starch. In rice kernel, the endosperm contains the highest amount of starch (Zhou *et al*, 2002).

Brown rice (BR) is the grain that remains after the husk has been removed and has higher nutrients than polished rice (Pal *et al*, 2016). During milling, bran and germ are removed for the consumption of polished grains. Bran and germ fractions of rice are a rich source of micro-nutrients but these decrease during the milling process. The bran fraction of rice has approximately 65% of fibre content, phenolics, vitamins, and minerals out of the total nutrient in the grain (Lerma-García *et al*, 2009).

Brown rice contains higher lipid contents than milled rice because outer bran layers contain more concentrated lipids (up to 20%) as described by Thomas *et al* (2015) and Zhou *et al* (2002). (Bryant *et al*, 2013) evaluated 202 genotypes of brown rice, where protein content ranged from 5.40 to 11.90%. Protein content may vary significantly depending on the geographical area and genetic diversity. The mineral contents are found abundant in brown rice, where the concentration of calcium, manganese, zinc,

and iron ranges from 72-128, 21.90-43.80, 22.50-32.70, and 5.10- 9.75 mg/kg, respectively (Srinuttrakul & Busamongkol, 2014).

Conventional processing methods such as soaking and germination used to enhance the nutritional value, bioactive components such as antioxidant activity, total polyphenolic, and flavonoid content, and decrease the anti-nutrients such as trypsin inhibitor, tannin, and phytic content in food grains (Embaby, 2010). In the food processing industry, fermentation is a widely used method to preserve and enhance the shelf-life of food products. It helps to improve the food texture, flavour, and digestibility (Khalil, 2006). During the roasting treatment, the breakdown of cell walls and membranes occurs, resulting in a release of insoluble ester bonds with enhanced soluble phenolic components and an increase in antioxidant properties. During roasting treatment, the physical qualities, flavour, and chemical composition of food get altered and antioxidant activity gets increased due to the Maillard reaction as reported by (Dewanto *et al*, 2002).

Germination has been reported to decrease the fat content (21.16%) after the germination in legumes and rice (Megat Rusydi *et al*, 2011). (Hahm *et al*, 2009) reported a decline in crude fat content with an increase in germination time in sesame seeds. A significant increment in antioxidant activity during germination has been reported in several studies. (Jan *et al*, 2017) reported an increased trend in antioxidant activity and values increased from 26.51 to 29.08% after 48 h of quinoa germination in various cultivars. According to (Acosta-Estrada *et al*, 2014), the interaction between the seed's protein and starch molecules during germination or the release of phenolic compounds from cell walls are both associated with an increment in antioxidant activity.

MATERIALS AND METHODS

Materials

The IP-577410 cultivars of paddy were procured from ICAR- Pusa New Delhi and multiply in the Eternal University field. The chemicals utilized in the current studies were purchased from Qualigens, BDH chemicals, Hi-Media, and Sigma.

Physico-chemical evaluation

Raw paddy and paddy after the processing treatments were subjected to physico-chemical

analysis in the laboratories, of Eternal University in the Department of Food Technology located at Sirmour, Himachal Pradesh, India.

Physical and functional parameters

Physical parameters such as 1000 kernel weight were estimated as per the method of (Committee, 2000). Vernier calliper was used to measure the length, breadth and thickness. The procedure described by Huang *et al*, 2005 was used to evaluate the bulk density (BD), Jones *et al*, 2000 for tap density (TD), Sosulski (1962) for water absorption capacity (WAC), Kaur *et al* (2015) for oil absorption capacity (OAC) and Stojceska *et al* (2008) for water solubility index (WSI).

Chemical parameters

The moisture content was measured by using the hot air oven to dry the sample as per (AOAC, 1990). Various instruments such as Fibroplus FBS 08P (Pelican Inc.), Soxoplus SPS 06 AS (Pelican Inc.), and Kjelo plus Kjeldist CAS VA (Pelican Inc.) were used to determine the crude fibre, crude fat, and crude proteins, respectively. Ash content was measured as per the method described by (Ranganna, 1986). The total carbohydrate content was determined by difference, and calculated by subtracting the measured crude fat, crude protein, crude fibre, ash, and moisture content from 100. The Atwater factor was used to determine the calorific value. The calorific value was determined by multiplying crude protein, crude fats, and carbohydrates by the Atwater factor of 4.0, 9.10, and 4.2 KCal/g, respectively (WHO, 1973). The method described by (AOAC, 1990) was used to analyse the mineral content such as Cu, Fe, Mn, and Ca by using AAS (Atomic Absorption Spectrometer).

The antioxidant activity was determined as free radical scavenging activity according to the method described by (Bouaziz *et al*, 2008). The tannins (%) were estimated as per the method described by (Saxena *et al*, 2013) with minor modifications. The phytic content (mg/g) was evaluated as per the method described by (Gao *et al*, 2007). The total phenolic content (mg GAE/100g) was estimated by using the Folin-Ciocalteu reagent following a slightly modified method of (Ainsworth and Gillespie, 2007).



Figure 1. Soaking and germination treatment of paddy

PROCESSING TREATMENTS

Soaking and germination processing treatments were carried out in accordance with the methodology employed by (Egli *et al*, 2002). As depicted by Figure 1, the cleaned seeds of brown rice were soaked in distilled water in 1:5. The seeds were soaked for 12 and 24 h at room temperature and subjected to dried in hot air oven for 24 h at 40°C. For germination treatment, seeds being soaked for 16 h and divided into three group (approximately 20 g soaked seeds for each group) and allowed to germinate for varying time interval. For 24, 48, and 72 h, the germination process was conducted in an incubator set at 25°C with periodically sprinkling the water to keep the muslin cloth wet during germination. Following each germination interval, germinated samples were dried over 24 h at 40°C in hot air oven. Samples were then sealed and kept in airtight packages at 4°C until they could be examined further.

With a few modest modifications, natural fermentation process using the methodology developed by (Park *et al*, 2020). Sample of brown rice flour (20 g) was gently combined with distilled water (60 ml). An incubator set at 37°C was used to conduct natural fermentation for 12, 24, and 36 h. naturally occurring microbes in seeds were the cause of fermentation. The samples taken at each time point were oven-dried at 50°C to equilibrate the moisture content. After being dried in a blender, the samples were filtered through a 60-mesh stainless steel sieve, packed in polyethylene bags, and kept at 4°C until they were used.

As per the method describe by (Day and Morawicki, 2016) with minor modification grains were subjected to ferment with baker's yeast (*Saccharomyces cerevisiae*). The 20g brown rice flour and 120 ml distilled water was added in 500 ml conical flask and mixed properly. The samples were autoclaved after adjusting the pH to 4.5 and

Table1. Physical, functional and optical characteristics of raw grains.

Parameter	Brown Rice
Length (mm)	5.37±0.06
Width (mm)	1.67±0.06
Thickness (mm)	1.73±0.06
1000 kernel Wt. (g)	21.50±0.10
Bulk density (g/cm ³)	0.79±0.02
Tap density (g/cm ³)	0.83±0.02
Swelling Capacity (%)	5.00±1.0
Water absorption capacity (ml/g)	1.23±0.06
Water solubility index (%)	5.20±0.10
Oil absorption capacity (ml/g)	2.57±0.12
L*	80.00
a*	2.39±0.01
b*	10.21±0.01

The table's values are presented as mean±SD

Table 2. Nutritional profile of raw grains of brown rice.

Parameter	Values
Moisture (%)	9.29± 0.01
Fat (%)	1.94±0.04
Fibre (%)	1.76±0.04
Ash (%)	1.47±0.01
Protein (%)	7.54±0.01
Carbohydrate (%)	78.01±0.07
Calorific Value (Kcal/100g)	375.42±0.08
Antioxidant activity (% inhibition)	40.61±0.12
Tannin (%)	0.557±0.006
Phytic acid (%)	1.30±0.03
Total Phenolic content (mg GAE/100g)	184.60±0.87
Flavonoids (mgRE/100g)	48.97±0.64
Trypsin inhibitor (mgTIA/100g)	50.35±
Cu (mg/kg)	0.96±0.02
Fe (mg/kg)	0.66
Zn (mg/kg)	0.04
Mn (mg/kg)	0.02
Ca (mg/kg)	0.06

The table's values were presented as mean±SD

Saccharomyces cerevisiae (0.4g) was then added for conducting fermentation process. Conical flasks were properly mixed and then placed in incubator at 37°C for 12, 24, and 36 h. Following each fermentation interval, the fermented samples were hot-dried at 50°C and converted to fine powder. Until further examination, flour was kept in sealed airtight packages at 4°C.

RESULTS AND DISCUSSION

Physical properties

The data pertaining to physical and optical parameters of raw grains is presented in Table1. The

brown rice length, breadth, and thickness were found to be 5.37, 1.67, and 1.73 mm, respectively. The 1000 kernel weight was observed as 21.50g.

The optical parameters such as L* value for brown rice grains were determined as 81.10, a* value as 2.39, and b* value as 10.21, respectively. The greater the value of L*, the brighter will be the flour as L* represents brightness in the sample. The values for a* represent the red to the green color quality of the samples. Similarly, the value of b* represents the blue to yellow quality of samples. The functional parameters such as bulk and tap density of brown rice were 0.79 and 0.83 g/cm³ respectively. Water absorption capacity, water solubility index, oil

Effect of Various Processing Methods on Nutritional and Anti-Nutritional Compositions

Table 3. Nutritional profile of brown rice affected by soaking and germination at different time intervals.

Parameter	Time interval (h)					
			Soaking		Germination	
	0	12	24	24	48	72
Moisture (%)	9.29 ±0.01 ^c	9.40 ±0.05 ^b	9.47 ±0.04 ^{ab}	9.50 ±0.13 ^{ab}	9.55 ±0.06 ^a	9.23 ±0.02 ^c
Fat (%)	1.94 ±0.04 ^a	1.85 ±0.01 ^b	1.83 ±0.01 ^{bc}	1.82 ±0.01 ^{bc}	1.81 ±0.01 ^{cd}	1.78 ±0.01 ^d
Fibre (%)	1.76 ±0.04 ^e	1.81 ±0.01 ^d	1.83 ±0.0 ^d	1.97 ±0.02 ^c	2.02 ±0.01 ^b	2.06 ±0.02 ^a
Ash (%)	1.47 ±0.01 ^a	1.46 ±0.01 ^{ab}	1.45 ±0.01 ^{bc}	1.44 ±0.01 ^c	1.43 ±0.01 ^d	1.41 ±0.01 ^e
Protein (%)	7.54 ±0.01 ^f	7.71 ±0.01 ^e	7.83 ±0.02 ^d	8.27 ±0.02 ^c	8.33 ±0.03 ^b	8.44 ±0.02 ^a
Carbohydrates(%)	78.01 ±0.07 ^a	77.76 ±0.04 ^b	77.59 ±0.03 ^c	77.00 ±0.15 ^d	76.87 ±0.04 ^e	77.07 ±0.03 ^f
Calorific value (Kcal/100g)	375.42 ±0.08 ^a	374.31 ±0.26 ^b	373.81 ±0.20 ^{bc}	373.05 ±0.61 ^c	372.62 ±0.20 ^d	373.06 ±0.16 ^d
Antioxidant activity (% inhibition)	40.61 ±0.12 ^f	42.23 ±0.29 ^e	43.17 ±0.16 ^d	60.18 ±0.16 ^c	67.14 ±0.06 ^b	72.13 ±0.10 ^a
TPC (mg GAE/100g)	184.60 ±0.87 ^f	218.38 ±1.28 ^e	227.01 ±0.43 ^d	247.69 ±1.35 ^c	258.98 ±0.85 ^b	291.81 ±3.86 ^a
Flavonoids (mgRE/100g)	48.97 ±0.64 ^f	50.49 ±0.39 ^e	53.28 ±0.81 ^d	59.19 ±1.40 ^c	61.47 ±0.39 ^b	64.76 ±0.39 ^a
Trypsin inhibitor (mgTIA/100g)	0.86 ±0.03 ^a	0.84 ±0.02 ^a	0.81 ±0.01 ^b	0.79 ±0.01 ^b	0.58 ±0.01 ^c	0.41 ±0.01 ^d
Tannin (%)	0.557 ±0.006 ^a	0.420 ±0.006 ^b	0.410 ±0.008 ^b	0.312 ±0.010 ^c	0.275 ±0.005 ^c	0.241 ±0.009 ^f
Phytic acid(%)	1.30 ±0.03 ^a	1.28 ±0.01 ^{ab}	1.26 ±0.01 ^b	1.21 ±0.02 ^c	1.19 ±0.01 ^d	1.14 ±0.01 ^d
Cu (mg/kg)	0.96 ±0.01 ^e	0.98 ±0.01 ^d	0.99 ±0.01 ^d	1.03 ±0.01 ^c	1.05 ±0.01 ^b	1.10 ±0.01 ^a
Fe(mg/kg)	0.56 ±0.03 ^d	0.59 ±0.01 ^c	0.61 ±0.01 ^c	0.98 ±0.01 ^b	1.02 ±0.01 ^a	1.04 ±0.01 ^a
Zn (mg/kg)	0.24 ±0.01 ^e	0.25 ±0.01 ^e	0.28 ±0.01 ^d	0.35 ±0.01 ^c	0.38 ±0.01 ^b	0.41 ±0.01 ^a
Mn (mg/kg)	0.42 ±0.01 ^e	0.43 ±0.01 ^e	0.49 ±0.01 ^d	0.63 ±0.02 ^c	0.67 ±0.01 ^b	0.72 ±0.01 ^a
Ca (mg/kg)	5.17 ±0.06 ^e	5.26 ±0.04 ^d	5.33 ±0.01 ^d	5.76 ±0.03 ^c	5.90 ±0.01 ^b	6.03 ±0.01 ^a

The table's values were presented as mean±SD; Values with in rows sharing the same letters were not significantly different according to Duncan's LSD post hoc analysis at $P \leq 0.05$

absorption capacity, and swelling capacity of brown rice were 1.23ml/g, 5.20%, 2.57 ml/g and 5% respectively.

The data (Table 2) described the nutritional profile of raw grains of brown rice and found to contain 9.29% of moisture, 1.94% of crude fat, 1.76% of crude fiber, 1.47% of ash content, 7.54% of crude protein, 78.01% of carbohydrates, and 375.42 Kcal/100g of calorific value. It also contained about 40.61% of antioxidant activity, 184.60 mg GAE/100g of TPC, and 48.97 mg RE/100g of flavonoid contents. Anti-nutritional components such as tannins, phytic acid, and trypsin inhibitor activities in brown rice were

reported as 0.21%, 1.36%, and 0.86 mg TIA/100g, respectively. The mineral contents such as Zn, Cu, Fe, Mn, and Ca have been reported as 0.24, 0.96, 0.56, 0.42, and 5.17 mg/kg, respectively.

Effect of soaking and germination on the nutritional profile of brown rice

The data (Table 3) illustrated the nutritional profile of brown rice affected by soaking and germination at different time intervals i.e. 24 h (G24), 48 h (G48) and 72 h (G72) and revealed that, in brown rice, the moisture and fat content ranged between 9.29 in raw grain (RG) to 9.23 % in (G72) and 1.94 (RG) to

1.78% (G72), respectively. Following germination treatment, the fat content was decreased by 8.25% when compared to the fiber content of raw and germinated, the fiber content of brown rice increased significantly ($P \leq 0.05$) from 1.76% (RG) to 2.06% (G72) resulting in a 17.05% increase. Ash content decreased by 4.14% which is non-significant and values varied from 1.47(RG) to 1.41% (G72).

Crude protein

After 72 h of germination, the crude protein content increased from 7.54% (RG) to 8.44% (G72) resulting in a significant ($P \leq 0.05$) and an increment of 11.94%. In brown rice, the carbohydrate contents and calorific value decreased significantly ($P \leq 0.05$) from 78.01 (RG) to 77.07% (G72) to and from 375.42 (RG) to 373.06 (G72) Kcal/100g, respectively. The antioxidant activity increased by 40.61 (RG) to 72.13% (G72) with a significant increase ($P \leq 0.05$). The antioxidant activity increased by 77.62%. The phenolic components increased from 184.60 (RG) to 291.81 mg GAE/100g (G72) with a significant increment of ($P \leq 0.05$). After 72 h of germination, the phenolic content increased by 58.08%.

Flavonoid content

A significant ($P \leq 0.05$) increment in flavonoid content also observed during germination process increased from 48.97 (RG) to 64.76 mg RE/100g (G72) resulting in a 32.24% increase in flavonoid contents. Anti-nutrients such as tannin, phytic, and trypsin inhibitor activity declined from 0.557 (RG) to 0.241% (G72); 1.30 (RG) to 1.14% (G72); and 0.86 (RG) to 0.41 mg TIA/100g (G72), respectively, with a significant ($P \leq 0.05$) decrease. There was reduction in tannins (56.73%), phytic acid (12.31%), and trypsin inhibitor activity (52.33%) during the germination treatment.

Cu content

Although Cu content increased by 14.58% after germination and the value ranges from 0.96 (RG) to 1.10 mg/kg (G72), germination of the grains for 72 h is the best method to enhance the mineral content. After soaking and germination treatment, the Fe content increased from 0.56 (RG) to 1.04 mg/kg (G72) and Zn from 0.24 (RG) to 0.41 mg/kg (G72). Following these treatments, there were 85.71 and 70.84% increase in Fe and Zn content, respectively observed. After germination, the manganese content increased by 71.43 and 16.63%, respectively as the values for Mn and Ca content increased from 0.42 (RG) to 0.72 mg/kg (G72) and 5.17 (RG) to 6.03 mg/kg (G72).

Effect of fermentation

The brown rice was subjected to fermentation treatments i.e. natural fermentation carried out for 12, 24 and 36 h named as (NF12), (NF24), and (NF36) respectively and fermentation with *S. cerevisiae* for 12, 24, and 36 h named as (SCF12), (SCG24), and (SCF36), respectively. The fat content decreased significantly ($P \leq 0.05$) from 1.94 (RG) to 1.86% (SCF36), resulting in a 4.12% reduction in fat content observed after the fermentation treatment as per table 4. Similarly, in comparison to the fiber content of raw and fermented brown rice sample significant ($P \leq 0.05$) reduction observed from 1.76% (RG) to 1.70% (NF36) or 3.41%. After 36 h of fermentation, the crude protein content was increased significant ($P \leq 0.05$) from 7.54 (RG) to 8.34% (SCF36) showing a 10.61% increase in protein content. The carbohydrate and calorific values declined significantly ($P \leq 0.05$) from 78.01 (RG) to 77.37% (SCF36) and 375.42 (RG) to 375.28 Kcal/100g (SCF12), respectively.

In brown rice, bio-active components such as antioxidant activity, total phenolic and flavonoid content increased significantly ($P \leq 0.05$) from 40.61 (RG) to 60.11% (SCF36), 184.60 (RG) to 246.47 mgGAE/100g (SCF36), and 48.97 (RG) to 57.67 mgRE/100g (NF36), respectively.

The results obtained during the study reported the increase in antioxidant activity (48.02%), TPC (33.52%), and flavonoid (17.77%) content of treated grains. Trypsin inhibitor, tannin and phytic content decreased significantly ($P \leq 0.05$) from 0.86 (RG) to 0.45 mgTIA/100g (SCF36), 0.557 (RG) to 0.272% (NF36) and 1.30 (RG) to 0.74% (SCF36), respectively. Reduction in anti-nutritional components i.e. trypsin inhibitor activity (47.67%), tannin (51.17%) and phytic (43.08%) content after the fermentation for 36 h was observed.

Mineral content in brown rice increased significantly ($P \leq 0.05$) by 16.67% in Cu content after fermentation. The values increased from 0.96% (RG) to 1.12 mg/kg (NF36) after the fermentation treatments. Similarly, Fe content increased from 0.56 (RG) to 0.71 mg/kg (NF36), Zn content from 0.24 (RG) to 0.42 mg/kg (NF36), Mn content from 0.42 (RG) to 0.62 mg/kg (NF36), and Ca content from 5.17 (RG) to 5.54 mg/kg (NF36). There were 26.79, 75, 47.62, and 7.16% increase in Fe, Zn, Mn, and Ca content, respectively observed after the fermentation process.

Effect of Various Processing Methods on Nutritional and Anti-Nutritional Compositions

Table 4. Effect of fermentation at different time intervals on the nutritive value of Brown rice.

Parameter	Raw (0 h)	Natural Fermentation			Fermentation with <i>S. cerevisiae</i>		
		12 h	24h	36 h	12 h	24h	36 h
Moisture (%)	9.29 ±0.01 ^b	9.32 ±0.01 ^a	9.33 ±0.02 ^a	9.33 ±0.01 ^a	9.24 ±0.02 ^d	9.26 ±0.01 ^c	9.28 ±0.01 ^{bc}
Fat (%)	1.94 ±0.04 ^a	1.92 ±0.04 ^a	1.92 ±0.03 ^a	1.91 ±0.01 ^{ab}	1.92 ±0.01 ^a	1.89 ±0.01 ^{ab}	1.86 ±0.01 ^c
Fibre (%)	1.76 ±0.04 ^a	1.74 ±0.03 ^{ab}	1.73 ±0.01 ^{ab}	1.70 ±0.01 ^b	1.75 ±0.01 ^a	1.73 ±0.01 ^{ab}	1.70 ±0.02 ^b
Ash (%)	1.47 ±0.01 ^a	1.45 ±0.01 ^{bc}	1.44 ±0.01 ^{cd}	1.42 ±0.01 ^f	1.46 ±0.01 ^{ab}	1.44 ±0.01 ^{cd}	1.43 ±0.01 ^{de}
Protein (%)	7.54 ±0.01 ^f	7.66 ±0.01 ^e	7.70 ±0.01 ^d	8.13 ±0.02 ^c	8.30 ±0.02 ^b	8.33 ±0.01 ^a	8.34 ±0.02 ^a
Carbohydrate (%)	78.01 ±0.07 ^a	77.91 ±0.05 ^b	77.88 ±0.02 ^b	77.51 ±0.03 ^c	77.29 ±0.01 ^d	77.34 ±0.01 ^d	77.37 ±0.03 ^d
Calorific Value (Kcal/100g)	375.42 ±0.08 ^a	375.36 ±0.19 ^a	375.34 ±0.18 ^a	375.43 ±0.07 ^a	375.28 ±0.09 ^a	375.31 ±0.05 ^a	375.40 ±0.09 ^a
Anti-oxidant activity (%inhibition)	40.61 ±0.12 ^g	51.07 ±0.56 ^f	52.74 ±0.21 ^e	54.64 ±0.06 ^c	53.72 ±0.12 ^d	58.54 ±0.26 ^b	60.11 ±0.21 ^a
Total Phenolic content (mg GAE/100g)	184.60 ±0.87 ^f	187.60 ±0.22 ^e	189.60 ±0.22 ^d	190.15 ±0.05 ^d	198.39 ±0.56 ^c	232.52 ±1.54 ^b	246.47 ±1.09 ^a
Flavonoids (mgRE/100g)	48.97 ±0.64 ^e	53.28 ±0.81 ^c	55.39 ±0.39 ^b	58.43 ±0.39 ^a	51.42 ±0.25 ^d	53.95 ±0.25 ^c	57.67 ±1.48 ^a
Trypsin inhibitor (mgTIA/100g)	0.86 ±0.03 ^a	0.83 ±0.01 ^b	0.76 ±0.01 ^c	0.55 ±0.02 ^d	0.75 ±0.01 ^c	0.54 ±0.01 ^d	0.45 ±0.03 ^e
Tannin (%)	0.557 ±0.006 ^a	0.519 ±0.006 ^b	0.511 ±0.005 ^b	0.486 ±0.007 ^c	0.298 ±0.006 ^d	0.282 ±0.006 ^e	0.272 ±0.01 ^e
Phytic acid (%)	1.30 ±0.03 ^e	1.28 ±0.01 ^{ab}	1.27 ±0.01 ^{bc}	1.25 ±0.01 ^c	0.97 ±0.01 ^d	0.80 ±0.01 ^f	0.74 ±0.01 ^g
Cu (mg/kg)	0.96 ±0.02 ^e	1.05 ±0.03 ^c	1.09 ±0.01 ^b	1.12 ±0.01 ^a	0.98 ±0.01 ^e	1.01 ±0.01 ^d	1.05 ±0.03 ^c
Fe (mg/kg)	0.56 ±0.03 ^e	0.63 ±0.01 ^c	0.67 ±0.01 ^b	0.71 ±0.01 ^a	0.60 ±0.02 ^d	0.62 ±0.01 ^c	0.64 ±0.01 ^c
Zn (mg/kg)	0.24 ±0.01 ^f	0.27 ±0.02 ^e	0.34 ±0.03 ^b	0.42 ±0.02 ^a	0.29 ±0.09 ^{de}	0.30 ±0.01 ^{cd}	0.32 ±0.01 ^{bc}
Mn (mg/kg)	0.42 ±0.01 ^e	0.53 ±0.02 ^c	0.58 ±0.02 ^b	0.62 ±0.01 ^a	0.43 ±0.01 ^e	0.45 ±0.01 ^d	0.52 ±0.01 ^c
Ca (mg/kg)	5.17 ±0.06 ^d	5.24 ±0.01 ^c	5.39 ±0.02 ^b	5.54 ±0.05 ^a	5.40 ±0.01 ^b	5.44 ±0.01 ^b	5.45 ±0.01 ^b

Values in the table were presented as mean±SD; Values with in rows sharing the same letters were not significantly different according to Duncan's LSD post hoc analysis at $P \leq 0.05$

Effect of processing treatments

The effect of processing treatment (soaking and germination) on brown rice revealed that there was 8.25% reduction observed in fat content after germination processing treatment. During the germination of brown rice, Megat Rusydi *et al* (2011) also reported similar decreased trend in fat content With an increase in germination time, Hahm *et al* (2009) reported that crude fat content decreased because fatty acids are converted to water and carbon

dioxide through oxidation, which provides energy for germination. This was due to the fact that fat served as the primary carbon source for seed growth (Bau *et al*, 1997). The crude fiber and crude protein content significantly ($P \leq 0.05$) increased in present study during germination of brown rice by 17.05 and 11.94%. (Moongngarm and Saetung, 2010), reported 7.96% increment in crude fibre and 28.65% in crude protein content. According to Bau *et al* (1997), the increment in protein content was either caused by the process of enzymatic production of protein or a change

in composition brought out by the breakdown of other components. Nonogaki *et al* (2010) reported that during the germination treatment hormonal changes were considered responsible for increasing the protein content. The antioxidant activity, TPC, and flavonoid content increased significantly ($P \leq 0.05$) and there was a 77.62% increment observed in antioxidant activity, 58.08% increase in phenolic, and 32.24% increase in flavonoid content after 72 h of germination. Similar increasing trend after germination of grain was also reported by (Kaur *et al*, 2017). Similarly, Chauhan (2018) reported that the trypsin inhibitor activity decreased in germinated finger millet to the extent of 52.22%. According to (Kumar *et al*, 2019) the apparent decrease in trypsin inhibitor activity during germination might be due to the reason that trypsin inhibitors are used as a source of energy and undergo breakdown by pancreatic and peptic hydrolytic enzymes. Germination of the grain for 72h is the suitable way to enhance the mineral content and there was significant ($P \leq 0.05$) increases in Cu, Fe, Zn, Mn and Ca content by 14.58, 85.71, 70.84, 71.43, and 16.63%, respectively. (Chinma *et al*, 2015) also reported similar increase in Ca, Fe, and Zn by 8, 33.80, and 59.82%, respectively after the germination process.

The moisture and fat content of brown rice during fermentation process varied non-significantly ($P \leq 0.05$) and there was 4.12% reduction in fat content after fermentation treatment. The fiber content also gets decreased significantly ($P \leq 0.05$) during fermentation resulting in a 3.41% reduction when compared to the fiber content of raw grains. In brown rice, there was a significant ($P \leq 0.05$) increase in crude protein content, resulting in a 4.75% increase in protein content after 36 h of fermentation. Ilowefah *et al* (2015) also reported 7.75% decrease in fat content and 12.99% increase in crude protein content after fermentation of brown rice. This result was comparable with other studies that reported increase in protein content of cereals and legumes after natural fermentation for 4 days. The values for carbohydrate decreased significantly ($P \leq 0.05$) and calorific value increased significantly ($P \leq 0.05$).

In brown rice, bio-active components such as antioxidant activity, total phenolic and flavonoid content increased significantly ($P \leq 0.05$) during fermentation treatments. There was significant increase in antioxidant activity (31.59%), TPC (52.65%), and flavonoids (6.62%) content. Ilowefah *et al* (2015) reported 11.71% increment in TPC after fermentation treatment of rice. There was significant

reduction in anti-nutritional components i.e. trypsin inhibitor activity (47.67%), tannin (31.25%), and phytic (33.98%) content after the fermentation for 36 h. During the fermentation of brown rice, (Nnam and Obiakor, 2003) also reported similar decrease trends in anti-nutritional components after 48 h. Liang *et al* (2008) reported similar decreasing trend (48.8%) during fermentation of brown rice. Mineral content in brown rice grains, were increased significantly ($P \leq 0.05$) and there was an increase in Cu (45.50%), Fe (26.04%), Zn (31.93%), Mn (49.44%), and Ca (9%) after the fermentation process. (Nnam and Obiakor, 2003) reported increase in Ca (55.81%), Fe (12.77%), and Zn (33.99%) after the fermentation of brown rice. (Katina *et al*, 2005) reported that during fermentation, the pH of phytase enzyme was get declined which reduces the phytic acid complex and enhance the mineral content.

CONCLUSION

The study revealed that during processing treatments such as soaking, germination, and fermentation treatments, different physico-chemical parameters such as crude fiber, mineral content, antioxidant activity, TPC, and flavonoid content increased significantly ($P \leq 0.05$). The processing treatments resulted in a significant decreased ($P \leq 0.05$) in anti-nutritional components such as tannin and phytic components which are responsible for binding the micro-nutrients. Therefore, the use of different processing treatments helps to enhance the nutritional and bioactive components of brown rice. The flour obtained after milling of germinated and fermented brown rice can be utilized with other flour for the preparation of innovative bakery products. Thus, it can be stated that the application of different processing techniques in enhancing the utilization of brown rice by incorporating them and can be used for value addition of functional food products with high nutritional value, decreased anti-nutrients, and increased bioavailability of micro-nutrients.

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Effect of Various Processing Methods on Nutritional and Anti-Nutritional Compositions

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Efficacy of Growth Regulators on Sprouting of Bush Pepper Cuttings (*Piper nigrum* L.)

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ABSTRACT

Bush pepper propagation through cuttings often faces challenges in sprouting and growth, necessitating effective use of growth regulators to enhance establishment and productivity. Hence, the present study was carried out in Sirumalai, located in the Dindigul district of Tamil Nadu, over the period 2020-2022. The experimental setup followed a Completely Randomized Design (CRD), comprising 12 distinct treatments with three replications each. The findings indicated that treating with Indole-3-Butyric Acid (IBA) at 1000 ppm notably improved the shoot growth characteristics. Specifically, it reduced the time required for sprouting (18.89 days), increased the sprouting percentage (78.64%) and improved the leaf area (104.03 cm²) at 180 days after planting (DAP). Furthermore, it promoted shoot height (34.96 cm and 42.77 cm), increased the number of leaves (4.48 and 9.51) and enhanced leaf dimensions (length: 6.40 cm and 9.88 cm; width: 4.52 cm and 8.00 cm) at both 90 and 180 DAP. These results were statistically on par with the effects observed at a higher IBA concentration of 1250 ppm, whereas the untreated control exhibited the least favourable growth outcomes. In conclusion, this investigation identified IBA at 1000 ppm as the optimal treatment for promoting rooting, sprouting and overall growth performance in bush pepper cuttings.

Key Words: Bush Pepper, Growth, Regulators, Shoot, Sprouting, Leaves.

INTRODUCTION

Black pepper crop belongs to the family Piperaceae, with Vietnam, Indonesia, India and Brazil recognized as the leading producers (Anonymous, 2019). In recent years, the cultivation of bush pepper both in open fields and protected environments has gained traction, particularly in the Konkan region of Maharashtra, encompassing areas such as Sindhudurg, Ratnagiri, Thane, Palghar and Raigarh (Sharon *et al*, 2019). Bush pepper plants have an economic lifespan of approximately 12-15 years, with yields beginning in the second year of planting, producing about 1 kg of green berries per bush. By the fourth year and beyond, yields typically increases to 2-3 kg of green berries per bush. The variety Panniyur-2, utilized in this experiment, originates from the Pepper Research Station in Panniyur. It is an open-pollinated progeny of the Balankotta variety, known for its shade tolerance and suitability for all pepper-growing regions in Kerala. Panniyur-2 is highly productive, with alternate bearing characteristics, making it a valuable cultivar for cultivation.

Cultivating bush pepper has become an important approach to address the imbalance between the supply and demand of black pepper (Madhura *et al*, 2000). Moreover, the rising interest among urban dwellers in growing bush pepper in home gardens and terrace spaces has led to a surge in the need for quality planting materials (Ramya *et al*, 2017). This trend highlights the dual importance of bush pepper cultivation for commercial production and small-scale urban farming. The main objectives of the study were to evaluate the effectiveness of different concentrations of growth regulators, particularly Indole-3-Butyric Acid (IBA), on the sprouting and growth performance of bush pepper cuttings. The research aimed to identify the most suitable treatment for enhancing rooting, shoot development, and overall plant vigor under the agro-climatic conditions of Sirumalai, Tamil Nadu.

MATERIALS AND METHODS

The current study was conducted at Sirumalai in Dindigul district during the 2020-2022 cropping season, following a Completely Randomized Design (CRD) with 12 treatments and three replications.

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Healthy black pepper plants of the variety Panniyur-2, aged over six years, were selected as the source for cuttings. These mother plants, grown in the Sirumalai estate, provided plagiotropic shoots, which were used to prepare cuttings. The cuttings, measuring 20 cm in length and containing 3-4 nodes, were obtained from the middle portion of the shoots. Leaves were removed, leaving only the petioles attached. After collection, the cuttings were thoroughly washed with distilled water and allowed to air-dry in shade for 10 minutes before being subjected to growth regulator treatments. Solutions of plant growth regulators-Indole-3-Butyric Acid (IBA), α -Naphthalene Acetic Acid (NAA), and Indole-3-Acetic Acid (IAA)-were prepared following standardized procedures. For application, the lower 2 cm segment of each cutting, including the basal node, was immersed in the respective solution for 15 seconds. After treatment, the cuttings were transplanted into polybags containing a rooting substrate, ensuring the basal node was properly embedded in the medium. Control cuttings were planted directly without exposure to growth regulators. The experiment was conducted inside a mist chamber located in the field. Manual Misting equipment, fixed at a height of 2 meters, maintained a controlled environment with temperatures ranging from 35-38°C and humidity levels around 90%. The conditions were consistently maintained during the entire experimental period to promote rooting and shoot emergence in the cuttings.

RESULTS AND DISCUSSION

The influence of various growth regulators at different concentrations on the time required for the first sprout emergence, sprouting percentage, shoot length, number of leaves, leaf length, leaf width and leaf area in bush pepper cuttings is summarized in Table 1. The data highlight the significant effects of treatments on these growth parameters at 90 and 180 days after planting (DAP), as well as on the leaf area at 180 DAP.

Days taken for the first sprout

A significant variation was observed in the days taken for the first sprout to appear among cuttings treated with different growth regulators. The earliest sprouting was recorded in cuttings treated with T₄ (IBA @ 1000 ppm), which required 18.89 d, closely followed by T₅ (IBA @ 1250 ppm) with 19.67 days for sprouting. Conversely, the longest duration for sprouting was observed in the untreated control, with an average of 40.25 days. It might be due to promotion of faster cell division and callusing by auxin, which helps to start physiological activities in plant parts resulting in early

sprouting of cuttings. Similar results were reported by Akshay *et al* (2019) in black pepper and Bhagwat *et al* (2021) in betel vine.

The same treatments also significantly enhanced the sprouting percentage compared to the control, as detailed in Table 1. The highest sprouting percentage (78.64%) was achieved with T₄ (IBA @ 1000 ppm), which was statistically on par with T₅ (IBA @ 1250 ppm), showing a sprouting percentage of 76.50%. The control exhibited the lowest sprouting percentage (38.81%). This effect could be linked to auxin-induced cell division and the initiation of sprouting, along with the buildup of carbohydrates within the cuttings. Comparable observations have also been documented by Kumari *et al* (2019) in *Rauvolfia serpentina* and *Gymnema sylvestre*, Pawar *et al* (2020) in bush pepper and Bhagwat *et al* (2021) in betel vine.

Shoot length

Significant variations in shoot length were observed across treatments at both 90 and 180 DAP. The highest shoot length was recorded in T₄ (IBA @ 1000 ppm), with values of 34.96 cm and 42.77 cm, respectively. This was statistically at par with T₅ (IBA @ 1250 ppm), which recorded 34.48 cm and 41.95 cm. The control treatment resulted in the shortest shoot lengths, measuring 25.59 cm and 30.12 cm at 90 and 180 DAP, respectively. The increase in shoot length by application of IBA might be due to increase in cell division and cell elongation caused by actions of auxins which helped in better utilization and uptake of water and nutrients resulted in higher shoot length.

Number of leaves per cutting

The data show significant differences in the number of leaves per cutting at both time points. The maximum number of leaves (4.48 and 9.51) was observed in cuttings treated with T₄ (IBA @ 1000 ppm), followed closely by T₅ (IBA @ 1250 ppm), with 4.39 and 9.30 leaves per cutting, respectively. The control treatment yielded the fewest leaves, with 2.06 and 4.12 leaves at 90 and 180 DAP. Leaf length was significantly influenced by the treatments. The longest leaves were observed in T₄ (IBA @ 1000 ppm), measuring 6.40 cm and 9.88 cm at 90 and 180 DAP, respectively, which was statistically on par with T₅ (IBA @ 1250 ppm), recording 6.1 cm and 9.4 cm. The shortest leaves were found in the control treatment, with lengths of 1.34 cm and 3.06 cm.

Efficacy of Growth Regulators on Sprouting of Bush Pepper Cuttings

Table 1: Efficacy of growth regulators on sprouting of bush pepper cuttings.

Treatment	Days taken for sprouting	Sprouting (%)	Shoot height (cm)		Number of leaves per cutting		Leaf length		Leaf width		Leaf area (cm ²)
			90 days	180 days	90 days	180 days	90 days	180 days	90 days	180 days	
T ₁ - Control	40.25	38.81	25.59	30.12	2.06	4.12	1.34	3.06	1.22	2.28	64.89
T ₂ - IBA @ 500ppm	27.79	60.53	29.61	37.02	3.38	7.06	4.1	6.78	3.02	5.4	86.13
T ₃ - IBA @ 750ppm	24.23	67.77	30.95	39.32	3.82	8.04	5.02	8.02	3.62	6.44	93.21
T ₄ - IBA @ 1000ppm	18.89	78.64	34.96	42.77	4.48	9.51	6.40	9.88	4.52	8.00	104.03
T ₅ - IBA @ 1250ppm	19.67	76.52	34.48	41.95	4.39	9.3	6.10	9.46	4.31	7.58	101.29
T ₆ - NAA @ 250 ppm	33.13	49.67	27.6	33.57	2.72	5.67	2.72	4.92	2.12	3.84	75.51
T ₇ - NAA @ 500 ppm	29.57	56.91	28.9	35.87	3.16	6.57	3.64	6.16	2.71	4.88	82.59
T ₈ - NAA @ 750 ppm	22.45	71.39	31.62	40.47	4.04	8.53	5.48	8.64	3.91	6.96	97.41
T ₉ - NAA @ 1000ppm	26.01	64.15	30.28	38.17	3.60	7.55	4.56	7.40	3.32	5.92	89.66
T ₁₀ - IAA @ 100ppm	38.47	42.43	26.26	31.27	2.28	4.69	1.80	3.68	1.52	2.80	68.43
T ₁₁ - IAA @ 200ppm	34.91	46.05	26.93	32.42	2.50	5.10	2.26	4.3	1.82	3.32	71.97
T ₁₂ - IAA @ 300ppm	31.35	53.29	28.27	34.72	2.94	6.08	3.18	5.54	2.44	4.36	79.05
S. Ed.	0.75	1.52	0.25	0.52	0.08	0.19	0.19	0.26	0.12	0.21	1.42
C.D (P=0.05)	1.5	3.05	0.51	1.04	0.16	0.38	0.38	0.52	0.25	0.43	2.85

Leaf width

Leaf width also showed significant variation among treatments. T₄ (IBA @ 1000 ppm) recorded the widest leaves, with widths of 4.52 cm and 8.00 cm at 90 and 180 DAP, respectively. This was statistically at par with T₅ (IBA @ 1250 ppm), which recorded 4.31 cm and 7.58 cm. The control treatment produced the narrowest leaves, measuring 1.22 cm and 2.28 cm at 90 and 180 DAP. At 180 d after planting (DAP), the treatments had a marked influence on the leaf area of bush pepper cuttings. The maximum leaf area (104.03 cm²) was observed in cuttings treated with T₄ (IBA @ 1000 ppm), which was statistically comparable to T₅ (IBA @ 1250 ppm) with a leaf area of 101.29 cm². In contrast, the control group recorded the lowest leaf area (64.89 cm²), which was significantly lower than all other treatments.

This response might be attributed to the role of auxin in enhancing cell wall plasticity, which increases the permeability of cells to water and nutrients, thereby promoting cell enlargement, callus formation, and overall growth of plant parts. The application of auxin may also stimulate photosynthetic activity and other physiological functions in the leaves, potentially contributing to the rise in leaf number in the treated cuttings. The increase in leaves per cutting could further be explained by the preferential allocation of assimilates to leaf buds, as leaves not only serve as major sites for photosynthesis and respiration but also produce endogenous auxins essential for plant development (Damer *et al*, 2014). Similar findings were reported by Rema and Krishnamoorthy (1993) in Cinnamon, Bharti *et al* (2016) in Sarpagandha and Diwakar *et al* (2011) in Guggul.

CONCLUSION

The study conclusively highlighted the efficacy of Indole-3-Butyric Acid (IBA) in enhancing the rooting and growth performance of bush pepper cuttings. The results clearly demonstrated that IBA at a concentration of 1000 ppm was the most effective treatment for promoting sprouting, shoot development and overall plant growth. This treatment significantly reduced the time to sprouting, achieved the highest sprouting percentage and improved critical growth parameters such as shoot height, number of leaves and leaf dimensions at 90 and 180 d after planting. The findings provide a practical recommendation for nursery and field-level propagation of bush pepper, suggesting that the application of IBA at 1000 ppm offers a cost-effective and efficient method to enhance the productivity and quality of propagation materials for this economically important crop. These results also indicate the potential of IBA in standardizing propagation protocols for large-scale commercial cultivation.

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Efficacy of Integrated Nutrient Management on Rhizome Productivity in Mango Ginger (*Curcuma amada* Roxb.)

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ABSTRACT

An experiment on the effect of integrated nutrient management on the rhizome productivity of mango ginger (*Curcuma amada* Roxb.) was conducted at a farmer's field in Vadapalani village, Erode district during 2022-2023. The research investigated how integrated nutrient management (INM) influences the growth performance of rhizomes in mango ginger (*Curcuma amada* Roxb.). A total of 11 treatments used in this experiments were as T₁ - 75% RDF + Vermicompost @ 5 t/ha+ Panchagavya @ 3%, T₂ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Panchagavya @ 3%, T₃ - 75% RDF + Vermicompost @ 5 t/ ha+ Vermiwash @ 10%, T₄ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Vermiwash @ 10%, T₅ - 75% RDF + Vermicompost @ 5 t/ ha+ Humic acid @ 0.2%, T₆ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Humic acid @ 0.2%, T₇ - 75% RDF + Vermicompost @ 5 t/ ha+ Amrit Pani @ 3 %, T₈ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Amrit Pani @ 3 %, T₉ - 75% RDF + Vermicompost @ 5 t/ ha + Chitosan @ 0.1 %, T₁₀ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Chitosan @ 0.1 % and T₁₁ - Control. The results demonstrated significant improvements across various growth parameters in treatments integrating organic and inorganic nutrient sources. Treatment T₉, comprising 75% RDF, Vermicompost @ 5 t ha⁻¹ and chitosan @ 0.1%, emerged as the most effective. It achieved the shortest sprouting duration (12.09 d), tallest plant height (124.39 cm), maximum tiller count (6.23 tillers/plant), the highest leaf count (21.85 leaves/plant), longest leaf length (73.27 cm) and the greatest leaf breadth (32.72 cm) and maximum pseudostem girth (11.26 cm). Additionally, T₉ recorded the highest curcumin content (2.48%). These outcomes highlighted the synergistic benefits of combining organic and inorganic nutrient sources in promoting superior plant growth and rhizome quality.

Keywords: Mango ginger, Vermicompost, Chitosan, Curcumin and INM

INTRODUCTION

Mango ginger (*Curcuma amada* Roxb.) is a distinctive rhizomatous spice belonging to the family Zingiberaceae. Although it bears a close visual resemblance to common ginger, its flavor is strikingly similar to that of raw mango. Morphologically akin to turmeric (*Curcuma longa* L.), mango ginger is considered to have originated in the Indo-Malayan region and is now cultivated widely across tropical areas (Sasikumar, 2005). The plant typically reaches a height of about 1 meter and is characterized by oblong to lanceolate leaves. Its rhizomes are fleshy, buff-colored, and exhibit a sympodial branching pattern, noted for their sharp, tangy mango-like aroma and pungency. Despite its rich composition of bioactive constituents, mango ginger remains an underutilized medicinal spice. The rhizomes are widely incorporated in Indian and Southeast Asian culinary traditions,

contributing a zesty, citrus-like flavor to pickles and various dishes. Traditionally, the plant has been used to support digestion, alleviate inflammation, and manage respiratory conditions. Its therapeutic applications are well recognized in Ayurvedic and Unani medicine systems, where it functions as a laxative, diuretic, and a remedy for several ailments (Policegoudra *et al*, 2010). Scientific studies have highlighted its anti-inflammatory, antibacterial, antifungal, and antioxidant properties (Chandarana *et al*, 2005), enhancing its value in both food and health sectors. In the context of sustainable agriculture, Integrated Nutrient Management (INM) which combines organic manures with chemical fertilizers has been advocated to improve crop productivity and maintain soil health. This balanced nutrient approach enhances soil structure, water retention, and fertility while reducing ecological damage. Moreover, INM practices are instrumental in promoting better growth and

Table 1. Impact of Integrated Nutrient Management on rhizome productivity of Mango Ginger (*Curcuma amada* Roxb.).

Treatment	Days taken for sprouting	Plant height (cm)	Number of tillers plant ⁻¹	Number of leaves plant ⁻¹	leaf length (cm)	leaf breadth (cm)	Pseudostem girth (cm)	Curcumin content (%)
T ₁ - 75% RDF + Vermicompost @ 5 t ha ⁻¹ + Panchagavya @ 3%	14.49	116.79	4.69	19.19	66.24	29.92	9.41	2.19
T ₂ - 75% RDF + Groundnut cake @ (200 kg ha ⁻¹) + Panchagavya @ 3%	20.27	98.72	2.72	12.48	54.17	22.88	6.89	1.6
T ₃ - 75% RDF + Vermicompost @ 5 t ha ⁻¹ + Vermiwash @ 10%	15.65	113.16	4.26	17.82	63.06	28.52	8.56	2.06
T ₄ - 75% RDF + Groundnut cake @ (200 kg ha ⁻¹) + Vermiwash @10%	21.39	95.13	2.33	11.17	52.27	21.43	6.66	1.46
T ₅ - 75% RDF + Vermicompost @ 5 t ha ⁻¹ + Humic acid @ 0.2%	13.30	120.41	5.11	20.54	69.75	31.33	10.31	2.33
T ₆ - 75% RDF + Groundnut cake @ (200 kg ha ⁻¹) + Humic acid @ 0.2%	19.17	102.33	3.11	13.78	56.30	24.30	7.31	1.73
T ₇ - 75% RDF + Vermicompost @ 5 t ha ⁻¹ + Amrit Pani @ 3 %	18.03	105.93	3.52	15.09	58.48	25.71	7.81	1.84
T ₈ - 75% RDF + Groundnut cake @ (200 kg ha ⁻¹) + Amrit Pani @ 3 %	22.44	91.53	1.98	9.83	50.32	19.96	6.46	1.35
T ₉ - 75% RDF + Vermicompost @ 5 t ha ⁻¹ + Chitosan @ 0.1 %	12.09	124.39	6.23	21.85	73.27	32.72	11.26	2.48
T ₁₀ - 75% RDF + Groundnut cake @ (200 kg ha ⁻¹) + Chitosan @ 0.1 %	16.83	109.52	3.88	16.42	60.63	27.10	8.16	1.94
T ₁₁ - Control	23.61	87.92	1.68	8.53	48.52	18.49	6.16	1.21
S.Ed	0.54	1.69	0.50	0.62	1.67	0.72	0.43	0.07
CD (p=0.05)	1.14	3.56	1.07	1.29	3.51	1.38	0.91	0.12

optimizing curcumin levels in *C. amada* by sustaining a stable nutrient environment within the soil.

MATERIALS AND METHODS

The present investigation was conducted at Vadapalani village in Erode district from July 2022 to January 2023. The experimental design followed a Randomized Block Design (RBD) comprising eleven treatments with three replications. A total of 11 treatments used in this experiments were as T₁ - 75% RDF + Vermicompost @ 5 t/ha+ Panchagavya @ 3%, T₂ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Panchagavya @ 3%, T₃ - 75% RDF + Vermicompost @ 5 t/ha+ Vermiwash @ 10%, T₄ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Vermiwash @10%, T₅ - 75% RDF

+ Vermicompost @ 5 t/ ha+ Humic acid @ 0.2%, T₆ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Humic acid @ 0.2%, T₇ - 75% RDF + Vermicompost @ 5 t/ ha+ Amrit Pani @ 3 %, T₈ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Amrit Pani @ 3 %, T₉ - 75% RDF + Vermicompost @ 5 t/ ha + Chitosan @ 0.1 %, T₁₀ - 75% RDF + Groundnut cake @ (200 kg/ ha) + Chitosan @ 0.1 % and T₁₁ - Control. In each replication, five plants were randomly chosen, tagged and labeled for recording various growth parameters. The average values of these five plants were used for analysis. The collected data were subjected to statistical analysis using the standard method outlined by Panse and Sukhatme (1985) using WASP 2.0. Critical differences (CD) were calculated at a 5% level of significance.

Efficacy of Integrated Nutrient Management on Rhizome Productivity in Mango Ginger

RESULTS AND DISCUSSION

The data (Table 1) indicated significant variations among treatments regarding parameters such as sprouting duration, plant height, leaf count, tiller count, leaf length, leaf breadth, pseudostem girth and curcumin content. The shortest sprouting duration was observed in T₉ (75% RDF + Vermicompost @ 5 t/ha + Chitosan @ 0.1%), taking 12.09 d, followed by T₅ (75% RDF + Vermicompost @ 5 t/ha + Humic Acid @ 0.2%) at 13.30 d. Conversely, the longest sprouting duration was recorded for T₁₁ (Control - 100% RDF) at 23.61 d.

Plant height also varied significantly across the treatments. The maximum plant height (124.39 cm) was observed in T₉, followed by T₅ (120.41 cm), while the minimum was recorded in T₁₁ (87.92 cm). These findings aligned with prior studies by Anburani and Manivannan (2002), who reported that combining inorganic and organic NPK sources improves turmeric (*Curcuma longa*) plant height. Mahanthesh *et al* (2009) also demonstrated that integrated nutrient management (INM) enhances growth parameters in turmeric. The application of chitosan likely contributed to increased nitrogen metabolism, as reported by Thengumpally (2019) in Kasturi turmeric, where chitosan-treated plants exhibited superior growth.

According to Theunissen *et al* (2010), nitrogen supports photosynthesis, cell division, growth and protein synthesis, processes augmented by the addition of Vermicompost alongside inorganic fertilizers. Kadam and Kamble (2020) further emphasized that nutrient availability promotes luxuriant plant growth, facilitated by Vermicompost growth-promoting substances, enhanced microbial activity and reduced nitrogen leaching. Similarly, the number of tillers per plant showed significant differences, with T₉ exhibiting the highest value (6.23), followed by T₅ (5.11) and T₁₁ the lowest (1.68). Treatment T₉ exhibited superior performance across all measured leaf growth parameters, recording the highest leaf count per plant (21.85), the longest leaf length (73.27 cm) and the greatest leaf breadth (32.72 cm). Treatment T₅ followed with corresponding values of 20.54 leaves per plant, 69.75 cm leaf length and 31.33 cm leaf breadth, whereas T₁₁ consistently displayed the lowest values, with 8.53 leaves per plant, a leaf length of 48.52 cm and a leaf breadth of 18.49 cm. The enhanced leaf growth observed in T₉ can be

attributed to improved nutrient availability, particularly nitrogen and potassium, which play vital roles in cellular elongation and expansion processes.

The synergistic effect of integrating organic and inorganic fertilizers, augmented by chitosan application, likely facilitated optimized nutrient absorption and utilization, thereby promoting superior leaf development and overall plant vigor (Prabhu *et al*, 2010).

The pseudostem girth was significantly influenced by the nutrient management treatments, with T₉ exhibiting the maximum pseudostem girth (11.26 cm), followed by T₅ (10.31 cm), while T₁₁ recorded the smallest girth (6.16 cm). These growth improvements can be attributed to enhanced enzymatic activity, such as chitinase and protease production, resulting from Vermicompost and other organic amendments. Such amendments improve soil microflora and nutrient availability (Kumar *et al*, 2018). Gradual nutrient release from organic sources, such as manures and biofertilizers, enriches soil humus content and fosters beneficial microbial activity, as reported by Amala *et al* (2019) and Lohar and Hase (2021). Consistent with Nagarjuna *et al* (2021), integrated application of organic and inorganic nutrients enhances turmeric growth. Furthermore, chitosan treatments improve nitrogen and potassium uptake while moderating calcium absorption, thus optimizing nutrient utilization and promoting plant growth.

Regarding curcumin content, the results in Table 1 revealed significant treatment effects. The highest curcumin content (2.48%) was recorded in T₉, followed by T₅ (2.33%), with the lowest in T₁₁ (1.21%). According to Namdeo (2007), chitosan enhances secondary metabolite production by activating plant defense-related genes, as supported by Gorelick and Bernstein (2014).

CONCLUSION

The study highlighted the effectiveness of integrated nutrient management (INM) in enhancing mango ginger (*Curcuma amada* Roxb.) growth and productivity. Treatment T₉ (75% RDF, Vermicompost @ 5 t/ha and chitosan @ 0.1%) consistently outperformed others, demonstrating superior growth parameters and curcumin content. The results affirm the synergistic benefits of combining organic and inorganic nutrients with biostimulants for sustainable and high-quality mango ginger production.

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Efficacy of Pest Management Modules against Aphids and Pod Borer Complex of Indian bean

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ABSTRACT

The field experiment was carried out at KRCCH (Kittur Rani Channamma College of Horticulture) Arabhavi, Karnataka during Rabi season of 2021 and 2022 to investigate the comparative biological effectiveness of different modules against aphids and pod borer complex in Indian bean (*Lablab purpureus* L.). Among all the modules chemi intensive module (Thiamethoxam 25 WG @ 0.2g/l – Fipronil 5 SC @ 1ml/l – Spinosad 45 SC @ 0.3ml/l – Emamectin benzoate 5 SG @ 0.2 g/l) was most efficient in reducing aphid population after 10 days of second spray (0.45 aphids/plant) and it was followed by IPM module (Neem cake (1q/acre) - Azadirachtin 1500 ppm @ 4 ml/l – Difenthiuron 50 WP @ 0.5 g/l - Spinosad 45 SC @ 0.3ml/l with maize and coriander grown at the border of main crop) which recorded 4.64 (aphids/plant). Chemical intensive module was also effective in reducing pod borer infestation by recording lowest mean percent pod damage of 7.11 and was followed by IPM module which recorded 9.92 percent pod damage. The highest yield, 14.37 (t /ha) was recorded from chemi-intensive module and IPM was next best module (13.40 t /ha). Additionally, highest B:C ratio (4.01) was found in chemi intensive module followed by IPM module (3.67). IPM module was found to be safe for predators (spiders and coccinellids) by recording highest number of natural enemies (3.29/plant and 3.47/plant, respectively) after two weeks of first day and fourth spray.

Keywords: Aphid, Pod borer, Thiamethoxam 25 WG, Azadirachtin, Indian bean.

INTRODUCTION

The Indian bean (*Lablab purpureus* L.) is an important pulse and vegetable crop in India and grown for its tender pods, seeds and also for fodder. The crop is cultivated in dry tropical parts of Asia, In India, Andhra Pradesh, Karnataka, Kerala Tamil Nadu and Assam are known for cultivating Indian bean (Anonymous, 2008). This crop is mainly affected by about 30 species of insects, among these pod borers *Helicoverpa armigera* Hubner, *Maruca testulalis*, *Adisura atkinsoni* (Moore) *Exelastis atomosa* are the most destructive, often leading to yield loss of up to 80-100 per cent (Sachan and Katti, 1994). Among sucking insect pests, *Bemisia tabaci* Gennadius, *Empoasca kerri* and *Aphis craccivora*, are causing considerable damage to leaves, buds, flowers and pods of Indian beans. Among them, *A. craccivora* causes a 25 to 80 per cent reduction in yield by sucking the sap from the ventral surface of tender leaves, growing shoots, flower stalks and pods. The chemical control of sucking pest and pod borer complex have been recommended by many workers on different beans to suppress their

population effectively (Yadav *et al*, 2011). Since the pods are directly consumed as vegetables, the pest management especially the pod borer control has to be on organic basis, hence to reduce the pesticide load on crop the present research was undertaken to evaluate different pest controlling different modules like bio-intensive module, chemi-intensive module, integrated modules against pest of Indian bean.

MATERIALS AND METHODS

The present experiment on evaluation of different pest management modules against pest complex of Indian bean (*Lablab purpureus* L) was conducted during Rabi season of 2021 and 2022 at KRCCH, Arabhavi, Karnataka in medium black soil under irrigated conditions.

The experiment was laid out in simple randomized block design (RBD) with five modules and replicated four times each (Table 1). The each experiment module size was 5 x 20 m² with row to row and plant to plant distance of 60 and 30 cm, respectively. The bush type hybrid ASPL0063 was

Table 1: Treatment details followed.

Module	Treatment
M ₁	Neem cake (2.50q/ha) – <i>Lecanicillium lecani</i> @ 5g/l - <i>Nomuraea rileyi</i> @5g/l (2 sprays each at 10 days interval) (Module 1)
M ₂	Thiamethoxam 25 WG @ 0.2g/l – Fipronil 5 SC @ 1ml/l – Spinosad 45 SC@ 0.3ml/l – Emamectin benzoate 5 SG @ 0.2 g/l (Module 2)
M ₃	Neem cake (2.50q/ha) - Azadirachtin 1500 ppm @ 4 ml/l – Difenthiuron 50 WP @ 0.5 g/l - Spinosad 45 SC@ 0.3ml/l with maize and coriander as a border crop (Module 3)
M ₄	RPP (Dimethoate 30EC @ 1.70 ml/l – Quinalphos 25 EC@2ml/l) (Module 4)
M ₅	Untreated control (Module 5)

used for the experiment and was sown during October (*Rabi* season) 2021 and 2022. The Indian bean was grown using the specified agronomical practices. According to treatments, in module-1 and module-3, Neem cake (2.50q/ha) was applied to the soil at the time of sowing. After 15 days of sowing, in all modules biopesticides and insecticides were applied in sequence keeping 10 days interval by using knapsack sprayer. An untreated control block was also maintained for comparison.

Observations on aphids were recorded by counting aphid's nymphs and adults from five randomly selected and labeled plants of each module. Aphids were observed from three leaves top, middle and bottom and expressed as number per plant. Pods infestation was noted by counting the healthy and infested pods at each harvest. The pod borer infestation(%) was calculated.

Statistical analysis

The aphid population and pod damage data were transformed using the square root and arc sine transformation, respectively and subjected for statistical analysis by using ANOVA. The means were tested for significance using LSD at 5% level for interpretation using standard statistical techniques (Steel and Torrie, 1980).

Pod Yield and Economics.

Pod yield at each picking was recorded, cumulated to get total yield after completion of all pickings and later computed on a hectare basis. Before statistical analysis, cumulative pod yield data of each module was subjected to suitable statistical transformations. The total cost of cultivation was computed by adding common input cost of cultivation such as treatment costs and labour charges. The gross return per treatment was computed by multiplying the

total yield per hectare by the current market price. While net returns for each module treatments were calculated by deducting the total cost spent towards treatments application from gross returns. Each treatment's benefit-cost (B:C) ratio was calculated by dividing gross returns from treatments total cost (Shabozoi *et al*, 2011).

RESULTS AND DISCUSSION

The aphid infestation at different time intervals after the initial spray is depicted in table 2. A day before first spray, the aphids per plant were in the range of 34.30 to 90.50. Significant aphid population data difference was not observed among the different treatments. However, after five days of the first spray found more effective with respect to aphid's population. Among all the modules evaluated the treatment M-2, chemi intensive module (Thiamethoxam 25 WG @ 0.2g/l – Fipronil 5 SC @ 1ml/l – Spinosad 45 SC@ 0.3ml/l – Emamectin benzoate 5 SG @ 0.2 g/l) was effective in reducing aphid population after 5 days of first spray (16.47 aphids/plant) and it was followed by IPM module (Neem cake (1q/acre) - Azadirachtin 1500 ppm @ 4 ml/l – Difenthiuron 50 WP @ 0.5 g/l - Spinosad 45 SC@ 0.3ml/l with maize and coriander as border crop) which recorded the 22.13 aphids per plant. Thereafter, the aphids count decreased after ten days of first spray and minimum aphid population was recorded in M-II (7.15 aphids/plant) followed by M-1 module (11.08 aphids/plant).

Five days after application of treatments at second time also M-2, chemi intensive module was efficient in reducing aphid population (0.68 aphids/plant) and next good module was M-3, which recorded 5.34 aphids per plant. After 10 days of second spray same trend was noticed in reducing aphid number, by recording lowest population (0.45

Efficacy of Pest Management Modules against Aphids and Pod Borer Complex of Indian bean

Table 2: Efficacy of different modules against aphids infestation in Indian bean.

Module	Treatment	No. of aphids/plant				
		I Spray			II Spray	
		DBS	5 DAS	10 DAS	5 DAS	10 DAS
M ₁	Neem cake (2.50q/ha) – <i>Lecanicillium lecani</i> @ 5g/l - <i>Nomuraea rileyi</i> @5g/l (2 sprays each at 10 days interval) (Module 1)	34.30 (5.14)	16.97 (3.69)	11.08 (3.04)	8.91 (2.77)	6.27
M ₂	Thiamethoxam 25 WG @ 0.2g/l – Fipronil 5 SC @ 1ml/l – Spinosad 45 SC@ 0.3ml/l – Emaxectin benzoate 5 SG @ 0.2 g/l (Module 2)	90.50 (8.28)	16.47 (3.59)	7.15 (2.52)	0.68 (1.22)	0.45
M ₃	Neem cake (2.50q/ha) - Azadirachtin 1500 ppm @ 4 ml/l – Difenthiuron 50 WP @ 0.5 g/l - Spinosad 45 SC@ 0.3ml/l with maize and coriander as a border crop (Module 3)	34.90 (5.16)	22.13 (4.17)	19.42 (3.93)	5.34 (2.22)	4.64
M ₄	RPP (Dimethoate 30EC @ 1.70 ml/l – Quinalphos 25 EC@2ml/l) (Module 4)	85.67 (8.04)	39.21 (5.47)	33.43 (5.09)	18.67 (3.87)	21.84
M ₅	Untreated control (Module 5)	83.17 (7.94)	103.85 (8.78)	134.68 (10.07)	110.72 (9.10)	86.97
CD @ 5%		1.1	1.3	0.6	0.9	0.7
SEm ±		0.3	0.4	0.2	0.3	0.2

Note- DBS- Day Before Spray; DAS- Days After Spray and Figures in the parenthesis are square root transformed values

Table 3: Effectiveness of modules against pod borer complex in Indian bean.

Module No	Treatment	Percent pod damage (Picking wise)					
		I	II	III	IV	Mean	ROC (%)
M ₁	Neem cake (2.50q/ha) – <i>Lecanicillium lecani</i> @ 5g/l - <i>Nomuraea rileyi</i> @5g/l (2 sprays each at 10 days interval) (Module 1)	20.64 (26.98)	20.44 (26.82)	16.83 (24.19)	12.14 (20.29)	17.51	50.80
M ₂	Thiamethoxam 25 WG @ 0.2g/l – Fipronil 5 SC @ 1ml/l – Spinosad 45 SC@ 0.3ml/l – Emaxectin benzoate 5 SG @ 0.2 g/l (Module 2)	9.49 (17.89)	10.37 (18.63)	5.80 (13.88)	2.78 (9.57)	7.11	80.02
M ₃	Neem cake (2.50q/ha) - Azadirachtin 1500 ppm @ 4 ml/l – Difenthiuron 50 WP @ 0.5 g/l - Spinosad 45 SC@ 0.3ml/l with maize and coriander as a border crop (Module 3)	12.07 (20.27)	13.29 (21.35)	8.12 (16.54)	6.20 (14.14)	9.92	72.13
M ₄	RPP (Dimethoate 30EC @ 1.70 ml/l – Quinalphos 25 EC@2ml/l) (Module 4)	18.28 (25.29)	19.55 (26.21)	11.78 (20.04)	9.35 (17.76)	14.74	58.59
M ₅	Untreated control (Module 5)	30.37 (33.40)	34.94 (36.17)	39.19 (38.70)	37.88 (37.97)	35.59	--
CD @ 5%		2.6	3.4	2.6	2.7	-	-
SEm ±		0.8	1.4	0.8	0.9	-	-

Note- Figures in the parenthesis are arc-sine transformed values
ROC : Reduction over control

aphids/plant) in M-2 module and was followed by M3 module which recorded the 4.64 aphids per plant. Yadav *et al* (2011) also revealed that dimethoate,

imidacloprid and thiamethoxam treatments were the most effective in decreasing the sucking insect pests of cluster bean.

Table 4: Impact of different modules on natural enemies and pod yield in Indian bean.

Module No	Treatments	No. of predators/plant*				Yield (t/ha)	IOC (%)	B :C
		Pre count	15 DAS (II Spray)	15 DAS (IV Spray)	Mean			
M1	Neem cake (2.50q/ha) – <i>Lecanicillium lecani</i> @ 5g/l - <i>Nomuraea rileyi</i> @5g/l (2 sprays each at 10 days interval) (Module 1)	1.05 (1.33)	2.76 (1.74)	3.80 (1.94)	3.28	13.10	31.67	3.57
M ₂	Thiamethoxam 25 WG @ 0.2g/l – Fipronil 5 SC @ 1ml/l – Spinosad 45 SC@ 0.3ml/l – Emamectin benzoate 5 SG @ 0.2 g/l (Module 2)	1.99 (1.56)	0.13 (1.05)	0.45 (1.14)	0.29	14.37	44.45	4.01
M ₃	Neem cake (2.50q/ha) - Azadirachtin 1500 ppm @ 4 ml/l – Difenthiuron 50 WP @ 0.5 g/l - Spinosad 45 SC@ 0.3ml/l with maize and coriander as a border crop (Module 3)	1.08 (1.33)	3.29 (1.85)	3.47 (1.90)	3.38	13.40	34.70	3.67
M ₄	RPP (Dimethoate 30EC @ 1.70 ml/l –Quinalphos 25 EC@2ml/l) (Module 4)	2.17 (1.60)	0.38 (1.13)	0.65 (1.20)	0.56	13.15	32.12	3.59
M ₅	Untreated control (Module 5)	1.53 (1.45)	3.14 (1.81)	5.37 (2.22)	4.26	9.95	--	2.47
CD @ 5%		NS	0.3	0.4	-	1.2	-	-
SEm ±		0.1	0.1	0.1	-	0.4	-	-

Note- DBS- Day before Spray; DAS- Days after spray and Figures in the parenthesis are SQRT transformed values

*Spiders and coccinellids.

IOC: Increase over control: B: C: Benefit:cost ratio

The pooled data of per cent pod damage given in table 3, Chemical module (M-2) was very efficient, which recorded lowest per cent of pod damage (7.11) by reducing 80.02 per cent pod damage over control followed by M-III which recorded 9.92 per cent of pod damage and highest 35.59 per cent of pod damage was observed in Module 5, untreated control.

The highest pod yield of 14.37(t/ha) was obtained from chemi-intensive module and IPM was next best module (13.40 t/ha). There was 44.45 per cent rise in yield compared control (M-5) was noticed in M-2 module. The next group in order of efficacy consist of M-4 (Dimethoate 30EC @ 1.70 ml/l –Quinalphos 25 EC@2ml/l), M-1 (Neem cake (2.5q/ha) – *Lecanicillium lecani* @ 5g/l - *Nomuraea rileyi* @5g/l) and M-5 (untreated control). The maximum returns per rupee of expenditure (cost: benefit ratio) of 4.01 was obtained from chemi-intensive module and was followed by IPM module (3.67) compare to rest of the modules (Table 4). Singh and Singh (2017) concluded

that Spinosad 60g a.i./ha followed by Emamectin benzoate 8g a.i./ha were the best treatments in minimizing *Maruca vitrata* larval population infesting greengram. Byrappa *et al* (2014) reported that among biopesticides, sequential application of NSKE-HaNPV-Bt was effective against insect pests. HaNPV was also efficient against *Helicoverpa armigera* (Hubner) larvae. IPM module (M-3) was found be safe for predators (spiders and coccinellids) by recording highest number of predators (natural enemies) after 15 days of first day and fourth spray (3.29/plant and 3.47/plant respectively).

CONCLUSION

The results of the present study clearly revealed that chemi-intensive module proved superior in managing sucking pest and pod borer complex in Indian bean and next best module was integrated pest management approach module which serves as a alternative to chemicals in managing sucking pest and pod borer complex in Indian beans.

Efficacy of Pest Management Modules against Aphids and Pod Borer Complex of Indian bean

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Endophytic Potential of Indigenous *Beauveria bassiana* against *Spodoptera litura* Fabricius in Cabbage

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ABSTRACT

The need of today's world is enhanced production and quality of the crops in an eco-friendly manner. In the absence of complete host plant resistance in crops against insect pests, biological control forms a more sustainable and integral part of management ecosystem. Microbial biological control agents, especially entomopathogenic fungi (EPF), offer eco-friendly pest management solutions. Unlike other pathogens, EPF can infect pests upon contact with their propagules. However, environmental factors like temperature, UV light and pollutants often reduce the effectiveness of epiphytic EPF in the field. Endophytic EPF, residing within plant tissues, are gaining popularity for their resilience under adverse conditions. Hence, the research was conducted to observe the endophytic effect of native *Beauveria bassiana* UHSB-END1 against *Spodoptera litura* in cabbage. The bioassay investigations pertaining to both *in-vivo* and *in-planta* revealed that *S. litura* mortality peaked at 30 days after inoculation. Furthermore, larvae that consumed cabbage leaves colonized by fungi showed disrupted growth and abnormal developmental patterns, indicating a negative impact on their physiological development. By introducing this native biological product to control insect pests in cabbage habitats, it is possible to produce with minimal pesticide residue for commercial consumption while maintaining environmental integrity.

Keywords: *Beauveria bassiana*, Biological control, Cabbage, Endophyte, *Spodoptera litura*.

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* (L.) Alef.) is one of the most common cole crops grown worldwide. Despite being the world's second-largest producer of cabbage, India may still do more in terms of productivity, production and insect pest control. Insect pest complexes that infest cabbage from germination to harvesting are the main obstacles to its cultivation (Yogananda *et al*, 2023). Among the various insect pests, the tobacco caterpillar, *Spodoptera litura* F. (Noctuidae: Lepidoptera) stands out as one of the most destructive, causing substantial and recurring yield losses in cabbage cultivation each year. Commonly referred to as the tropical armyworm, *S. litura* is a highly polyphagous and economically significant pest that feeds on a diverse array of crops, including vegetables, fruits, tea, ornamental flowers, green manures and several weed species. Its major host plants include tobacco, chickpea, cotton, cabbage, soybean, lucerne and beet. The larvae of *S. litura* are particularly

damaging, with the potential to cause yield losses ranging from 26% to as high as 100% under severe infestation posing a serious threat to agricultural productivity (Tuan *et al*, 2017). Farmers find it challenging to control this polyphagous pest; therefore, they rely solely on synthetic insecticides. Excessive and random pesticide use is known to have a significant negative impact on the environment and society, as well as lead to higher production costs (Aktar *et al*, 2009).

Hence, it is high time to find out an alternate option to reduce the pest population with minimum pesticide residue for consumers and leaves the environment unaffected. One of the major approaches in the IPM is the use of biocontrol agents like fungi, bacteria, viruses and nematodes. Due of their superior ability to transmit disease to insects, by direct penetration of the cuticle unlike bacteria or viruses, fungi are the most important insect pest management agents (Khan *et al*, 2012). Among the Entomopathogenic fungi (EPF), *Beauveria bassiana* is

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well adapted and giving protection against various insect pests that are causing economical injury to the crops (Ownley *et al*, 2008). Although, *B. bassiana* has been widely utilized as an effective biocontrol agent for managing insect pest populations. However, its efficiency in field applications is often compromised due to the direct exposure of its propagules to harmful environmental factors such as ultraviolet (UV) radiation, fluctuating temperatures, and inconsistent humidity levels (Omukoko and Turoop, 2017). These challenges significantly reduce its persistence and performance. To address this limitation, the endophytic establishment of *B. bassiana* within plant tissues has emerged as a promising and sustainable strategy. This approach not only protects the fungus from adverse environmental conditions but also enhances its systemic activity within the plant, offering long-term protection against the notorious pests (Litwin *et al*, 2020). Successful colonization of *B. bassiana* has been documented in various crops, including maize, tomato, cabbage, cucumber, melon, potato, cotton and rice, where it has shown the potential to defend against a broad spectrum of insect pests and plant diseases, thereby contributing to improved crop health and yield. (Vega, 2018). With these evidences about endophytic *B. bassiana*, our main objective is to evaluate the efficacy of native isolate of the fungus, *B. bassiana* UHSB-END1 against *S. litura* at different days post inoculation (dpi) in cabbage.

MATERIALS AND METHODS

The laboratory and pot experiments were conducted in the year 2022 at Department of Entomology, College of Horticulture, Bagalkot, Karnataka, India (16.16910 N latitude, 75.66150 E longitude). The cabbage variety 'Saint' was utilized in the study. The cabbage seeds were surface sterilized using 2% sodium hypochlorite for about 2 minutes, thereafter by a 70% alcohol treatment for 3 minutes. Subsequently, the seeds were rinsed three times with autoclaved sterile water to eliminate any remaining traces of sodium hypochlorite and alcohol. The disinfected seeds were then air dried for 30 minutes under a Laminar Airflow Hood (LAF) using sterile filter papers. To verify that the surface sterilization technique was effective, a batch of randomly selected surface sterilized seeds was plated on PDA media. After incubation for a week, no microbial development was observed. Pro-trays loaded with sterilized growing media (coco peat) were used to sow both treated and untreated seeds and they were placed within a growth chamber. After germination, seedlings were grown up to 25 days in pro-trays in controlled condition and later

transferred into the pots containing sterilized soil and compost (1:1) and initiated imposition of treatments accordingly (Jamunarani *et al*, 2022, Yogananda *et al*, 2023).

A wild population of *Spodoptera litura* was initially acquisition from vegetable fields located at the College of Horticulture, Bagalkot, India. The population was subsequently reared in the laboratory on a diet of castor and cabbage leaves, maintained at 28 ± 1 °C under natural light conditions. For experimental purposes, second instar larvae were periodically sourced from this established culture as needed, following the method described by Sowmya *et al* (2017). The experiment was structured using a completely randomized design, consisting of six treatments with three replications each, and each replication included five plants. The different treatments used to colonize endophytic *B. bassiana* in the cabbage are detailed in (Table 1).

The bio-efficacy of *Beauveria bassiana* strain UHSB-END1 was evaluated at various stages of cabbage growth specifically at 30, 45 and 60 days of post-inoculation. For each treatment, 20 second-instar larvae of *Spodoptera litura* were fed with leaves colonized by the fungus, while another group of 20 larvae of the same instar was provided with non-colonized leaves, serving as the control. To maintain leaf freshness, the cabbage samples were replaced every other day. Larval mortality was monitored on the 2nd, 4th, 6th, 10th and 15th days after feeding at a room temperature of 28 ± 1 °C with relative humidity maintained between 70–75% and it continued until the insect life cycle was complete (Jamunarani *et al*, 2022). In the same manner, pot experiment was conducted to evaluate the efficacy of endophytic *B. bassiana* UHSB END1 against *S. litura*. About 20 larvae of second instar *S. litura* were selected and challenge inoculation on cabbage plants at 30 dpi. Insect-released cabbage leaves were covered with pin-holed plastic bags to keep the insects contained while they fed. To assure fresh nourishment till the end of the larval stage the live larvae were carefully moved to a fresh leaf of the same cabbage plant for every fifth day. The observation on the morality of *S. litura* was recorded at five, ten and 15 days after release (DAR) (Yogananda *et al*, 2023).

Insect mortality data from both laboratory and in planta experiments were analysed using one-way

Endophytic Potential of Indigenous *Beauveria bassiana* against *Spodoptera litura* Fabricius

Table 1. Experimental setup to evaluate the effectiveness of *Beauveria bassiana* UHSB-END1 in managing *Spodoptera litura* infestation in cabbage.

Treatment	Method	Dosage (g/l)
T ₁	Seed treatment	5
T ₂	Seedling root dip treatment	5
T ₃	Soil drenching	10
T ₄	Foliar Spray	5
T ₅	Combination of all treatments	(T ₁ +T ₂ + T ₃ +T ₄)
T ₆	Untreated control	-

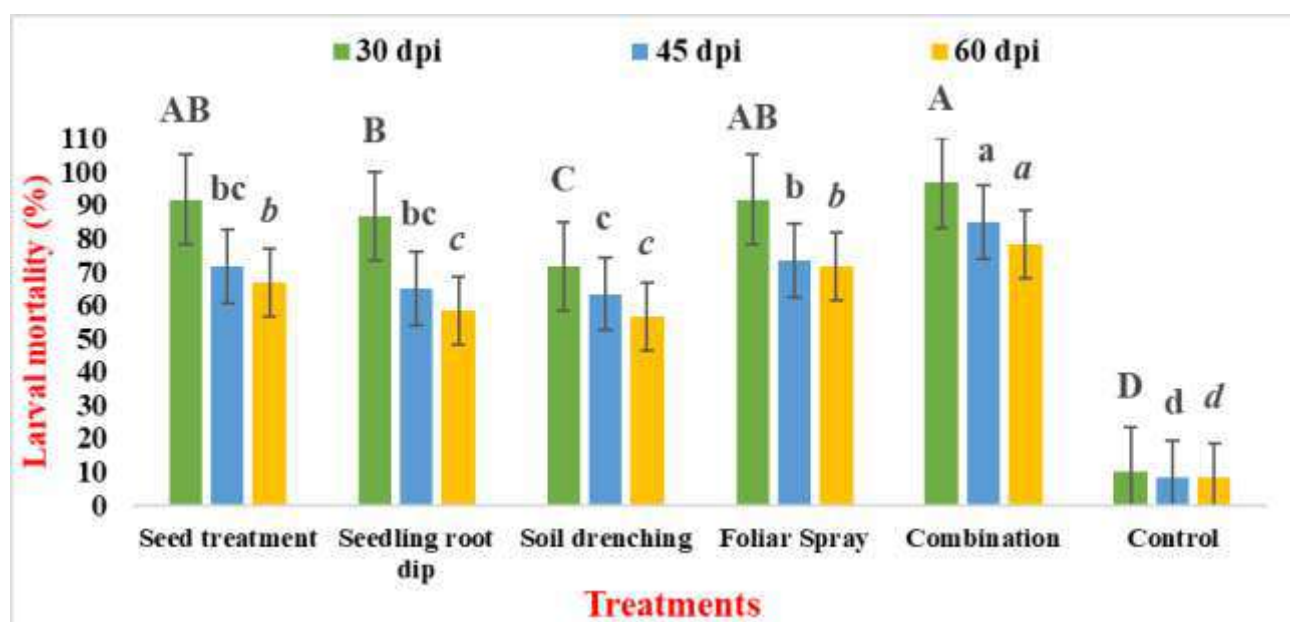


Fig 1. Assessment of the entomopathogenic potential of endophytic *Beauveria bassiana* UHSB-END1 against *Spodoptera litura* at 30, 45 and 60 days of post-inoculation in cabbage

ANOVA. Additionally, data related to sub-lethal effects, such as larval growth and development, were also examined through one-way ANOVA based on a completely randomized design, employing Duncan's Multiple Range Test (DMRT) using IBM SPSS software (version 16).

RESULTS AND DISCUSSION

The pathogenicity of endophytic *Beauveria bassiana* against *Spodoptera litura* showed significant variation among the different treatments. The combination treatment resulted in the highest mortality rate (96.67%), which was statistically significant, followed by both the foliar spray and seed treatment, each recording a mortality rate of 91.67%. The seedling root dip treatment recorded the mortality of larvae (86.67%) and least mortality was observed in

Soil drenching treatment (71.67%) at 30 dpi ($F_{5,17}=238.182$; $p<0.05$). Similarly, at 45 dpi ($F_{5,17}=98.200$; $p<0.05$) combination treatment recorded highest mortality (85%), followed by foliar spray (73.33). The mortality in seed treatment (71.67%) was statistically, on par with Seedling root dip treatment (65%) and least mortality was observed in Soil drenching treatment (63.33%). Similar trend was noticed at 60 dpi ($F_{5,17}=225.600$; $p<0.05$), significantly high mortality of larvae was recorded in the combination treatment (78.33%). The mortality in foliar application (71.67%) was on par with Seed treatment (66.67%). The least mortality was observed in soil drenching (56.67%) which was statistically similar with seedling root treatment (58.33%). The minimum natural mortality of *S. litura* was ranged from 8.33% to 10%, which was recorded in uncolonized control plants (Fig 1).

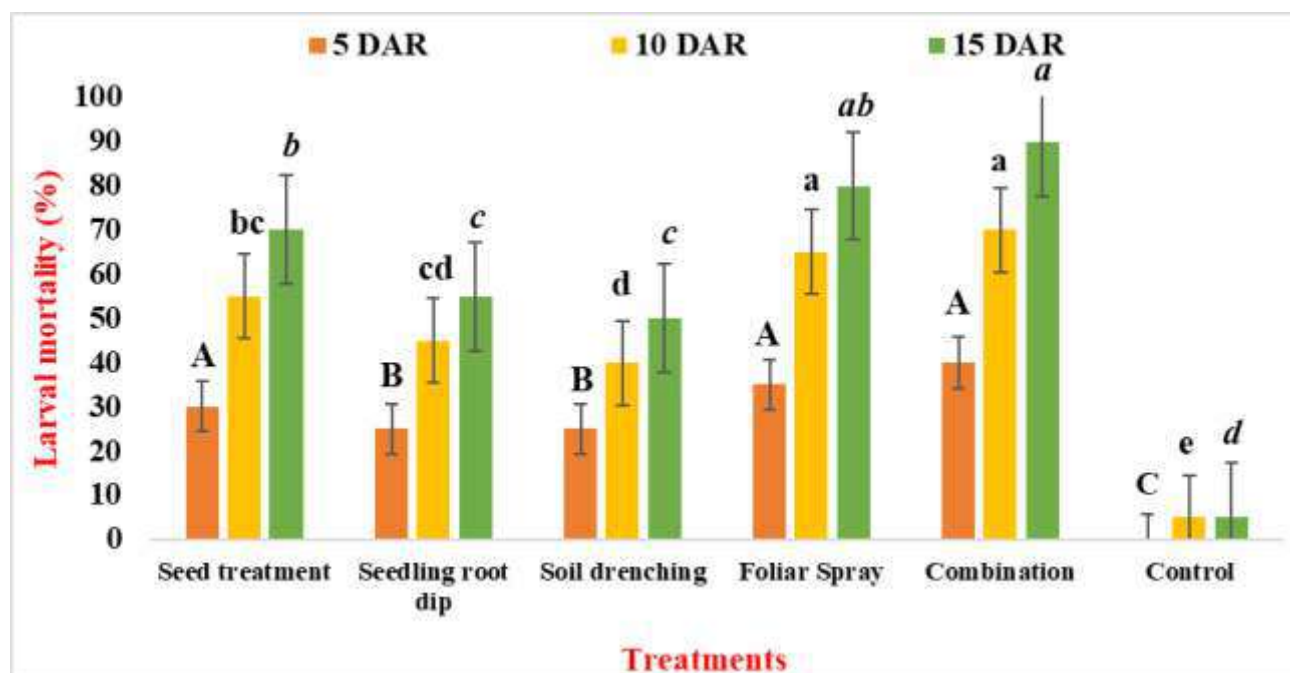


Fig 2. Effectiveness of the endophytic *Beauveria bassiana* UHSB-END1 in cabbage at 30 days after inoculation under *in-planta* conditions against *Spodoptera litura*

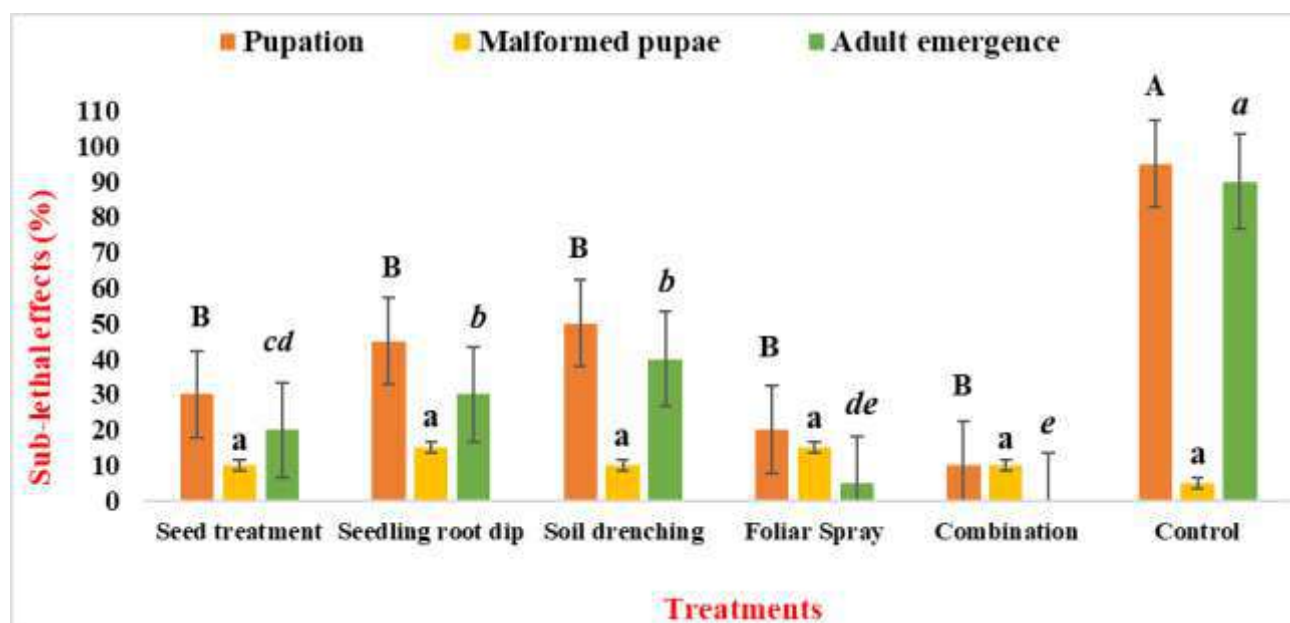


Fig 3. Influence of endophytic *Beauveria bassiana* UHSB-END1 on the growth and development of *Spodoptera litura* under *in-planta* in cabbage at 30 days of post inoculation

The pot culture experiment proved impact of established *B. bassiana* on *S. litura* larvae as evidenced by 25-40% mortality of larvae in different treatments at five DAR ($F_{5,17}=19.971$; $p<0.05$). Similarly, by the end of ten DAR larval mortality was noticed in the range of 40-70% ($F_{5,17}=49.200$; $p<0.05$). After 15 DAR the combination treatment recorded the significant highest

(90%) cumulative mortality of *S. litura*, followed by foliar spray (80%). Seed treatment recorded cumulative mortality of 70%. The mortality in seedling root dip method (55%) and soil drenching (50%) were on par with each other ($F_{5,17}=46.629$; $p<0.05$). The maximum of 5% mortality was noticed in untreated control even after 15 DAR (Fig 2). Significant



Fig. 4. The effectiveness of endophytic *Beauveria bassiana* UHSB-END1 on *Spodoptera litura* was evaluated at 30, 45, and 60 days of post inoculation under laboratory conditions (a), dead larvae and malformed pupae (b), progression of mycosis on malformed pupae (c) and malformed adult (d)

variations were seen in the effects of each treatment on *S. litura* pupation ($F_{5,17}=6.400$; $p<0.05$). In comparison to the control, pupation was significantly decreased in all the treatments. Likewise, the highest malformed pupae were recorded in the treatments when compared to control ($F_{5,17}=0.850$; $p<0.05$). The adult emergence was almost nil in the combination treatment and only 5% in foliar application ($F_{5,17}=28.378$; $p<0.05$). About 90% healthy adults were emerged in the untreated control treatment (Fig 3).

S. litura is a polyphagous pest that feeds voraciously and has posed a serious threat to various horticultural and agricultural crops around the world (Ahmad *et al*, 2007). In order to reduce the farmers' total reliance on pesticides, Biological control of insect pests has recently received a lot of attention. Entomopathogenic fungi are cheaper and environmentally safe for pest management than pesticides, and they are compatible with IPM. The endophytic colonisation of native *B. bassiana* UHSB-END1 led to an elevation in *S. litura* mortality. The

laboratory bioassay results show that the maximum mortality of *S. litura* during early period of the crop (30 dpi) maybe due to high persistence, colonization and recovery of the fungus. The mortality of *S. litura* decreases as the crop matures at 45 and 60 dpi due to poor persistence and recovery of the fungus. In support to this, Yogananda *et al.* (2023) reported that the highest lethality of *M. persicae* and *P. xylostella* under *in vivo* condition was noted at 30 dpi. The mortality started to decline significantly around 45 dpi and it was lowest at 60 dpi. Similarly, the indigenous isolate of endophytic *B. bassiana* UHSB-END1 was efficient in causing the mortality of *S. litura* at *in planta* where, mortality is noticed from three days after feeding on to the colonized leaves. Interestingly, beyond inducing larval mortality, the various treatments also influenced the growth and developmental patterns of *Spodoptera litura* larvae. Noticeably, significant reduction in per cent pupation, increased pupal malformation and adult emergence was drastically reduced across different treatments. Coordinating with results of Jamunarani *et*

al. (2022) where, endophytic *B. bassiana* UHSB-END1, was efficient in causing the mortality of *S. litura* both *in vivo* and *in planta* experiment. Moreover, *S. litura* larvae that consumed colonized leaves showed irregularities in their growth and development. The mortality of the larvae was largely influenced by the method used to introduce the fungus as an endophyte in the host plants (Wagner & Lewis, 2000; Qayyum *et al*, 2015). It is likely that the pest suppression occurred due to antibiosis or feeding deterrence, triggered by secondary metabolites produced by the endophytic entomopathogenic fungi within plant tissues, which possess both insecticidal and anti-feeding characteristics (Vega *et al*, 2008; Gurulingappa *et al*, 2011).

CONCLUSION

Indiscriminate pesticide uses to manage the insect pests in cabbage ecosystem, increases production costs, reduces yield and poses health risks, as seen in a recent tragic incident where a 14-year-old girl died after consuming pesticide-sprayed cabbage. By introducing this native biological product to control insect pests in cabbage habitats, it is possible to produce with minimal pesticide residue for commercial consumption while maintaining environmental integrity. Further, field level studies are required in this direction. This offers a scientific foundation for future researchers to explore the diverse ecological interactions between this fungus and cabbage.

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Enhancing Longevity: Extending the Vase Life of *Asparagus setaceus* (syn. *plumosus*) with Chemical Preservatives

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ABSTRACT

Asparagus setaceus, also known as *Asparagus plumosus*, is a popular cut filler due to its delicate, feathery foliage and versatility in floral compositions. However, its tender nature makes it prone to mechanical damage, pests, and diseases, which affect its post-harvest quality and vase life. Hence, the present study was conducted at the College of Horticulture, Bagalkot, Karnataka, during 2018-2019 to devise the methods of extending vase life of *Asparagus setaceus* using chemical preservatives. Uniform, pest-free foliages were harvested for quality assessment. To improve longevity, chemical preservatives were used to maintain freshness and enhance water uptake, thereby increasing market value. The study tested six treatments: distilled water (control), 10% sucrose + 100 ppm 8-HQC, 10% sucrose + 200 ppm 8-HQC, 10% sucrose + 25 ppm BA, 10% sucrose + 0.5% boric acid, and 10% sucrose + 25 ppm BA + 0.5% boric acid. The experiment was conducted under ambient conditions, assessing parameters such as initial fresh weight, vase solution absorption, physiological weight loss, and vase life. Results revealed that the combination of 10% sucrose + 25 ppm BA + 0.5% boric acid (T6) resulted in the highest initial fresh weight, the greatest vase solution uptake, and the longest vase life (8.45 days). This treatment minimized weight loss and maintained the foliage's aesthetic quality. In contrast, treatments with distilled water or minimal additives showed shorter vase life and greater weight loss. The study concludes that the combination of 10 % Sucrose + 25 ppm BA + 0.5 % Boric acid effectively extends the vase life of *Asparagus setaceus*, making it a recommended preservative solution for the floriculture industry.

Key Words: *Asparagus setaceus*, Longevity, Pulsing, Sucrose, Boric Acid, Vase Life.

INTRODUCTION

Cut greens are essential in the floriculture industry, adding texture, depth, and natural appeal to floral arrangements. Their affordability makes them widely accessible for florists and consumers, enhancing both everyday displays and large-scale events. (Shirin *et al*, 2011). Cut greens are valued for their longevity, maintaining freshness and vibrancy in floral arrangements. Their varied shapes, textures, and lush green hues enhance the visual appeal, adding depth and contrast to floral designs. (Patel *et al*, 2016). *Asparagus setaceus* (also known as *Asparagus plumosus*) is a captivating filler foliage often used in floral arrangements. Belonging to the Liliaceae family, it is commonly called the asparagus fern due to its delicate, feathery leaves, which are actually modified stems or branches (Safeena *et al*, 2014). *Asparagus setaceus* is a popular ornamental plant renowned for its

delicate, feathery foliage and versatility in floral arrangements. Native to South Africa, it is commonly used as a filler in bouquets and floral designs due to its graceful appearance and adaptability to various conditions. This plant is characterized by its fine, fern-like leaves and can be grown both indoors and outdoors, making it a favored choice among florists and horticulturists. Its ability to retain freshness and its aesthetic appeal contribute significantly to its value in the floral industry.

Due to their delicate nature, cut greens are vulnerable to damage, pests, and diseases, affecting their post-harvest quality. Chemical preservatives, including carbohydrates, growth regulators, and germicides help enhance vase life by improving water absorption, reducing ethylene effects, and slowing senescence (Kumar and Singh, 2022). These treatments ensure cut greens remain fresh, cost-effective, and visually appealing in floral

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arrangements. According to Chutichudet *et al* (2011), extending the vase life of cut flowers relies on several key factors, including carbohydrates, preservatives, growth regulators, germicides, and organic acids. These substances impact critical physiological and biological processes, significantly improving post-harvest quality and longevity. Their effects include regulating water balance (absorption and transpiration) and modulating ethylene production, which is known to hasten flower aging. Thus, cut greens are indispensable in the floricultural industry, providing a cost-effective, long-lasting, and visually enriching component to floral arrangements and bouquets. Floral preservative solutions with surfactants and antimicrobial effects enhance water uptake and rehydrate cut flowers, maintaining their freshness and turgor, especially when stored or transported at ambient temperatures (Madhubala *et al*, 2022). In light of these observations, this research aimed to assess how different chemical preservatives, used in holding solutions, influence the postharvest longevity of *Asparagus setaceus*.

MATERIALS AND METHODS

The current investigation was conducted between 2018 and 2019 at the Department of Floriculture and Landscape Architecture, UHS, Bagalkot. A completely randomized design was used for the experiment, which included six treatments and three replications. T1: Distilled water; T2: 10% Sucrose + 100 ppm 8-HQC; T3: 10% Sucrose + 200 ppm 8-HQC; T4: 10% Sucrose + 25 ppm BA; T5: 10% Sucrose + 0.5% Boric acid; and T6: 10% Sucrose + 25 ppm BA + 0.5% Boric acid. Cut foliages of uniform size, free of pests and diseases, were selected and harvested to evaluate the keeping quality. Immediately following harvest, the cut foliages were transported to the laboratory for treatment. The experiment was conducted at ambient conditions in the laboratory, with a relative humidity of 55-60% per cent and at a temperature of 25 °C to 30 °C.

Observations recorded

Initial fresh weight (g): The initial fresh weight (recorded in grams) was measured as the difference in weight between: The complete setup (bottle + water + plant material) and the control (bottle + water alone) at the beginning of the vase life study.

Weight at senescence (g): At the conclusion of the experiment, the final weight at senescence was

calculated by subtracting the weight of the glass bottle with water from the total weight of the bottle containing both water and cut *Asparagus/Dracaena* leaves, with all measurements recorded in grams.

Quantity of vase solution absorbed (g): The net change in vase solution weight was calculated by subtracting the final weight from the initial weight, with results reported in grams

Physiological loss in weight (%): Physiological weight loss percentage was computed using the formula

$$PLW = \frac{IWA - FWA}{IWA} \times 100$$

where IWA = Initial Weight of Asparagus, FWA = Final Weight of Asparagus

Vase life (days): The vase life duration of cut *Asparagus* foliage was quantified by recording the number of days the material-maintained freshness in the preservative solution.

Colour of the foliage (L*, a*, b*): Foliage color was quantified using a ColorFlex EZ colorimeter (Model CFEZ 1919, HunterLab, Reston, VA) equipped with a 45 mm aperture. Following calibration with standard black and white reference tiles, color values were recorded in the CIE Lab* system, where L* represents lightness, a* indicates red-green chromaticity, and b* denotes yellow-blue chromaticity

RESULTS AND DISCUSSION

Initial fresh weight (g)

The data (Table 1) show how the application of several chemical preservatives affected the initial fresh weight of *Asparagus setaceus* syn. *plumosus*. It was found that the asparagus's initial fresh weight varied very little. The treatment with the highest initial fresh weight (8.66 g) was 10% sucrose + 25 ppm BA + 0.5% boric acid, followed by 10% sucrose + 0.5% boric acid (8.44 g). 5.66 g *i.e.*, minimum initial fresh weight was measured in 10% sucrose + 0.5% boric acid (T5). A 10% sucrose + 25 ppm benzyl adenine (BA) + 0.5% boric acid solution promoted the highest initial fresh weight because sucrose provides a significant energy source, BA acts as a growth regulator that enhances cell division and expansion, and boric acid supports improved water uptake and cell wall stability. This synergistic effect leads to better hydration, increased cell size, and overall improved fresh weight of the flowers (Kamenetsky and Galili, 2011).

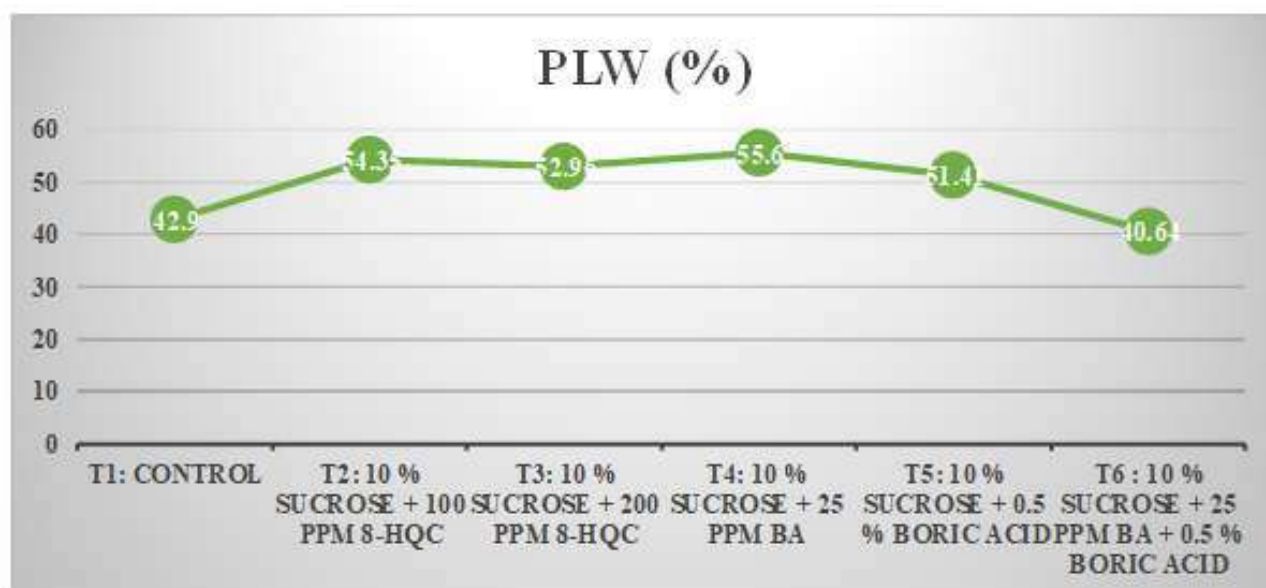


Fig 1: Physiological loss in weight of *A. setaceus* (syn. *plumosus*)

Weight at senescence (g)

The constant preservation of fresh weight and progressive decrease in fresh weight is an important prerequisite for extending the vase life of any cut foliage. Different pulsing chemicals have an impact on the ultimate fresh weight of *Asparagus setaceus* syn. *plumosus*. When combined with other preservatives, such as 10% sucrose + 25 ppm BA + 0.5% boric acid, the largest weight at senescence was reported (5.14 g), followed by 10% sucrose + 0.5% boric acid (4.82 g) (Table 1). It was lowest for cut foliages treated with 10% sucrose + 0.5% boric acid (T5) (2.75 g), which could be attributed to a decrease in water intake. This decline in water intake is caused by microbes blocking the vascular bundle. Sugar was mixed with germicides such as BA and Boric acid to prevent. Sugar would also enhance the effect of cytokinin, which delays the senescence in in rose (Mayak and Dilley, 1976). These results are in agreement with the findings of Knee (2000).

Quantity of vase solution absorbed (g)

Significant variations were noted among the chemicals used (Table 1). The highest volume of vase solution absorbed was 5.47 g with the treatment of 10% Sucrose + 25 ppm BA + 0.5% Boric acid, followed by 4.05 g with 0.5% Boric acid. The lowest absorption, 0.88 g, was recorded with distilled water. This may be attributed to the antimicrobial properties of the treatments, which help prevent the plugging of vascular bundles and improve water uptake. (Safeena *et al*, 2014). Similar results were reported in Solidago flowers (Hassan, 2005).

Physiological loss in weight (%)

The pulsing treatments had a notable impact on the physiological weight loss over the vase life of *Asparagus setaceus* (syn. *plumosus*) as shown in Table 1. Treatment T6 (10% Sucrose + 25 ppm BA + 0.5% Boric acid) achieved the lowest physiological weight loss at 40.64%, followed by T5 (10% Sucrose + 0.5% Boric acid) with 42.90%. The highest physiological weight loss of 55.60% was observed with treatment T4 (10% Sucrose + 25 ppm BA).

Vase life (days)

As shown in Table 1, different chemical treatments significantly influenced the vase life of *Asparagus setaceus* (syn. *plumosus*). Among the tested solutions, the combination of 10% sucrose, 25 ppm benzyladenine (BA), and 0.5% boric acid (T6) proved most effective, extending vase life to 8.45 days. This was closely followed by the treatment containing 10% sucrose and 0.5% boric acid, which maintained foliage freshness for 8.02 d. In contrast, cut stems placed in distilled water (control) exhibited the shortest longevity, lasting only 6.28 d. The superior performance of BA-containing treatments may result from its dual function in acidifying the solution and suppressing microbial development (Reddy, 2004). Sucrose likely contributes to longevity by serving both as an osmotic regulator and metabolic energy source for cellular maintenance and structural integrity (Gowda and Gowda, 1990; Murali *et al*, 1991).

Color parameter analysis: The CIELAB color space measurements revealed the following characteristics:

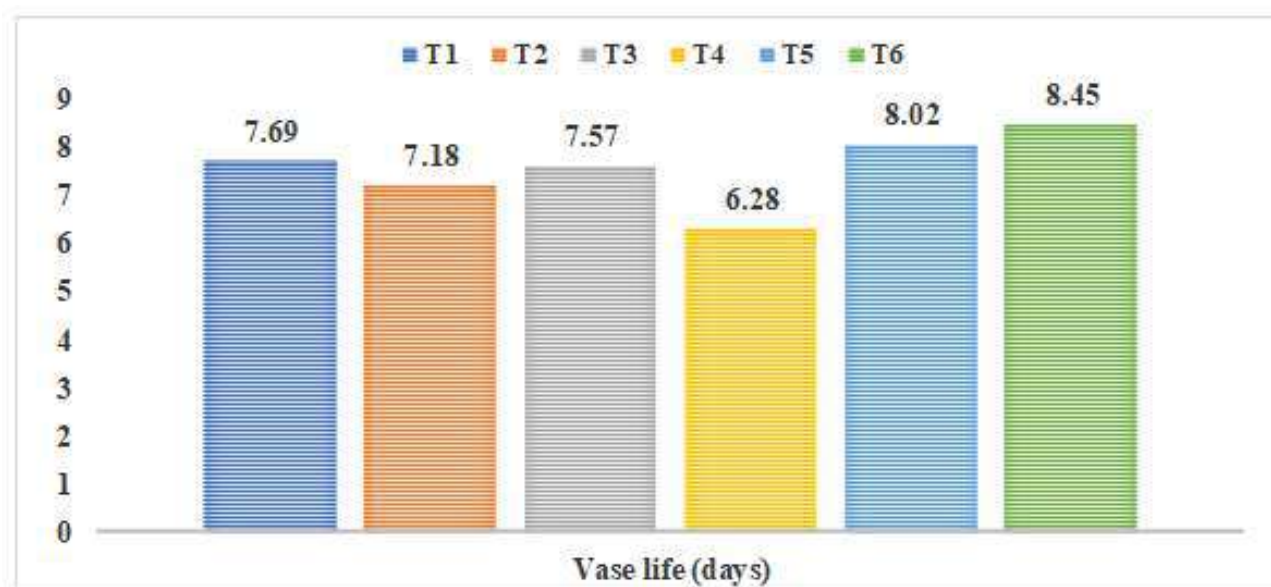


Fig 2: Vase life attributes of *A. setaceus* (syn. *plumosus*)

1. **Lightness (L^*):** Ranging from 0 (absolute black) to 100 (pure white), the L^* values demonstrated the relative brightness of the foliage.
2. **Green-red spectrum (a^*):** All treatments showed negative a^* values, confirming the dominant green coloration of the foliage, as negative values indicate green tones while positive values would suggest red hues.
3. **Yellow-blue spectrum (b^*):** This axis measured color variation between yellow (positive values) and blue (negative values).

Temporal color changes: Throughout the experimental period, all color coordinates (L , a , and b) exhibited progressive increases. This upward trend in a values (toward less negative numbers) particularly indicated a gradual reduction in green intensity, suggesting chlorophyll degradation or color fading over time.

Instrumental colour L^* value of cut foliage

Instrumental colour L^* values of cut foliage's did not reveal significant differences among the treatments during vase life period (Table 2). There was an increase in L^* values with the period in vase life solutions in all the treatments. However, it was minimum in T_1 (16.58). A maximum L^* value among the treatments was noted in T_6 (18.52). Similarly at the end of vase life period, it was minimum in T_1 (22.38) and the maximum L^* value among the treatments was noted in T_6 (25.83). The increase in L^* values over time indicates that the cut foliage of Asparagus became

lighter or brighter during the vase life period in all treatments. The consistent trend of T_1 having the lowest L^* values and T_6 having the highest suggests a relative difference in the effectiveness of the treatments in influencing the lightness of the foliage. Understanding these changes is crucial for assessing the visual quality and marketability of the cut foliage. The lightness (L^* value) is a key factor in the visual appeal of the foliage, which can affect consumer preference and satisfaction.

Instrumental colour a^* value of cut foliage

Similar to L^* value, instrumental colour values for a^* value in Asparagus were also non-significant among the treatments during vase life period under ambient conditions (Table 2). The a^* values were seen to be negative and found to increase gradually in all the treatments during vase life period. Minimum a^* value was noted in T_1 (-7.25) in initial stage. On the contrary, maximum a^* value among the treatments were recorded in T_6 (-3.89). Similarly at the end of vase life period, it was minimum in T_1 (-4.13) and the maximum L^* value among the treatments was noted in T_6 (0.87). Throughout the vase life period, the green coloration of the Asparagus (indicated by the negative a^* values) diminished in all treatments. However, the degree of this change varied among treatments, with T_1 maintaining a stronger green color initially and at the end compared to T_6 , which showed a significant shift towards a less green or more neutral color. This information can help in understanding the visual quality and shelf life of Asparagus under different treatment conditions, which is crucial for both

Enhancing Longevity: Extending the Vase Life of *Asparagus setaceus*

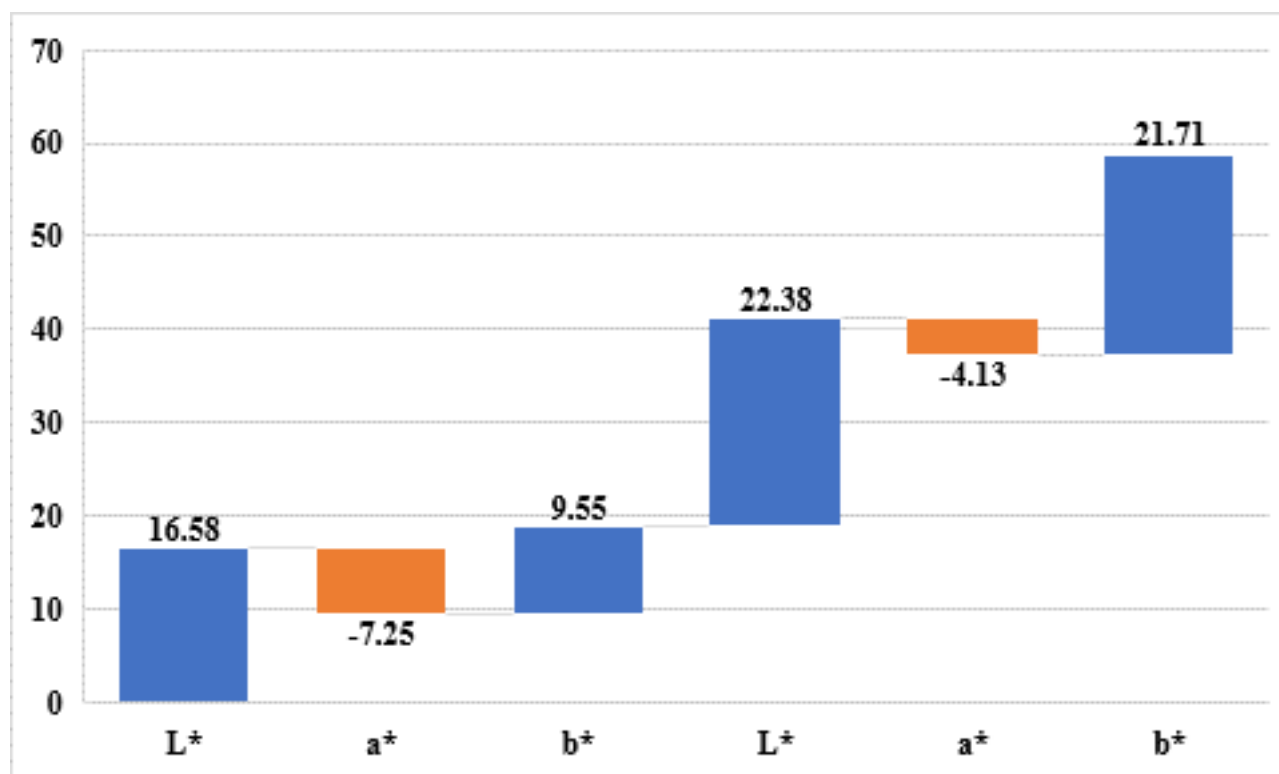


Fig 3: Effect of chemical preservatives on L*, a* and b* colour values of *A. setaceus* (syn. *plumosus*)

Table 1: Vase life attributes of *Asparagus plumosus* as influenced by chemical preservatives.

Treatment	Initial fresh weight (g)	Weight at senescence (g)	Quantity of vase solution absorbed (g)	PLW (%)	Vase life (days)
T1: Control	8.44	4.82	0.88	42.90	7.69
T2: 10 % Sucrose + 100 ppm 8-HQC	7.01	3.20	3.20	54.35	7.18
T3: 10 % Sucrose + 200 ppm 8-HQC	7.76	3.65	3.65	52.96	7.57
T4: 10 % Sucrose + 25 ppm BA	7.50	3.33	2.78	55.60	6.28
T5: 10 % Sucrose + 0.5 % Boric acid	5.66	2.75	4.05	51.41	8.02
T6: 10 % Sucrose + 25 ppm BA + 0.5 % Boric acid	8.66	5.14	5.47	40.64	8.45
Mean	7.50	3.82	3.34	49.47	7.53
S.Em ±	0.54	0.15	0.18	0.41	0.41
CD (0.01)	1.64	0.47	0.55	1.25	1.24

producers and consumers interested in the aesthetic and freshness of the produce.

Instrumental colour *b** value of cut foliage

The data on *b** value was found to increase gradually along the period of storage in all the treatments (Table 2). There were no significant differences among the treatments with respect to the *b** values during vase life period. However, *b** value was minimum noted in T1 (9.55) in initial stage. A maximum *b** value on the other hand was noted in T6

(12.75). Similarly at the end of vase life period, it was minimum in T1 (21.71) and the maximum *L** value among the treatments was noted in T6 (33.63). The increasing *b** values over time suggest that the *Asparagus* became more yellow during the vase life period in all treatments. The initial and final *b** values highlight the differences in the extent of yellowness between the treatments, with T1 consistently showing the least yellowness and T6 the most. Understanding these changes is important for assessing the visual quality and freshness of *Asparagus* under different storage conditions. The yellowness (*b** value) is a key

Table 2: Effect of chemical preservatives on L*, a* and b* colour values of *Asparagus plumosus* during vase life period.

Treatment	Leaf colour					
	Vase life days					
	Initial			Final		
	L*	a*	b*	L*	a*	b*
T1: Control	16.58	-7.25	9.55	22.38	-4.13	21.71
T2: 10 % Sucrose + 100 ppm 8-HQC	18.52	-7.06	11.25	25.48	-3.93	25.99
T3: 10 % Sucrose + 200 ppm 8-HQC	17.56	-4.23	10.47	24.71	-1.69	24.32
T4: 10 % Sucrose + 25 ppm BA	17.45	-3.89	10.58	24.36	-1.87	21.96
T5: 10 % Sucrose + 0.5 % Boric acid	15.88	-4.92	12.51	23.14	-0.99	31.93
T6: 10 % Sucrose + 25 ppm BA + 0.5 % Boric acid	18.72	-3.89	12.75	25.83	0.87	33.63
Mean	18.78	-5.24	11.83	18.47	-1.96	23.26
S.Em±	-	-	-	0.94	0.11	1.28
C.D. @1%	-	-	-	2.86	0.34	3.92

factor in the visual appeal and perceived freshness of the produce, influencing consumer preferences and marketability. Increase in lightness and yellowness and decrease in greenness, might be due to degradation of chlorophyll pigments which are responsible for green colour of foliages. Similar results were also obtained by Ji *et al* (2015).

CONCLUSION

The data indicated that treating *Asparagus setaceus* syn. *plumosus* with 10% sucrose and 0.5% boric acid results in the highest initial fresh weight and the greatest weight maintenance at senescence. This combination was particularly effective for initial hydration and weight retention, ensuring the foliage appears fresh and full soon after being cut. However, a more effective treatment for overall vase life involves a combination of 10% sucrose, 25 ppm benzyl adenine (BA), and 0.5% boric acid. This mixture maximized vase solution absorption, ensuring the cut foliage remains well-hydrated. Additionally, it minimized percentage weight loss (PLW), crucial for maintaining the aesthetic quality over time. The inclusion of BA significantly extended the vase life, making this combination the most comprehensive for maintaining cut flower quality. Thus, while sucrose and boric acid alone were effective for initial weight maintenance, adding BA optimizes hydration, reduced weight loss, and extended the longevity of the cut foliage. This combination can be recommended for achieving the best overall results in maintaining the quality of *Asparagus setaceus* syn. *plumosus*.

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Evaluation of Chrysanthemum (*Dendranthema grandiflora* Tzvelve) Varieties for Growth, Quality and Yield Under Northern Dry Zone of Karnataka

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ABSTRACT

Chrysanthemum is a herbaceous perennial flowering plant widely cultivated in India for both cut and loose flower production. These flowers are highly prized for their diverse shapes, sizes, unique forms, and vibrant colours. Due to their early blooming nature, efficient propagation techniques, and ease of cultivation, they offer great potential for commercial farming. Their appealing characteristics make them a profitable choice for growers. A research study was conducted during 2024-25 at the experimental block of the Department of Floriculture and Landscape Architecture, College of Horticulture, Bagalkot. The objective was to evaluate chrysanthemum varieties for loose flower production in the Northern Dry Zone of Karnataka. The experiment followed a Randomized Block Design with three replications, assessing eight chrysanthemum cultivars Poorva White, Poornima White, Poornima Yellow, Solo White, Scent White, Samruddhi White, Scent Yellow, and Aishwarya Yellow, based on growth and flowering parameters. Among the cultivars, Poornima Yellow recorded the tallest plant height (69.33 cm), produced the highest number of flowers per plant (68.33), and yielded the most flowers per plant (620.20 gm). Solo White had the greatest number of primary and secondary branches (19.00 & 17.62) and showed extensive plant spread in both east-west (44.07 cm) and north-south directions (83.70 cm). Scent White recorded the highest individual flower weight (17.46 gm). The earliest flowering, at 50% bloom (88.33 d), was observed in Poornima White, while Aishwarya Yellow had the shortest flowering duration (33.38 d). Aishwarya Yellow also exhibited the longest shelf life (5.74 d), whereas Scent Yellow showed the highest chlorophyll content (62.36 SPAD). Based on the findings, Poornima Yellow, Scent White, and Solo White were identified as the most suitable chrysanthemum cultivars for commercial cultivation in the Northern Dry Zone of Karnataka.

Keywords: Chrysanthemum, Flowering, Quality, Vegetative growth, Yield

INTRODUCTION

Chrysanthemums, or Guldaudi, are a significant floricultural crop in India, with a strong presence in the national flower market. These flowers are widely cultivated for various purposes such as loose flowers, cut flowers, pot mums, and as ornamental garden plants. Chrysanthemums stand out because of their broad range of flower colours, size and shape, which increase their demand in both domestic and international markets (Biralingappa, 2016). The flower is part of the Asteraceae family and has different cultivars suited to various environments. Their cultivation requires understanding the interplay between specific cultivars and the local environment, especially in terms of temperature and photoperiod. The development of chrysanthemums involves careful cultivar selection to meet market demand, which

changes annually as new cultivars are introduced based on consumer preferences (Srilata *et al*, 2015). The regions of West Bengal, Karnataka, Maharashtra, Tamil Nadu, and Andhra Pradesh are key players in chrysanthemum cultivation in India, where factors like soil, climate and growing practices directly influence the success of this floricultural crop. In this context, identifying suitable cultivars for specific regions becomes essential for maximizing yield and meeting consumer demand (Thakur *et al*, 2018)

MATERIALS AND METHODS

The research aimed to assess the performance of eight chrysanthemum cultivars under the climatic conditions of the Northern Dry Zone of Karnataka. The trial was conducted at the experimental field of the Floriculture Department, College of Horticulture, Bagalkot, during the 2024-25 growing season. The

cultivars studied included Poorva White, Poornima White, Poornima Yellow, Solo White, Scent White, Samruddhi White, Scent Yellow, and Aishwarya Yellow. The crop was grown in open field conditions, with an average annual rainfall of 562 mm.

The rooted chrysanthemum cuttings were transplanted at a spacing of 60×45 cm after incorporating well-decomposed farmyard manure (FYM) at a rate of 20 ton per hectare. A fertilization regimen of 120:150:100 kg NPK per hectare was applied using urea, single super phosphate (SSP), and muriate of potash. Nitrogen was administered in three stages initially as a basal dose, followed by subsequent applications at 30 and 45 d after planting. Pinching was performed once the plants reached a height of 15-20 cm, while disbudding was carried out for up to 60 d. Standard agronomic practices, including irrigation, weeding, hoeing and plant protection measures, were implemented as per crop requirements, adhering to established cultivation guidelines (Anon, 2014). Observations were recorded on key growth and flowering parameters, including plant height (cm) canopy spread in North-South and East-West directions (cm) the number of primary and secondary branches per plant, d to attain 50% flowering, flowering duration, flower diameter (cm), total flower count per plant, shelf life, chlorophyll concentration in flowers, and flower yield per plant. The cultivars were arranged in a randomized experimental design with three replications, and five plants were selected per replication for data collection. The recorded data were statistically analyzed using the Randomized Complete Block Design (RCBD).

RESULTS AND DISCUSSION

The recorded data on key growth parameters of different chrysanthemum cultivars at the grand growth stage, observed 90 d after planting, includes plant height, canopy spread in North-South and East-West directions, and the number of primary and secondary branches. These findings are presented in Table 1. At the growth stage, Poornima Yellow recorded the highest plant height, reaching 69.00 cm, followed by Scent White at 65.67 cm and Poornima White at 64.00 cm. Regarding plant spread, Solo White exhibited the largest canopy, extending 44.07 cm in the North-South direction and 83.70 cm in the East-West direction. Samruddhi White followed with a spread of 42.87 cm (N-S) and 66.63 cm (E-W), while Scent White measured 53.97 cm (N-S) and 41.07 cm (E-W).

Poornima Yellow demonstrated superior flowering performance, producing the highest number

of flowers per plant (68.83) and achieving the maximum yield per plant (620.62 g). Poornima White required the longest duration to reach 50% flowering, taking 98.62 d, whereas Aishwarya Yellow was the earliest to bloom at just 33.38 d and exhibited the longest shelf life of 5.74 d. Scent Yellow recorded the highest chlorophyll content, with a value of 62.36.

The variation in vegetative growth among different cultivars is primarily caused by genetic differences but can also be influenced by the environmental conditions in which each cultivar is grown, as noted by Prashant *et al* (2020).

An increased number of branches per plant facilitates the formation of more flower buds, thereby enhancing overall flower yield (Singh *et al*, 2019). Similar trends in vegetative growth characteristics have been reported in chrysanthemums by Thakur *et al* (2018) and Thiripurasundari *et al* (2021). Flowering traits and quality parameters, including days to 50% flowering, flowering duration, flower diameter and shelf life are detailed in Table 2. The shortest period to attain 50% flowering was recorded in Poornima White (98.62 d) which was statistically similar to Poornima Yellow (96.40 d) and Scent White (85.64 d). The longest flowering duration was observed in Aishwarya Yellow (33.38 d) closely followed by Samruddhi White (32.45 d) Poornima White (32.36 d) and Poornima Yellow (31.74 d). Conversely, Solo White exhibited the shortest flowering duration of 29.30 d.

The variation in flowering characteristics among chrysanthemum cultivars was influenced by their genetic traits, environmental conditions, and agronomic practices. The prevailing climate included an average night temperature of 18°C a day time temperature of 26°C and relative humidity of 75% alongside extended daylight exposure during planting (Thakur *et al*, 2018) Similar findings have been reported by Srilatha *et al* (2015) Suvija *et al* (2016) Madhumati *et al* (2018) and Thiripurasundari *et al* (2021).

Flower quality and yield characteristics, including flower weight the number of flowers per plant, yield per plant, and chlorophyll content, are summarized in Table 3. Poornima Yellow demonstrated the highest flower production per plant (68.33) followed closely by Samruddhi White (67.00) Solo White (60.67 cm) and Aishwarya Yellow (27.33 cm). The observed differences in flower weight may be attributed to variations in flower diameter (Beeralingappa, 2016), as well as genetic and environmental influences (Suvija *et al*, 2016).

Evaluation of Chrysanthemum (*Dendranthema grandiflora* Tzelve) Varieties

Table 1. Vegetative parameters in different cultivars of chrysanthemum as influenced by the environment.

Cultivar	Plant height (cm)	Plant spread (East West direction) (cm)	Plant spread (North-South direction) (cm)	Number of primary branches	Number of secondary branches
Poorva White	42.00	27.53	36.23	9.07	12.03
Poornima White	64.00	31.13	35.60	13.33	12.40
Poornima Yellow	69.00	32.97	34.77	12.60	14.97
Solo White	61.33	44.07	83.70	19.00	17.62
Scent White	65.67	41.07	53.97	10.47	14.07
Samruddhi White	63.33	42.87	66.63	12.30	7.23
Scent Yellow	55.67	37.67	62.13	10.00	7.20
Aiswarya Yellow	56.00	37.50	41.87	13.38	6.77
S.E.M	2.191	2.183	4.244	0.416	1.282
CD (5%)	6.646	6.622	36.23	1.261	3.890

Table 2. Flowering attributes in different cultivars of chrysanthemum as influenced by the environment

Cultivar	Days to 50% flowering	Duration of flowering (days)	Flower diameter (cm)	Shelf life (days)
Poorva White	88.49	31.25	4.51	5.73
Poornima White	98.62	32.36	4.44	5.64
Poornima Yellow	96.40	31.74	4.69	4.64
Solo White	91.20	29.30	4.83	4.68
Scent White	85.64	31.43	5.56	4.88
Samruddhi White	94.29	32.45	5.07	5.40
Scent Yellow	89.40	30.74	4.19	4.53
Aishwarya Yellow	95.67	33.38	4.52	5.74
S.E.M	0.643	0.366	1.640	0.209
CD (5%)	1.949	1.111	4.975	0.633

Comparable trends have been documented by Madhumati *et al* (2018) and Thakur *et al* (2018) in chrysanthemum.

Poornima Yellow recorded the highest flower count per plant (238.20) followed by Samruddhi White (67.00) whereas Poornima White exhibited the lowest flower production (22.67). The number of flowers per plant serves as a crucial indicator of genotype vigour in flower yield (Suvija *et al*, 2016). Similar observations were reported by Thakur *et al* (2018) Singh *et al* (2019) and Prasanth *et al* (2020) in chrysanthemum.

A significant variation in flower yield per plant was observed among the cultivars. Poornima Yellow recorded the highest flower yield (620.62 g) followed by Poorva White (434.43 g) while Poornima White exhibited the lowest yield (116.23 g). The differences in flower yield may be attributed to the genetic composition of the variety, its interaction with prevailing environmental conditions, and genotype specific traits (Srilatha *et al*, 2015).

The relationship between the number of flowers produced per plant and the number of primary and secondary branches directly influences flower

yield per plant (Singh *et al*, 2019). These findings are consistent with those reported by Suvija *et al* (2016) and Thiripurasundari *et al* (2021) in chrysanthemums.

In terms of shelf life, Aishwarya Yellow recorded the longest duration (5.74 d) closely followed by Poorva White (5.73 d) Poornima White (5.64 d) and Samruddhi White (5.40 d). Meanwhile, Scent Yellow had the shortest shelf life (4.53 d). The differences in shelf life may be attributed to genetic variations, petal arrangement, and environmental conditions that influence physiological processes such as cell turgidity, water loss due to evapotranspiration, and the breakdown of reserve food, all of which contribute to flower longevity (Beeralingappa *et al*, 2016).

The extended shelf life observed in certain cultivars is primarily due to a slower rate of evaporation and transpiration, along with favorable environmental conditions such as lower temperatures and minimal wind velocity (Suvija *et al*, 2016). Additionally, variations in flower shelf life among cultivars may result from differences in senescence behaviour, particularly the production of ethylene forming enzymes (Thiripurasundari *et al*, 2021).

Table 3. Flower quality and yield attributes in different cultivars of chrysanthemum

Cultivar	Number of flowers per plant	Yield/plant	Chlorophyll content (SPAD)	Flower Weight
Poorva White	24.33	434.43	60.80	17.46
Poornima White	22.67	116.23	53.47	4.29
Poornima Yellow	68.33	620.62	51.63	3.43
Solo White	60.67	234.40	56.12	10.23
Scent White	29.33	145.49	57.61	4.99
Samruddi White	67.00	409.50	56.53	6.78
Scent Yellow	61.67	358.90	62.36	5.82
Aiswarya Yellow	27.33	286.23	53.84	11.46
S.EM	2.817	23.339	0.648	1.668
CD (5%)	8.545	70.792	1.966	5.060

Comparable trends have been noted by Thakur *et al* (2018) in chrysanthemums.

Variation in SPAD values was observed, as presented in Table 3. Among the different cultivars, Scent Yellow exhibited the highest chlorophyll content, recording a SPAD value of 62.36, followed by Poorva White (60.80) and Scent White (57.61). Meanwhile, Poornima Yellow registered the lowest chlorophyll content with a SPAD value of 51.63. These differences may be attributed to the genetic characteristics of the cultivars and the influence of environmental factors. Similar findings have been reported by Aind *et al* (2021), supporting these observations.

CONCLUSION

Among chrysanthemum cultivars screened, cvs. Scent white, Poornima yellow and solo white were found highly suitable for commercial cultivation for the Northern dry zones of Karnataka due high yield and quality of flowers.

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Evaluation of Chrysanthemum (*Dendranthema grandiflora* Tzvelev) Varieties

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Evaluation of Chrysanthemum Cultivars for Cut Flower Production Under Polyhouse Conditions

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ABSTRACT

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is an economically significant ornamental crop with diverse applications including cut flowers, loose flowers and potted plants. This study evaluated the growth and flowering performance of ten chrysanthemum cultivars under polyhouse conditions at the College of Horticulture, Bagalkot. The experiment followed a Randomized Complete Block Design (RCBD) with three replications and data on key parameters such as plant height, spread, primary branches, stem girth, internodal length, flower count, flower diameter and ray floret dimensions were recorded and statistically analyzed. The results demonstrated significant variability among the cultivars. Bontempi excelled in vegetative growth, recording the highest plant height (122.42 cm), plant spread (N-S: 21.84 cm, E-W: 22.83 cm) and flower production (16.42 flowers per plant). Big White stood out for its flower diameter (7.94 cm) and ray floret length (2.82 cm), while Hamilton showed excellent overall growth and floral traits, including plant height (120.78 cm) and ray floret width (1.8 cm). Cultivars such as Arctic Queen and Champagne Yellow also displayed favorable characteristics, including floral quality and adaptability to polyhouse conditions. The findings underscore the influence of genetic potential and controlled environmental conditions on chrysanthemum performance. Cultivars like Bontempi, Hamilton, Arctic Queen, and Champagne Yellow emerged as highly suitable for commercial polyhouse cultivation due to their superior vegetative growth, flower quality and adaptability. This study provided valuable insights for optimizing chrysanthemum production under controlled environments to meet market demands.

Keywords: Chrysanthemum, Commercial, Floral trait, Morphology, Performance, Polyhouse.

INTRODUCTION

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is one of the most important ornamental crops, valued for its aesthetic appeal, diverse floral forms and wide applications in floriculture, including cut flowers, loose flowers and potted plants (Thakur *et al*, 2018; Tomar *et al*, 2022). It belongs to the family Asteraceae and is native to the Northern Hemisphere, particularly Europe and Asia, with China credited for its domestication and early hybridization efforts (Thakur *et al*, 2018). Globally, chrysanthemum ranks as the second most significant cut flower after rose, with the Netherlands, Italy, Colombia and the USA leading in its cultivation, largely under greenhouse conditions (Mandal *et al*, 2024).

In India, chrysanthemum is one of the five most commercially important flower crops identified by the All India Coordinated Floriculture Improvement Project (ICAR). The crop covers an area of approximately 11.05 Mha, with Himachal Pradesh

leading in cut flower production at 4.65 MT, followed by Assam and Haryana. Its commercial cultivation is widespread, primarily in Maharashtra, Rajasthan and Karnataka, as well as urban centers like Bangalore and Pune, where it is grown for decoration, floral arrangements and exhibitions (Mishra *et al*, 2003).

The adoption of polyhouse cultivation has gained traction in recent years, as this method provides a controlled environment that optimizes key growth factors such as light, temperature and humidity. Polyhouses allow year-round production of high-quality blooms, meeting the growing demand in domestic and export markets (Mandal *et al*, 2024). However, the performance of chrysanthemum cultivars under polyhouse conditions can vary significantly based on genetic potential, environmental conditions and management practices. Therefore, evaluating different chrysanthemum cultivars is essential to identify those with superior traits, such as higher yield, better quality and adaptability for polyhouse production.

Table 1. Growth Parameters of Cut Chrysanthemum Varieties Under Open Polyhouse Condition.

Variety	Plant height (cm)	Plant Spread (cm)		Primary branches (no.)	Stem girth (cm)	Internodal length (cm)
		NS	EW			
Bontempi	122.42	21.84	22.83	14.16	0.45	4.94
Bright Orange	114.71	20.63	20.75	8.11	0.88	4.64
Champagne Yellow	117.63	19.53	19.71	9.31	0.74	4.55
Feeling Green Dark	110.84	19.61	20.96	10.47	0.8	4.28
Arctic Queen	120.07	19.81	20.87	9.57	0.69	4.54
Pink Frost	111.82	18.98	19.65	7.94	0.78	4.15
Hamilton	120.78	20.48	21.49	12.69	0.48	4.89
Lollipop Purple	113.94	20.18	19.53	9.29	0.81	4.52
Big White	116.52	20.58	20.76	8.85	0.93	5.16
Lollipop Pink	112.78	19.93	20.69	9.11	0.79	4.6
S.Em ±	1.85	0.278	0.32	0.18	0.01	0.061
CD at 5%	5.51	0.825	0.94	0.522	0.03	0.180

MATERIALS AND METHODS

An experiment was carried out to assess the growth and flowering characteristics of different chrysanthemum cultivars under polyhouse conditions. The trial was conducted in a polyhouse located at the experimental plot of the Floriculture Department, College of Horticulture, Bagalkot, during the 2024–25 period. The site lies at a latitude of 16.18° N, a longitude of 75.7° E and an elevation of 533 meters above mean sea level. The controlled environment of the polyhouse provided favorable conditions for chrysanthemum cultivation, including regulated light, temperature and humidity, which are crucial for flower development.

The cultivars evaluated included Bontempi, Bright Orange, Champagne Yellow, Feeling Green Dark, Arctic Queen, Pink Frost, Hamilton, Lollipop Purple, Big White and Lollipop Pink. The experiment followed a Randomized Complete Block Design (RCBD) with three replications and 36 plants per plot were selected for observation.

Rooted chrysanthemum cuttings were planted inside the polyhouse, with spacing tailored to suit each cultivar's growth habit. Well-decomposed farmyard manure (FYM) was incorporated at a rate of 2 tons per 560 m² of polyhouse area to improve soil fertility and structure. Nutrient management was adjusted according to the specific requirements of each cultivar to support optimal vegetative and reproductive development. A single pinching was performed 45 days after planting to encourage lateral branching and enhance flowering. Artificial lighting was provided for up to eight weeks during periods of insufficient natural

light, ensuring consistent growth and flower production throughout the trial period.

Data were recorded on various growth and floral attributes, including plant height (cm), plant spread in both North–South and East–West directions (cm), number of primary branches, number of flowers per plant, flower diameter (cm), stem girth (cm) and internodal length (cm). Plant height, plant spread and internodal length were measured using a measuring scale, while stem girth and flower diameter were measured with a vernier caliper. The collected data were subjected to statistical analysis to assess the significance of variation among the treatments.

RESULTS AND DISCUSSION

The data pertaining to plant height, plant spread (North–South and East–West directions), number of primary branches, stem girth and internodal length at the grand growth stage (90 d after planting) of different cut chrysanthemum cultivars are presented in Table 1. At this stage, the cultivar Bontempi recorded the significantly highest plant height (122.42 cm), followed by Hamilton (120.78 cm) and Arctic Queen (120.07 cm). Bontempi also exhibited the maximum plant spread, with 21.84 cm in the North–South direction and 22.83 cm in the East–West direction. This was followed by Hamilton with 21.49 cm (E–W) and 20.48 cm (N–S) and Bright Orange with 20.63 cm (N–S) and 20.75 cm (E–W).

In terms of the number of primary branches per plant, Big White recorded the highest (14.16), followed by Hamilton (12.69) and Feeling Green Dark (10.47). Big White also had the greatest stem girth

Evaluation of Chrysanthemum Cultivars for Cut Flower Production Under Polyhouse Conditions

Table 2. Floral traits of cut chrysanthemum varieties under polyhouse condition.

Variety	Number of flower/plant (no.)	Flower diameter (cm)	Disc Diameter (cm)	Ray floret (cm)	
				Length	Width
Bontempi	16.42	4.4	1.8	2.6	1.82
Bright Orange	9.58	5.7	0	1.97	1.27
Champagne Yellow	8.97	6.23	0	2.38	1.23
Feeling Green Dark	11.42	4.5	0	0.92	0.73
Artic Queen	10.62	7.22	0	2.21	1.63
Pink Frost	9.97	5.32	1.9	1.92	1.56
Hamilton	14.76	4.5	1.68	2.4	1.8
Lollipop Purple	11.31	4.97	0	1.91	1.31
Big White	8.31	7.94	0.53	2.82	1.53
Lollipop Pink	10.14	6.1	0	2.08	1.6
S.Em ±	0.140	0.091	0.015	0.030	0.018
CD at 5%	0.42	0.27	0.046	0.090	0.054

(0.93 cm), followed by Bright Orange (0.88 cm). The maximum internodal length was observed in Big White (5.16 cm), followed by Bontempi (4.94 cm).

The data related to flowering parameters, including the number of flowers per plant, flower diameter, disc diameter and the length and width of ray florets at the grand growth stage (90 d after planting) of different cut chrysanthemum cultivars are presented in Table 2. The cultivar Bontempi recorded the maximum number of flowers per plant (16.42), followed by Bontemp (14.76). The largest flower diameter was observed in Big White (7.94 cm), followed by Arctic Queen (7.22 cm). The maximum disc diameter was noted in Bontempi (1.8 cm), followed by Hamilton (1.68 cm).

With respect to ray floret length, Big White recorded the highest value (2.82 cm), followed by Bontempi (2.6 cm). The maximum ray floret width was also recorded in Bontempi (1.82 cm), followed closely by Hamilton (1.8 cm).

Shankar and Tiwari (1993) suggested that plant height is an important criterion for selecting chrysanthemum cultivars. The performance of both standard and spray chrysanthemums was found to be satisfactory with the use of artificial illumination during the Rovan cyclone period for a duration of one month. Suvija *et al* (2016) stated that improved vegetative growth significantly contributes to increased flower yield in chrysanthemum. The

differences in the number of branches among cultivars could be attributed to the genetic makeup of the cultivars and the prevailing environmental conditions, as reported by Bennurmth (2020). Similar variations in branch number were also observed in chrysanthemum by Baskaran *et al* (2004) and Dahiya *et al* (2007).

Joshi *et al* (2009) stated that a higher number of branches may be attributed to the vigorous growth habit of the plant. Variation in internodal length among different varieties was also reported by Kumar *et al* (2014) in chrysanthemum. Differences among standard-type cultivars with respect to the number of flowers produced per plant were observed by Behera *et al* (2002) and Dilta *et al* (2005). The number of flowers per plant ranged from 39.89 to 109.67. Among the ten cultivars studied, the variation observed could be due to inherent genetic factors, as noted by Hemalatha *et al* (1992) in chrysanthemum. These findings are consistent with those reported by Dilta *et al* (2005) and Negi *et al* (2015) in chrysanthemum. Similar variability in the number of flowers per plant among cultivars was also documented by Dahiya *et al* (2007) and Punetha *et al* (2011) in chrysanthemum.

CONCLUSION

Among the chrysanthemum cultivars evaluated, the cultivars Bontempi, Hamilton, Arctic Queen and Champagne Yellow were found to be highly suitable for commercial cultivation under polyhouse conditions due to their superior vegetative growth,

floral traits and flower quality.

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Evaluation of Different Hybrids of *Petunia (Petunia hybrida)* for Growth, Quality and Yield Attributes Under Northern Dry Zone of Karnataka

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ABSTRACT

Petunia hybrida is widely recognized as a valuable and aesthetically pleasing annual flowering plant, holds significant commercial value due to its extended flowering period, making it a popular addition to gardens. The study aimed to evaluate eight different *Petunia* hybrids in terms of vegetative growth, flower quality and yield. The experiment was conducted in a Randomized Block Design with three replications at the Department of Floriculture and Landscape Architecture, College of Horticulture, UHS Bagalkot, Karnataka, during the 2024-25. The *Petunia* hybrids evaluated were White, Burgande, Stars Mixed, Red Star, Rose Star, Crimson Star, Bravo Mix, and Frost Blue. Significant differences were observed for all the parameters. The data revealed that hybrid Rose Star expressed highest plant spread in both direction E-W (65.54cm) and N-S (68.55cm), number of flowers (64.55), number of flower buds (67.58), leaf area (12.03cm²) and chlorophyll content (26.96) followed by Burgande. Maximum plant height was recorded in Frost Blue (26.74cm) followed by Burgande and minimum in Red Star (21.58cm). More number of leaves observed in the Crimson Star (1097.93) and less in White (681.95). Longest peduncle length exhibited by the Frost Blue (3.84cm). Hybrid Burgande (16.10) recorded highest number of branches followed by Rose Star and lowest in Crimson Star (10.72). The largest flower diameter (8.59cm) and flower weight (3.02g) belongs to Crimson Star followed by Stars Mixed. Higher flower yield per plant was recorded in Crimson Star (140.50g) and lower in Red Star (82.63g). The hybrid Bravo Mix expressed lowest plant spread in both direction E-W (54.85cm) and N-S (60.57cm), flower diameter (5.79cm), leaf area (6.07cm²) and chlorophyll content (11.09). Minimum number of flowers (49.46), number of flower buds (51.74), peduncle length (2.60cm) showed in Stars Mixed. Thus, out of 8 hybrids screened, *Petunia* Rose Star found promising for this zone followed by Burgande.

Keywords: Hybrid, *Petunia*, Quality, Vegetative growth, Yield

INTRODUCTION

Floriculture in India is experiencing rapid growth, driven by the country's diverse agro-climatic conditions. Over recent decades, ornamental plants have been cultivated for various purposes including decoration, loose flowers, cut flowers, dried flowers, garden landscape designs and bedding plants as well as for use in the food, pharmaceutical, cosmetic industries and phyto remediation. *Petunia* are now among the most economically significant ornamental plants worldwide. The genus *Petunia* includes about 30 species along with a synthetic garden species *P. hybrida*. Most of the *Petunias* cultivated today are hybrids, known for their short life cycle, wide range of colors, compact size, and ease of growth. *Petunias* are widely favoured as bedding plants due to their

adaptability, diverse varieties and extensive colour range. They are classified into four main groups based on flower size, color and growth habit: multiflora, milliflora, grandiflora and ground cover or spreading types. Additionally, *petunias* are categorized into two primary horticultural forms: the compact upright type which grows to a height of 15–25 cm (6–10 inches) and the sprawling long-stemmed balcony *petunia*, reaching about 46 cm (18 inches) in height, often utilized in hanging baskets and window boxes. These plants exhibit rapid growth and offer a wide array of colors, from pure white to deep crimson or purple, frequently adorned with speckles or veins in contrasting hues. When planting in containers, combining several *petunia* colors can create a vibrant and appealing display.

Petunias thrive in temperate climates and do not tolerate shade. In warm climates, they are grown as perennials. Petunias are quantitative long-day plants, meaning they can flower under any photoperiod, but they bloom faster under longer days. Short photoperiods (8-10 hrs) can delay flowering, slow down stem elongation, and encourage lateral branching. The ideal temperature range for flowering, plant height, and lateral branching is between 10–25°C (Kessler, 1999). Regular fertilization and rich, well-draining soil are essential for optimal blooming, allowing Petunias to flower throughout the season (Hoda and Mona, 2014). Petunias are available in both single-bloom and double-bloom varieties, with flowers about four inches in diameter. Petunia seeds especially rare varieties are often imported from other countries, which makes them quite expensive. Despite their short life cycle of about three to five months, Petunias continue to bloom for up to six months.

Currently, there is limited information on selecting suitable Petunia hybrids for the Northern Dry Zone of Karnataka. Evaluating hybrids for new environments is essential to understand their qualitative and quantitative traits under different climatic conditions. In view of the above facts, assessing the performance of various Petunia hybrids under the specific climatic conditions of Karnataka's Northern Dry Zone is essential for identify the most promising hybrids.

MATERIALS AND METHODS

The experiment was carried out during the 2024–25 period at the experimental farm of the Floriculture Department, College of Horticulture, University of Horticultural Sciences, Bagalkot. Petunia hybrids served as the experimental material. To identify the most suitable hybrids for the region, eight different hybrids were cultivated under open field conditions, employing a Randomized Complete Block Design (RCBD) with three replications. Measurements of plant height and spread were taken using a standard scale. Flower diameter was assessed with a Mitutoyo Vernier Caliper. Leaf chlorophyll content was quantified using a handheld SPAD-502 chlorophyll meter (Minolta, Japan) with three readings per plant per treatment. Leaf area was estimated using the graphical method.

Well-decomposed farmyard manure (FYM) and a prescribed quantity of NPK fertilizers comprising urea, single super phosphate (SSP) and muriate of potash (MOP) were administered to the plants. The nitrogen component was supplied in three stages:

initially as a basal application, followed by two additional doses at 30 and 45 days after planting. Cultural practices such as irrigation, weeding, hoeing and plant protection measures were implemented as needed, adhering to the standard package of practices for the crop (Anonymous, 2014).

RESULTS AND DISCUSSION

The vegetative growth of the petunia hybrids was assessed based on parameters such as plant height (cm), number of branches, plant spread (cm), number of leaves and leaf area (cm²), as detailed in Table 1. The data indicated significant variations across all traits studied. Among the hybrids, 'Frost Blue' exhibited the tallest plants, measuring 26.74 cm, followed closely by 'Burguande' at 25.72 cm and 'Rose Star' at 25.52 cm. In contrast, 'Red Star' had the shortest plant height at 21.58 cm. These differences in plant height are influenced by both genetic factors and environmental conditions, including production techniques and cultural practices. The observed outcomes are consistent with previous studies on various ornamental crops. Syamal and Kumar (2002) and Vikas *et al* (2015) reported similar findings in Dahlia, while Munikrishnappa (2011) and Chowdhuri *et al* (2015) observed comparable results in China Aster and Gladiolus respectively.

A notable variation in leaf production was observed across different hybrid cultivars, highlighting the influence of genetic factors on plant growth. The hybrid Crimson Star exhibited the highest leaf count, averaging approximately 1098 leaves per plant followed by the hybrids Star Mixed and Rose Star with averages of 962 and 896 leaves per plant, respectively. In contrast, the White hybrid had the fewest leaves, averaging about 682 per plant. Plant spread is vital for maximizing sunlight utilization and ensuring the vitality of flower crops. Rose Star produced maximum plant spread with a (N-S) of 68.55cm and (E-W) of 65.54cm which was at par with hybrids Burgande (N-S) of 68.03cm and (E-W) of 64.41cm and Star Mixed (N-S) of 65.34 cm and (E-W) of 63.61cm. This is likely due to the higher number of branches and more vigorous growth in these hybrids. The minimum number of plants spread (N-S) of 60.57cm and (E-W) of 54.85cm was registered in hybrid Bravo Mix this may be likely due to varietal differences and less vigorous growth. Research by Kumar *et al* (2010) and Gupta *et al* (2015) highlighted similar variations in vegetative growth parameters among Dahlia cultivars. In the evaluation of various Petunia hybrids, the hybrid Burgande exhibited the highest average number of branches per plant at 16.10, followed by Rose Star with

Evaluation of Different Hybrids of Petunia (*Petunia hybrida*)

Table 1. Various Vegetative parameters as influenced by different hybrids of Petunia

Cultivar	Plant height (cm)	Plant spread (East-West) (cm)	Plant spread (North-South) (cm)	No of leaves	Leaf area(cm ²)	No of branches
White	23.57	62.43	66.51	681.95	9.30	12.71
Burgande	25.72	64.41	68.03	811.1	9.91	16.10
Stars Mixed	21.77	63.61	65.34	962.02	6.90	11.69
Red Star	21.58	63.56	66.73	783.71	8.03	13.88
Rose Star	25.52	65.54	68.55	895.63	12.03	14.62
Crimson Star	24.33	58.15	64.48	1097.93	7.95	10.72
Bravo Mix	21.71	54.85	60.57	759.84	6.07	12.63
Frost Blue	26.74	60.10	64.48	860.30	7.08	11.70
S.EM(±)	0.54	0.61	0.42	0.67	0.34	0.64
CD (5%)	1.63	1.85	1.28	2.03	1.03	1.95

14.62 and Red Star at 13.88. Conversely, Crimson Star had the fewest branches, averaging 10.72 per plant. An increase in the number of branches typically leads to a higher number of leaves, which in turn enhances flower and tuber yield by improving the source-sink relationship. Regarding leaf area, Rose Star recorded the largest average leaf area at 12.03 cm², closely followed by Burgande at 9.91 cm² and White at 9.30 cm². The hybrid Bravo Mix had the smallest leaf area, averaging 6.07 cm². These variations in leaf area among hybrids may be attributed to genetic differences and growth vigor, as observed in previous studies on Gerbera cultivars by Shruti *et al* (2004) and Anop *et al* (2010).

The assessment of flower characteristics, yield and quality in Petunia hybrids encompassed various parameters including the number of flowers, flower bud count, flower diameter, flower weight, peduncle length, yield per plant and chlorophyll content. These metrics were systematically recorded and are detailed in Table 2. Highest number of buds (67.58) was recorded in hybrid Rose Star followed by hybrids Burgande (62.51) and Frost Blue (57.52). The minimum number of buds (45.51) was observed in hybrid Star Mixed. The maximum number of flowers (64.55) was recorded in hybrid Rose Star followed by hybrid Burgande (59.52) and Frost Blue (54.32). The minimum number of flowers was observed in hybrid Stars Mixed (42.63). A maximum diameter of full bloom (8.59cm) was recorded in hybrid Crimson Star, followed by hybrids Stars Mixed (7.49cm) and Red Star (6.45cm). The minimum diameter of bloom (5.79cm) was observed in hybrid Bravo Mix.

The hybrid Rose Star exhibited the highest bud count at 67.58, followed by Burgande at 62.51 and Frost Blue at 57.52. In contrast, Star Mixed recorded the lowest bud count at 45.51. Regarding flower production, Rose Star also led with 64.55 blooms, while Burgande and Frost Blue had 59.52 and 54.32 blooms, respectively. Star Mixed again had the fewest flowers at 42.63. In terms of bloom diameter, Crimson Star achieved the largest at 8.59 cm, followed by Star Mixed at 7.49 cm and Red Star at 6.45 cm. Bravo Mix had the smallest bloom diameter of 5.79 cm. Peduncle length of (3.83cm) was recorded longest in hybrid Frost Blue which was at par with Crimson star (3.73cm) followed by hybrid Bravo Mix (3.63cm). The shortest length (2.60cm) observed in Stars Mixed hybrid. Weight of flower differed significantly among the hybrids. Hybrid Crimson Star had the highest value (3.02g) followed by Stars Mixed (2.41g) whereas, the lowest weight of flower was recorded with Burgande (1.49g). Leaves play a crucial role in photosynthesis, with chlorophyll content being a key factor influencing growth and flower yield. The results showed that SPAD chlorophyll value was the highest (26.96) in Rose Star hybrid followed by Burgande (23.48) and Crimson Star (23.29). While, the lowest amount of chlorophyll was recorded in Bravo Mix (11.09cm). Yield per plant is more (140.50g) in hybrid Crimson Star followed by Rose Star (121.52g) and White (120.60g). The lowest yield was registered in hybrid Red Star (182.63g).

The increased flower production per plant and overall yield are closely associated with key morphological traits such as plant height, number of branches, leaf area and leaf count. These

Table 2. Various flowering parameters, flower quality and yield attributes as influenced by different hybrids of Petunia

Cultivar	No of flower per plant	No of buds	Diameter of flower (cm)	Peduncle length (cm)	Flower Weight (g)	Yield/plant (g)	Chlorophyll content (SPAD)
White	54.44	57.73	5.90	3.51	2.21	120.60	19.30
Burgande	59.52	62.51	6.19	2.87	1.49	88.47	23.48
Stars Mixed	42.63	45.51	7.49	2.60	2.41	102.86	17.89
Red Star	44.57	47.44	6.45	3.30	1.86	82.63	16.33
Rose Star	64.55	67.58	6.15	3.01	1.88	121.52	26.96
Crimson Star	46.44	49.43	8.59	3.73	3.02	140.50	23.29
Bravo Mix	57.56	60.56	5.79	3.63	1.92	110.33	11.09
Frost Blue	54.32	57.52	6.38	3.83	1.82	98.58	18.72
S.EM(±)	0.13	0.19	0.21	0.13	0.11	0.45	1.89
CD (5%)	0.39	0.59	0.64	0.31	0.34	1.37	5.75

characteristics enhance the plant's photosynthetic capacity leading to greater energy production and consequently, a higher number of larger flowers. Similar findings were observed by Ahmed and Gul (2002) in Dahlia; Munikrishnappa (2013) and Zosiamliana *et al* (2012) in China Aster; Ramachandrudu and Thangam (2010) in Crossandra; Deepti and Anil (2005) in Marigold; Gupta *et al* (2015) in Dahlia; Tirakannanavar *et al* (2015) in China Aster and in Chrysanthemum by Rajiv (2014).

CONCLUSION

It was concluded from this study that among Petunia hybrids, Rose Star was found most suitable for this area of Northern Dry Zone of Karnataka. Hybrids Burgunde and CrimsonStar also performed well.

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Evaluation of Gladiolus Cultivars for Cut Flower Production Under Open Field Conditions

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ABSTRACT

Gladiolus, a widely cultivated ornamental crop is valued for its vibrant spikes and adaptability to diverse climatic conditions. This study evaluated eight gladiolus varieties: Punjab Hybrid, Joshka, Chandavar, Punjab Dawn, Punjab Home, Souvik Biscuits, Pusa Suhagin and Arka Naveen under open-field conditions in the Northern Dry Zone of Karnataka. The experiment, conducted in a Randomized Complete Block Design (RCBD) with three replications, assessed key growth parameters such as plant height, number of leaves, leaf length and leaf area, along with floral traits including spike number, spike length, rachis length, floret count and floret diameter. Significant variability was observed among the varieties for all parameters. Arka Naveen recorded the tallest plants (96.4 cm) and largest leaf area (131.84 cm²), while Souvik Biscuits exhibited the highest number of leaves (12) and longest leaves (53.6 cm). In floral traits, Punjab Hybrid achieved the highest spike production (2.28 spikes per plant) whereas Souvik Biscuits recorded the longest rachis (42 cm). The maximum floret diameter (7.3 cm) was observed in Pusa Suhagin, highlighting its potential for aesthetic and commercial applications. The findings revealed substantial genetic variability among the gladiolus varieties, with Arka Naveen, Souvik Biscuits and Chandavar demonstrating superior growth and floral attributes. These results provide valuable insights for breeders and cultivators, offering a foundation for selecting high-performing varieties suitable for ornamental and commercial purposes. The study underscores the potential for optimizing gladiolus production in agro-climatic zones like Karnataka.

Keywords: Cultivar, Floral traits, Floret diameter, Genetic Variability, Gladiolus, Growth, Leaf area, Spike production.

INTRODUCTION

Gladiolus is a highly attractive bulbous cut-flower crop known for its large, well-textured and vividly colored spikes, which are in high demand in both international and domestic markets. In recent years, the demand for gladiolus has surged due to its ability to endure long-distance shipping and its wide range of colors, including blue, white, red, yellow, pink, mauve and various combinations. Gladiolus spikes are primarily used for garden displays, interior decoration and bouquet arrangements (Chadha and Sood, 2007). Globally, the total area under bulbous ornamentals is approximately 50,000 hectares, with gladiolus occupying around 9,500 ha. Major gladiolus-growing countries include the Netherlands, the UK, the USA, Japan, South Africa and Australia. The USA is a major producer of gladiolus, exporting 6.5 million gladiolus spikes annually while importing approximately 13 million cut stems per year (Kearney *et al*, 2004). In India, gladiolus is grown over an area of

25,000 ha, producing around 753 lakh spikes. It is commercially cultivated in several states, including West Bengal, Himachal Pradesh, Karnataka, Uttar Pradesh, Punjab and New Delhi (Rani *et al*, 2007). In Karnataka, gladiolus is grown throughout the year, particularly in the tropical regions of the state, where the favorable climate supports its cultivation. The state's climate, characterized by moderate temperatures and well-drained soils, provides optimal conditions for growing gladiolus. Major cultivation areas in Karnataka include regions with both open-field and controlled polyhouse conditions, where the crop is evaluated for its adaptability and flower quality. Gladiolus, with its rich varietal diversity, continues to see the introduction of new cultivars each year. As a result, evaluations of various gladiolus cultivars are regularly conducted to determine their suitability for growth in Karnataka's diverse agro-climatic zones (Krishnappa *et al*, 2015).

Table 1: Growth Performance of Gladiolus Varieties Evaluated Under Open Field Conditions.

Variety	Plant height (cm)	Number of leaf/plant (number)	Leaf length (cm)	Leaf area (cm ²)
Punjab Hybrid	75.5	11	44	80.78
Joshka	84	11	42	99.96
Chandavar	86.4	8	46	118.86
Punjab Dawn	95	10	47	124.64
Punjab Home	78	10	39	95.47
Souvik Biscuits	94.6	12	53.6	109.34
Pusa Suhagin	76.5	10	35	69.02
Arka Naveen	96.4	9	52.4	131.84
S.Em ±	1.510	0.132	0.479	1.63
CD at 5%	4.581	0.400	1.453	4.929

MATERIALS AND METHODS

The experiment was conducted at the Department of Floriculture and Landscape Architecture, College of Horticulture, Bagalkot, Karnataka, located in the Northern Dry Zone of Karnataka. The experimental site is positioned at a latitude of 16.18° N, a longitude of 75.7° E and an elevation of 533 meters above mean sea level. This region is characterized by semi-arid climatic conditions with moderate rainfall and distinct summer and winter seasons, making it highly suitable for gladiolus cultivation. The study was laid out in a Randomized Complete Block Design (RCBD), involving eight gladiolus varieties as treatments, each replicated thrice. The varieties selected for evaluation included Punjab Hybrid, Joshka, Chandavar, Punjab Dawn, Punjab Home, Souvik Biscuits, Pusa Suhagin and Arka Naveen. The plot layout was designed with a spacing of 30 cm between rows and 20 cm between plants, resulting in a population of 20 plants per plot. Uniform and healthy corms, free from pests and diseases, were carefully selected for planting to ensure consistent growth and accurate results.

All cultural practices were uniformly implemented across all treatments. The soil was thoroughly ploughed, leveled and raised beds were prepared to ensure proper drainage. Fertilization included a basal dose of NPK at 30:20:30 kg/ha, applied at planting, with nitrogen applied in two equal splits at 30 and 60 days after planting. Regular irrigation was provided at intervals of 7–10 days, depending on soil moisture levels. Manual weeding was carried out periodically to maintain weed-free plots. Plant protection measures were followed as per recommendations to control pests and diseases,

ensuring optimal crop growth and health. The observations were recorded from five randomly selected plants per treatment and the data were averaged to evaluate various growth and floral parameters. Growth parameters included plant height (cm), the number of leaves per plant, leaf length (cm) and leaf width (cm). Floral parameters assessed were the number of spikes per plant, spike length (cm), rachis length (cm), number of florets per spike and floret diameter (cm).

Instruments used for data collection included a measuring tape for assessing plant height, leaf length and width, a measuring scale for measuring spike and rachis lengths and a vernier caliper for recording floret diameter.

RESULTS AND DISCUSSION

Growth Parameters

The data on plant height, number of leaves per plant and leaf length (Table 1) revealed that the variety Arka Naveen exhibited the maximum plant height (96.4 cm) followed by Punjab Dawn (95 cm). The minimum plant height was recorded in Pusa Suhagin (75.5 cm). The variation in plant height could be attributed to genetic potential as reported by various studies on gladiolus growth patterns. Similar findings were observed by Meena *et al* (2016) in gladiolus varieties, where genetic variability significantly influenced plant height. The maximum number of leaves per plant (12) was recorded in Souvik Biscuits, whereas the minimum was observed in Chandavar (9). The variation in the number of leaves per plant could be due to the inherent genetic potential of the different cultivars, which influences leaf production and overall plant architecture. This is consistent with the findings

Evaluation of Gladiolus Cultivars for Cut Flower Production Under Open Field Conditions

Table 2: Floral Characteristics of Gladiolus Varieties Evaluated Under Open Field Conditions.

Variety	Number of spikes/plant (number)	Spike length (cm)	Rachis Length (cm)	Number of floret/spike (no.)	Floret diameter (cm)
Punjab Hybrid	2.28	49.6	25	10	5.2
Joshka	1.13	52	19	11	4.6
Chandavar	1.78	56	18	10	4.8
Punjab Dawn	1.13	48	20	12	5.1
Punjab Home	1.11	53	15.5	10	5.4
Souvik Biscuits	1.68	54.3	42	11	6.5
Pusa Suhagin	1.13	37	25.8	12	7.3
Arka Naveen	2.17	48.4	23	9	4.9
S.Em $\pm$	0.026	0.91	0.34	0.171	0.10
CD at 5%	0.078	2.29	1.04	0.518	0.30

of Swaroop (2015), who also observed variability in leaf number among gladiolus cultivars.

The maximum leaf length (53.6 cm) was recorded in Souvik Biscuits, followed by Arka Naveen (52.4 cm). The minimum leaf length was observed in Pusa Suhagin (35 cm). This significant variation could be attributed to the differences in the genetic makeup of the varieties, affecting the leaf development process. These findings were consistent with Mushtaq *et al.* (2018), who reported significant differences in leaf length across gladiolus cultivars. The maximum leaf area (131.84 cm²) was recorded in Arka Naveen, followed by Punjab Dawn (124.64 cm²). The minimum leaf area was observed in Pusa Suhagin (69.02 cm²).

Floral Parameters

The number of spikes per plant showed significant variation among the gladiolus cultivars. The highest number of spikes per plant was observed in Punjab Hybrid (2.28), Arka Naveen (2.17), while the lowest number of spikes per plant was recorded in Punjab Home (1.11). This variation in spike numbers can be attributed to the genetic differences among the cultivars, as noted by Rani *et al.* (2007), who highlighted the genetic potential's role in determining spike production.

Spike length also varied significantly among the gladiolus cultivars. The highest spike length was recorded in Chandavar (56 cm), followed by Souvik Biscuits (54.3 cm) and the lowest spike length was recorded in Pusa Suhagin (37 cm). This variation in spike length can be attributed to the genetic differences between cultivars, as supported by Islam *et al.* (2017) and Chourasia *et al.* (2015), who observed similar results, emphasizing the role of genetic potential in determining spike length in gladiolus.

The rachis length of gladiolus cultivars exhibited significant variation, with the maximum rachis length recorded in Souvik Biscuits (42 cm), followed by Pusa Suhagin (25.8 cm) and Punjab Hybrid (25 cm). The shortest rachis length was observed in Punjab Home (15.5 cm). This variation in rachis length can be attributed to the genetic traits of the cultivars and their interaction with environmental conditions. Swaroop (2015) also reported significant differences in rachis length among gladiolus cultivars due to both genetic and environmental factors. Regarding the number of florets per spike, significant differences were observed among gladiolus cultivars. The maximum number of florets per spike was recorded in Pusa Suhagin (12), Punjab Dawn (12) and followed by Joshka (11) and Souvik Biscuits (11), while the minimum number of florets per spike was recorded in Arka Naveen (10). The variation in the number of florets per spike can be attributed to the genetic potential of the cultivars. Similar findings were reported by Meena *et al.* (2016), who noted the significant role of genetic variability in determining the number of florets per spike in gladiolus.

The floret diameter also showed significant variation among gladiolus cultivars. The maximum floret diameter (7.3 cm) was observed in Pusa Suhagin, while the minimum floret diameter (4.6 cm) was recorded in Joshka. Other cultivars had floret diameters ranging from 4.8 cm (Chandavar) to 6.5 cm (Souvik Biscuits). The variation in floret diameter can be attributed to the inherent genetic differences of the cultivars, which influence their flower morphology. These findings are consistent with earlier reports indicating that genetic factors play a crucial role in determining the flower size in gladiolus (Chopade, 2011; Singh *et al.*, 2017).

CONCLUSION

The study demonstrated substantial variability in growth and flowering traits among gladiolus varieties, providing essential insights for selecting high-performing cultivars. Varieties like Arka Naveen, Souvik Biscuits and Chandavar exhibited superior growth and floral attributes, making them suitable for ornamental and commercial purposes. These findings serve as a valuable resource for growers and breeders to enhance gladiolus cultivation practices.

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Evaluation of Indigenous Endophytic *Beauveria bassiana* UHSB-END1 against Grape Mealy Bug *Maconellicoccus hirsutus* (Green)

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ABSTRACT

Grapes (*Vitis vinifera*), a crop of immense global importance, are cultivated for various purposes, including fresh consumption and processed products. However, grape cultivation faces critical challenges from insect pests such as mealybugs (*Maconellicoccus hirsutus*), which cause severe yield and quality losses, increase pesticide dependence and contribute to environmental degradation. Sustainable pest management strategies, such as the use of entomopathogenic fungi, has emerged as promising alternative to chemical pesticides, addressing these challenges while supporting eco-friendly agricultural practices. This study assessed the efficacy of endophytic *Beauveria bassiana* UHSB-END1, as a biological control agent against mealybugs in Thompson Seedless grapevines. Field experiment employed soil drenching, foliar sprays and combination of both treatments. The combination treatment having the highest efficacy of 96.79% reduction compared to untreated controls, while foliar sprays and soil drenching individually showed notable pest suppression. The integration of biological controls into pest management programs not only minimizes environmental impacts but also supports biodiversity and long-term vineyard health. To further enhance its applicability, optimization of *B. bassiana* formulations and delivery methods is recommended to ensure consistent performance across varying climatic conditions.

Keywords: *Beauveria bassiana*, Biological Control, Endophyte, Grape, Mealy bugs.

INTRODUCTION

Grapes (*Vitis vinifera*) are among the most extensively cultivated and economically important fruit crops worldwide, with a history of cultivation spanning several millennia (Singh and Singh, 2024). Originating in the Near East, grapes are now grown across diverse climatic zones, from temperate to subtropical regions, serving as the cornerstone for wine production, fresh consumption and processed goods such as raisins, juices and jams (This *et al.*, 2006). Beyond their commercial significance, grapes are highly valued for their phytochemical composition, which has become a focal point of research due to its health-promoting properties (Singh and Kaur, 2018). They are rich in bioactive compounds such as phenolic acids, flavonoids, tannins and stilbenes (e.g., resveratrol), which exhibit antioxidant, anti-inflammatory and cardioprotective effects (Kandyli, 2021). These compounds not only contribute to the sensory and nutritional quality of grape-based products but also support their role in addressing global health and wellness concerns.

Grapes have also emerged as a model system for studying plant physiology and stress responses due to their sensitivity to environmental stressors, including drought, salinity and temperature fluctuations. Advances in genomics and transcriptomics have facilitated significant progress in grapevine breeding programs, enabling the development of varieties with enhanced biotic and abiotic stress tolerance, higher yields and superior quality traits (Ollat *et al.*, 2018). As the demand for sustainable agriculture and functional foods continues to rise, the multidisciplinary study of grapes offers insights into their biological, nutritional and ecological significance.

However, grape production faces substantial challenges from insect pests, which threaten both the quality and quantity of yields. Pests such as the Mealybugs (*Maconellicoccus hirsutus*), Thrips (*Frankliniella occidentalis*) Grapevine Moth (*Lobesia botrana*) and Grape Phylloxera (*Daktulosphaira vitifoliae*), cause extensive damage to vines by feeding on leaves, stems, flowers and fruit, thereby impairing

photosynthesis, reducing fruit set and rendering produce unmarketable (Mani *et al*, 2008). In addition to direct economic losses, pest infestations increase production costs through higher pesticide usage, which often leads to pesticide resistance, environmental contamination and harm to beneficial organisms (Shabeer *et al*, 2022; Shabeer *et al*, 2024). Long-term effects of pest outbreaks, such as vineyard destruction by phylloxera or secondary infections like *Botrytis* bunch rot, further compound these issues (Granett *et al*, 2001). The socioeconomic implications are particularly acute for smallholder farmers lacking access to integrated pest management (IPM) or advanced pest control strategies. Yield reductions and quality deterioration can result in lower market prices, reduced income and financial instability. Effective pest management, emphasizing biological controls, resistant cultivars and precision agriculture technologies, is crucial for minimizing these impacts (Sinno *et al*, 2021).

Among biological control methods, entomopathogenic fungi such as *Beauveria bassiana* have garnered attention for their eco-friendly pest management capabilities. *B. bassiana* infects pests through spore contact, employing enzymes like chitinases and proteases to penetrate the host cuticle and proliferate internally, ultimately causing death (Vega, 2018). This fungus has demonstrated efficacy against various pests, including mealybugs, aphids and grapevine moths, making it a valuable tool in IPM strategies (Faria and Wraight, 2007). Studies indicate its effectiveness in managing mealybugs, which are vectors for grapevine leafroll-associated virus (GLRaV), thereby improving grapevine health and yield (Pietersen *et al*, 2017). Furthermore, *B. bassiana* formulations can be optimized for diverse climatic conditions, enhancing their application in varied agricultural systems (Inglis *et al*, 2001). Despite these advantages, environmental factors such as temperature, humidity and UV exposure can influence its field performance, necessitating improved delivery systems and formulation technologies (Jaronski, 2010; Yogananda *et al*, 2023). The adoption of *B. bassiana* offers economic and ecological benefits, including reduced pesticide residues, enhanced biodiversity and alignment with consumer demand for sustainable agricultural practices. The integration of biological controls like *B. bassiana* (UHSB-END1) into insect pest management programs represents a promising step toward sustainable grape production. By mitigating the negative impacts of pests while reducing dependence

on chemical pesticides, these strategies hold potential for improving the resilience, productivity and environmental sustainability of viticulture systems globally.

MATERIALS AND METHODS

A study was conducted to evaluate the endophytic nature of *B. bassiana* and its efficacy against major insect pests of grape at Main Horticultural Research and Extension Centre, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka (16.16°N, 75.61°E and 563 m above MSL) during October, 2023 to February, 2024. Grape variety Thompson Seedless was used for field level studies. The crop was maintained according to the package of practice of University of Horticultural Sciences, Bagalkot. The treatments were imposed after 10 days of forward pruning. Five treatments with four replications were laid out in a Randomized Block Design (RBD) (Table 1). The treatments were imposed after 10, 30, 60 and 90 days after forward pruning. Observations on mealy bug colonies (adults and nymphs) were recorded and expressed as number per vine. Three vines were selected randomly in each replication, in each vine top, middle and bottom leaves were selected for recording observation on pest population. For mealybugs pre-treatment counts was made a day before treatment and post treatment counts was made at 3, 7 and 10 days after application of treatments.

Further, the Henderson and Tilton (1955) formula was used to calculate the reduction in pest population over control.

$$\text{Reduction in pest population (\%)} = 100 \times \left[1 - \left(\frac{T_a \times C_b}{T_b \times C_a} \right) \right]$$

Where, T_a = Population in treatment plot after spray

C_a = Population in control plot after spray

T_b = Population in treatment plot before spray

C_b = Population in control plot before spray

Statistical analysis

The data on mealy bug colonies was subjected to square root transformation was analysed by ANOVA of the randomised complete block design and means were compared at $p \leq 0.05$ CD using Duncan's multiple range test (DMRT). Web Based Agricultural Statistics Software Package (WASP v. 2.0) was used for all the statistical analysis.

RESULTS AND DISCUSSION

First and second application

There were no mealybug colonies during first and second application of treatments. The distribution of mealybug colonies among the different treatment a day before the imposition of treatment was uniform with non-significant difference. The application of *B. bassiana* treatments in early stages of plants as propellant method under the field level. In the present study, there was no mealybug colonies during bud initiation period after forward pruning (October 2023) might be due to lesser vegetative and reproductive growth of plants and also unfavorable environmental conditions like high rain fall, low temperature and high relative humidity which led to absence of insect pest population during first and second application of treatments. However, after panicle initiation and fruit setting the mealybugs infestation gradually increased. Application of *B. bassiana* UHSB-END1 treatments at regular interval during crop growth till harvesting led to the decline in mealy bug population in the early phase.

Third application

There was significant reduction in mealybug colonies with compared to untreated control in three days after treatment imposition. Among the different treatment the lowest mealybug colonies was noticed in combination treatment (5.00 per vine) which followed by foliar spray (5.25 mealybugs per vine), soil drenching (5.75 mealybugs per vine) and recommended package of practices with 5.75 per vine. The untreated control again recorded highest mealy bug colonies (7.50 per vine). Application of treatments (7 DAT) significantly reduced grape mealybug colonies was found in combination treatment (4.25 per vine). The soil drenching (5.00 per vine) and foliar spray (4.75 per vine) treatment both are on par with other. The recommended package of practices was recorded 5.50 mealybugs per vine. However, they were significantly superior over untreated control which registered 7.75 mealybugs per vine. The combination treatment consistently proved to be superior over other treatment recording 3.25 mealy bugs per vine (10 DAT) and followed by foliar spray with 4.25 per vine. The soil drenching (4.50 per vine) was on par with recommended package of practices by registering 5.25 mealybugs per vine, however found to be superior over untreated control which recorded 8.25 mealybugs per vine.

Fourth application

One day before the imposition of the treatment during fourth application, significantly highest

mealybug colonies were observed untreated control (8.75 per vine) followed by recommended package of practices (5.50 per vine). The lowest thrips population was noticed in combination of treatments (2.75 mealybug colonies/vine). Three days after treatment, there was significant variation among different treatments. The combination treatment was on top by recording 1.75 mealy bug colonies per vine. The foliar spray with 2.50 mealy bug colonies per vine, soil drenching with 3.50 mealy bug colonies per vine and recommended package of practices with 5.00 mealy bug colonies per vine were significantly superior over untreated control (9.50 mealybug colonies/vine). After the imposition of treatments (7 DAT) significantly lowest mealybug colonies were noticed in combination treatment (1.00 per vine). Followed by, foliar spray (1.50 per vine), soil drenching (2.25 mealybug colonies/vine) and recommended package of practices (4.25 mealybug colonies/ vine) which differed statistically with each other and were significantly superior over untreated control (10.25 per vine). Ten days after fourth application of treatments, the combination treatment proved to be the best among other treatments with lowest mealybug colonies (0.25 per vine). The foliar spray and soil drenching were on par with other by recording 0.75 and 1.50 thrips per three leaves, respectively. Recommended package of practices was significantly inferior over other treatment by registering 3.50 mealybug colonies per vine. However, found to be superior over untreated control which recorded 10.75 mealybugs per vine.

Per cent population reduction over control

Overall reduction of the thrips population over the control was calculated and it was observed that, the highest population reduction was achieved in combination of treatments with 96.79 per cent. Whereas, foliar spray with 91.20 per cent followed by soil drenching 83.81 per cent. However, minimum of 62.23 per cent reduction was observed in recommended package of practices. The indigenous isolate *B. bassiana* UHSB-END1 effectively colonized various grape leaf tissues across different planting material. In this study, a strong symbiotic relationship was observed between the endophytic isolate and the grape plants during the active growth phase, regardless of the colonization method used (soil drenching, foliar spray or a combination). The highest colonization rates were recorded during the early stages of plant growth. (Jaber, 2015; Mantzoukas, 2021).

These results are in line with findings of Rondot and Reineke (2018) who reported the reduction in grape mealy bug infestation by Endophytic *B.*

Table 1: Treatment details for evaluation of *B. bassiana* UHSB-END1 against mealy bugs under field conditions.

Treatment	Detail	Dosage
T ₁	Soil drenching	10g/le
T ₂	Foliar Spray	5g/l
T ₃	Combination of treatments	10+5g/l
T ₄	Recommended package of practices of UHS, Bagalkot	—
T ₅	Untreated control	—

Table 2: Bio-efficacy of *Beauveria bassiana* UHSB-END1 against grape mealy bug (*Maconellicoccus hirsutus*) during 2023-24 (third application)

Treatment	Dosage (g/ml)	Number of mealy bug population (per vine)				
		1 DBT	3 DAT	7 DAT	10 DAT	Mean
T ₁ - Soil drenching	10	6.25 (2.49)	5.75 (2.39) ^b	5.00 (2.23) ^{bc}	4.50 (2.12) ^{bc}	5.38
T ₂ - Foliar spray	5	5.75 (2.39)	5.25 (2.29) ^b	4.75 (2.18) ^{bc}	4.25 (2.06) ^c	5.00
T ₃ - Combination of treatments (T ₁ +T ₂)	10+5	5.25 (2.28)	5.00 (2.23) ^b	4.25 (2.06) ^c	3.25 (1.80) ^d	4.44
T ₄ - Recommended package of practice	-	6.25 (2.49)	5.75 (2.40) ^b	5.50 (2.34) ^b	5.25 (2.29) ^b	5.69
T ₅ - Untreated control	-	7.25 (2.69)	7.50 (2.73) ^a	7.75 (2.79) ^a	8.25 (2.87) ^a	7.69
S. Em ±	-	-	0.09	0.09	0.01	-
C. D. at 5%	-	-	0.24	0.24	0.20	-
CV (%)	-	-	6.45	6.70	5.74	-

Table 3: Bio-efficacy of *Beauveria bassiana* UHSB-END1 against grape mealy bug (*Maconellicoccus hirsutus*) during 2023-24 (fourth application)

Treatment	Dosage (g/ml)	Number of mealy bug population (per vine)				
		1 DBT	3 DAT	7 DAT	10 DAT	Mean
T ₁ - Soil drenching	10	4.25 (2.06) ^c	3.50 (1.87) ^c	2.25 (1.65) ^c	1.50 (1.40) ^c	2.88
T ₂ - Foliar spray	5	3.75 (1.93) ^c	2.50 (1.57) _{cd}	1.50 (1.40) _{cd}	0.75 (1.10) _{cd}	2.13
T ₃ - Combination of treatments (T ₁ +T ₂)	10+5	2.75 (1.65) ^d	1.75 (1.31) ^d	1.00 (1.18) ^d	0.25 (0.84) ^d	1.44
T ₄ - Recommended package of practice	-	5.50 (2.34) ^b	5.00 (2.23) ^b	4.25 (2.18) ^b	3.50 (2.00) ^b	4.56
T ₅ - Untreated control	-	8.75 (2.96) ^a	9.50 (3.08) ^a	10.25 (3.28) _a	10.75 (3.35) _a	9.81
S. Em ±	-	0.09	0.11	0.13	0.01	-
C. D. at 5%	-	0.24	0.29	0.35	0.20	-
CV (%)	-	7.10	9.49	11.85	5.74	-

bassiana. The *B. bassiana* was detected as an endophyte in mature grapevine plants up to five weeks after last application with significant reduction of infestation with grape leafhopper. Moloinyane and Nchu (2019) noticed the reduction of mealy bugs incidence in grape plant due the volatile compounds produced by endophytic *B. bassiana*. Kanitkar *et al* (2020) evaluated the bio-efficacy of Brigade-BL (*B. bassiana*) under field conditions as an entomopathogenic fungi mealy bugs (*M. hirsutus*) on Thompson Seedless grapes during 2014-15, wherein they found the drastic reduction in mealy bug

population to the tune of 67.82 per cent in the foundation pruning compared to untreated control. Sayed *et al* (2020) highlighted the regional specificity of isolates and reported on the virulence of two EPF isolates, Bb-Taif1 and Bb-Taif2, when colonized endophytically in grapevine. Among the two, Bb-Taif1 was more effective and caused higher mortality in the aphid *A. illinoisensis* compared to Bb-Taif2. Similarly, Rasool *et al* (2021) demonstrated that colonization by *M. robertsii* and *B. bassiana* significantly reduced the population of the two-spotted spider mite 15 days after infestation.

Evaluation of Indigenous Endophytic *Beauveria bassiana* UHSB-END1 against Grape Mealy Bug

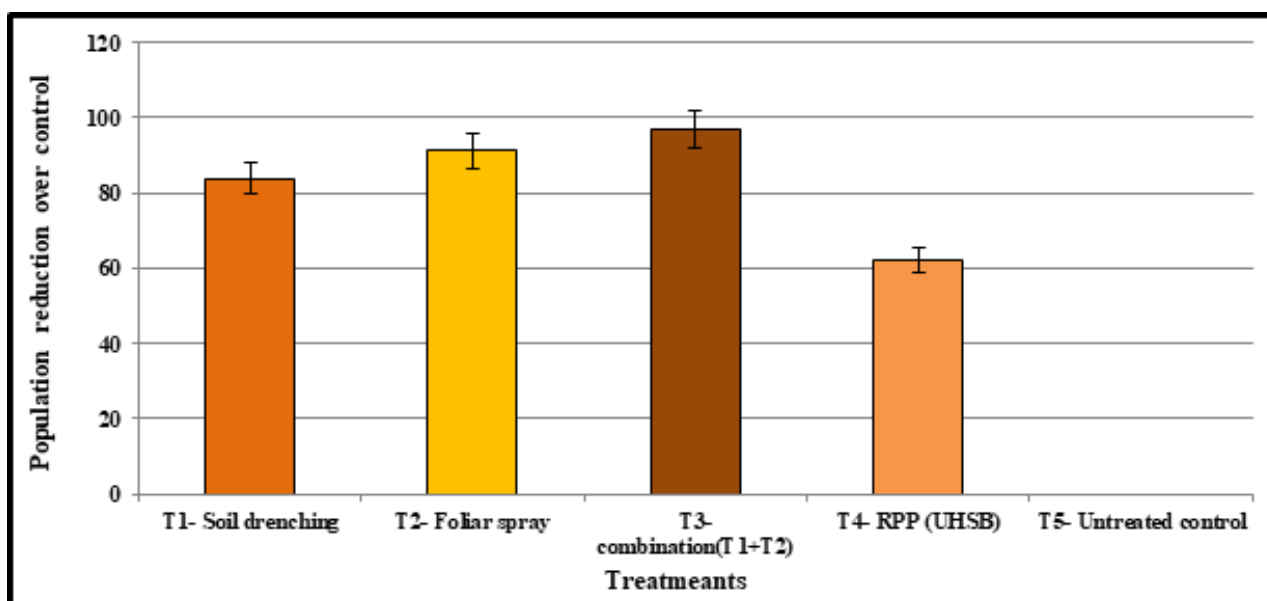


Fig. 1: Influence of endophytic *Beauveria bassiana* UHSB-END1 in reducing mealybug population over control

CONCLUSION

This study reinforced the critical role of entomopathogenic fungi in fostering resilience and sustainability in viticulture systems, providing a pathway for more environmentally conscious and economically viable grape production. The efficacy of *Beauveria bassiana* UHSB-END1 as a potential biological control agent against grape mealybug (*Maconellicoccus hirsutus*), achieving a reduction in pest population. The endophytic colonization of grapevine tissues by *B. bassiana* further enhanced plant resilience, aligning with sustainable agricultural practices. Environmental factors such as temperature and humidity influenced pest dynamics, suggesting the need for improved formulations for broader applicability. These findings support the integration of *B. bassiana* UHSB-END1 into Integrated Pest Management (IPM) strategies to enhance grapevine health, reduce environmental impacts and promote sustainable viticulture. Future research should explore its optimization under diverse climatic conditions for long-term viability.

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Evaluation of Marigold Varieties for Growth and Quality Parameters

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ABSTRACT

The present study was carried out in Northern Dry Zone of Karnataka during the 2024–25 at the Experimental Farm of the Department of Floriculture and Landscape Architecture, College of Horticulture, University of Horticultural Sciences, Bagalkot, to evaluate the performance of seven marigold varieties: M Yellow, Girland, Arka Pari, Pusa Narangi Gaiinda, Pusa Basanti Gaiinda, Arka Shubha, and Arka Abhi. The trial followed a Randomized Block Design (RBD) with three replications, and data were collected on various growth and quality parameters. Among the varieties assessed, Pusa Basanti Gaiinda demonstrated the best overall performance. It recorded the greatest plant height (86.67 cm), widest plant spread (East-West: 71.33 cm; North-South: 78.69 cm), and highest number of branches per plant (12.83). It also showed the maximum stem girth (25.75 mm), individual flower weight (8.85 g), and flower diameter (55.42 mm). Notably, it had the longest shelf life (5.50 days), enhancing its market value. These results indicate that Pusa Basanti Gaiinda is particularly well-suited for cultivation in the Northern Dry Zone of Karnataka, offering high potential for commercial floriculture in regions with similar climatic conditions.

Key Words: Growth, Marigold, Northern Dry Zone, Pusa Basanti Gaiinda, Quality

INTRODUCTION

Marigold is cultivated across nearly all states in India, covering an area of 66.13 thousand hectares and yielding 603.18 thousand metric tons of loose flowers. Karnataka holds the position of the second leading marigold-growing state in the country, with cultivation spread over 12.10 lakh units of land and a flower yield reaching 87.34 lakh units in quantity. It is surpassed only by Madhya Pradesh, where marigold is grown more extensively, covering 14 lakh land units and generating an output of 94 lakh units. Other states where marigold is grown on a commercial scale include Gujarat, Andhra Pradesh, Haryana, West Bengal, and Maharashtra (Anonymous, 2018).

Marigolds are mainly grown for their aesthetic beauty, wide range of forms and colours, as well as for industrial purposes. They are used in decoration, adornment, and landscape enhancement. The continuous pursuit of improved genotypes and varieties fuels the assessment of existing types to attain optimal flower yield, quality, and diversity. Marigold (*Tagetes* spp.), often referred to as 'Gaiinda' or a flower without a receptacle, is a highly favored and adaptable ornamental plant belonging to the Compositae family.

Marigolds are widely grown for their eye-catching blooms, vivid colors, attractive form, and wide range of sizes, shapes, and structures (Naik *et al*, 2019). They are believed to have originated in regions of Central and South America, with Mexico considered their primary center of origin. The genus name *Tagetes* is derived from 'Tages,' a mythological demigod admired for his beauty. This genus comprises approximately 33 species. Marigolds are mainly grouped into two categories: African marigolds and French marigolds (Yadav *et al*, 2015). African marigolds are diploid, containing 24 chromosomes, while French marigolds are tetraploid with 48 chromosomes. Other notable species in the *Tagetes* genus include *T. tenuifolia*, *T. lacera*, *T. limmonni*, *T. lucida*, *T. minuta*, and *T. pusilla*.

MATERIALS AND METHODS

The current study was undertaken during the Rabi season, from October 2024 to January 2025. The experiment was designed using a Randomized Block Design (RBD) with three replications and included seven marigold varieties: M Yellow, Girland, Arka Pari, Pusa Narangi Gaiinda, Pusa Basanti Gaiinda, Arka Shubha, and Arka Abhi. Seeds were initially sown in pro trays filled with cocopeat in September. After about

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a month, when seedlings developed three to four leaves, they were transplanted at a spacing of 45 cm × 30 cm. Recommended agronomic practices and pest management techniques were applied as needed throughout the growing period. Data collection was carried out 90 days after transplanting by selecting five plants at random from each replication for each variety. The recorded data were used to compute mean values for all traits studied, and statistical analysis was conducted using OPSTAT software.

RESULTS AND DISCUSSION

Growth parameters

Growth parameters such as plant height, spread, stem girth, and leaf length and width were recorded in marigold varieties at the grand growth stage. The results revealed significant differences in plant height among the varieties, which ranged from 29.89 cm to 86.67 cm. The tallest plant, measuring 86.67 cm, was found in the Pusa Basanti Gaiinda variety (Table 1), making it the most superior, followed by Arka Shubha at 81.44 cm. The shortest plant height, at 29.89 cm, was observed in the M Yellow variety. This variation in plant height is likely due to the genetic makeup of the varieties, which affects meristematic activity, cell division, and elongation during early growth, as well as the synthesis of phytohormones and the influence of environmental conditions. Similar results were obtained by Mahanta *et al* (2020), Prateeksha *et al* (2024), and Bhusaraddi *et al* (2022).

The plant spread in the East-West direction varied between 26 cm and 71.33 cm. Pusa Basanti Gaiinda exhibited the largest spread (71.33 cm) (Table 1), followed by Arka Shubha (65.78 cm) and Arka Abhi (55.00 cm). In the North-South direction, Pusa Basanti Gaiinda also showed the greatest spread (78.69 cm), followed by Arka Abhi (67.89 cm). The M Yellow variety had the smallest spread in both directions, with 26.00 cm in the East-West direction and 28.36 cm in the North-South direction. These variations are likely due to the genetic potential of the varieties, which influence the number of branches produced, as well as the impact of climatic conditions. Similar findings were reported by Naik *et al* (2019), Shilpa *et al* (2022), and Bhusaraddi *et al* (2022).

The number of primary branches varied from 5.50 to 12.83, with Pusa Basanti Gaiinda having the highest number (12.83) (Table 1), followed by Arka

Shubha (9.61) and Arka Abhi (7.33). The lowest number of primary branches was recorded in M Yellow (5.50). Secondary branches ranged from 16 to 23.12, with Pusa Basanti Gaiinda again showing the highest number (23.12), followed by Arka Shubha (22.33) and M Yellow (20.5). The fewest secondary branches were observed in Arka Abhi (16). These variations are likely due to the genetic makeup of the varieties, which influence photosynthesis rates and, in turn, the number of branches produced, as well as the effect of environmental factors that affect light interception. Similar results were observed by Palthe *et al* (2019), Prateeksha *et al* (2024), and Sharma *et al* (2021).

Leaf length ranged from 14.56 cm to 8.99 cm, with Pusa Basanti Gaiinda having the longest leaf length (14.56 cm). Pusa Narangi Gaiinda followed with a leaf length of 10.16 cm (Table 1). On the other hand, Arka Abhi had the shortest leaf length (8.99 cm). The leaf width varied between 13.56 cm and 5.67 cm, with the widest leaves observed in Pusa Basanti Gaiinda (13.56 cm), which was significantly greater than the other varieties. Following this, Pusa Narangi Gaiinda (9.00 cm), Arka Shubha (7.44 cm), and Girland (6.82 cm) showed the next highest leaf widths. The variety Arka Pari had the narrowest leaves, measuring just 3.48 cm. The differences in leaf length and width across varieties may be attributed to their genetic makeup, which influences the number of branches and, subsequently, the number of leaves produced. Similar results were reported by Sharma *et al* (2021) and Shilpa *et al* (2022).

The highest stem girth was recorded in Pusa Basanti Gaiinda (25.75 mm), followed by Arka Abhi (16.37 mm), Arka Pari (15.78 mm), and Arka Shubha (15.23 mm) (Table 1). In comparison, Pusa Narangi Gaiinda had a stem girth of 14.65 mm, while the lowest stem girth was observed in Girland (9.93 mm). This variation is likely due to the genetic characteristics of the varieties, which influence cell division in the lateral meristem, as well as the varieties' adaptability to the climate, leading to differences in stem girth. Similar findings were reported by Mahanta *et al* (2020) and Chethan *et al* (2024).

Quality Parameters

The fresh weight of flowers ranged from 8.85 g to 4.77 g, with Pusa Basanti Gaiinda having the highest fresh weight (8.85 g), followed by M Yellow (Table 2). The lowest fresh weight was recorded in Arka Pari

Evaluation of Marigold Varieties for Growth and Quality Parameters

Table 1. Growth parameters of different marigold varieties at grand growth stage.

Variety	Plant height (cm)	Plant spread E-W (cm)	Plant spread N-S (cm)	Stem girth (mm)	Primary branches	Secondary branches	Leaf length (cm)	Leaf width (cm)
M Yellow	29.89	26.00	28.36	14.04	5.50	20.5	9.31	5.84
Girland	79.67	54.67	55.03	9.93	6.67	27.5	9.83	6.82
Arka Pari	33.44	42.78	46.06	15.78	6.50	21.5	9.33	5.67
Pusa Narangi Gaiinda	62.22	51.56	48.50	14.65	7.00	19.5	10.16	9.00
Pusa Basanti Gaiinda	86.67	71.33	78.69	25.75	12.83	23.12	14.56	13.56
Arka Shubha	81.44	65.78	67.72	15.23	9.61	22.33	9.25	7.44
Arka Abhi	73.11	55.00	67.89	16.37	7.33	16	8.99	6.80
S. Em±	1.94	3.75	4.154	1.47	1.75	1.78	0.77	0.63
CD @ 5%	5.98	11.55	12.80	4.516	5.38	5.54	2.36	1.95

Table 2. Quality parameters of different marigold varieties at grand growth stage

Variety	Individual flower weight (g)	Flower diameter (mm)	Shelf life (days)
M Yellow	7.71	45.04	4.35
Girland	6.76	43.82	4.21
Arka Pari	4.77	29.47	3.91
Pusa Narangi Gaiinda	5.41	40.48	4.20
Pusa Basanti Gaiinda	8.85	55.42	5.50
Arka Shubha	5.11	38.20	3.35
Arka Abhi	5.56	41.14	3.25
S. Em±	0.24	1.04	0.25
CD @ 5%	0.76	3.20	0.78

(4.77 g). These variations are primarily due to the genetic potential of the varieties, as well as the influence of external climatic conditions. Similar findings were reported by Bhatwal *et al* (2019) and Tiwari *et al* (2020). The longest shelf life was recorded in Pusa Basanti Gaiinda (5.50 days), followed by M Yellow (4.35 days), Girland (4.21 days), and Arka Pari (3.91 days) (Table 2).

The shortest shelf life was observed in Arka Abhi (3.25 days). These variations are mainly attributed to the genetic potential of the varieties, as well as the influence of external climatic conditions. Similar findings were reported by Naik *et al* (2019) and Sharma *et al* (2021). The flower diameter ranged from 55.42 cm to 29.47 cm, with Pusa Basanti Gaiinda having the largest diameter (55.42 cm), followed by M Yellow (45.04 cm), Girland (43.82 cm), and Arka Abhi (41.14 cm) (Table 2). The smallest flower diameter was recorded in Arka Pari (29.47 cm). These variations are primarily due to the genetic potential of the varieties, as well as the influence of external climatic conditions. Similar results were observed by Prateeksha *et al* (2024) and Mahanta *et al* (2022).

CONCLUSION

Among the seven varieties of marigold studied, the variety Pusa Basanti Gaiinda was found to be superior when compared with other varieties in terms of growth and quality parameters followed by the variety Girland. Hence the varieties of marigold Pusa Bsanati Gaiinda and Girand found to be best suitable to grow in Northern dry zone of Karnataka.

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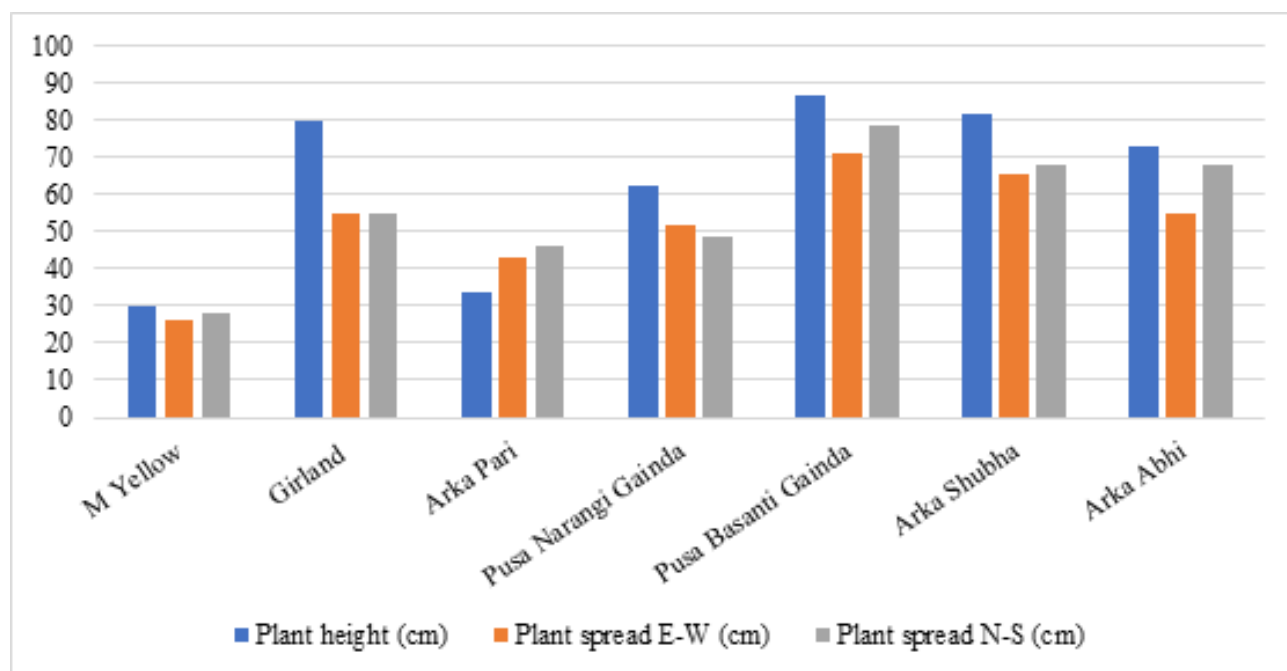


Fig 1. Growth parameters of different varieties of marigold

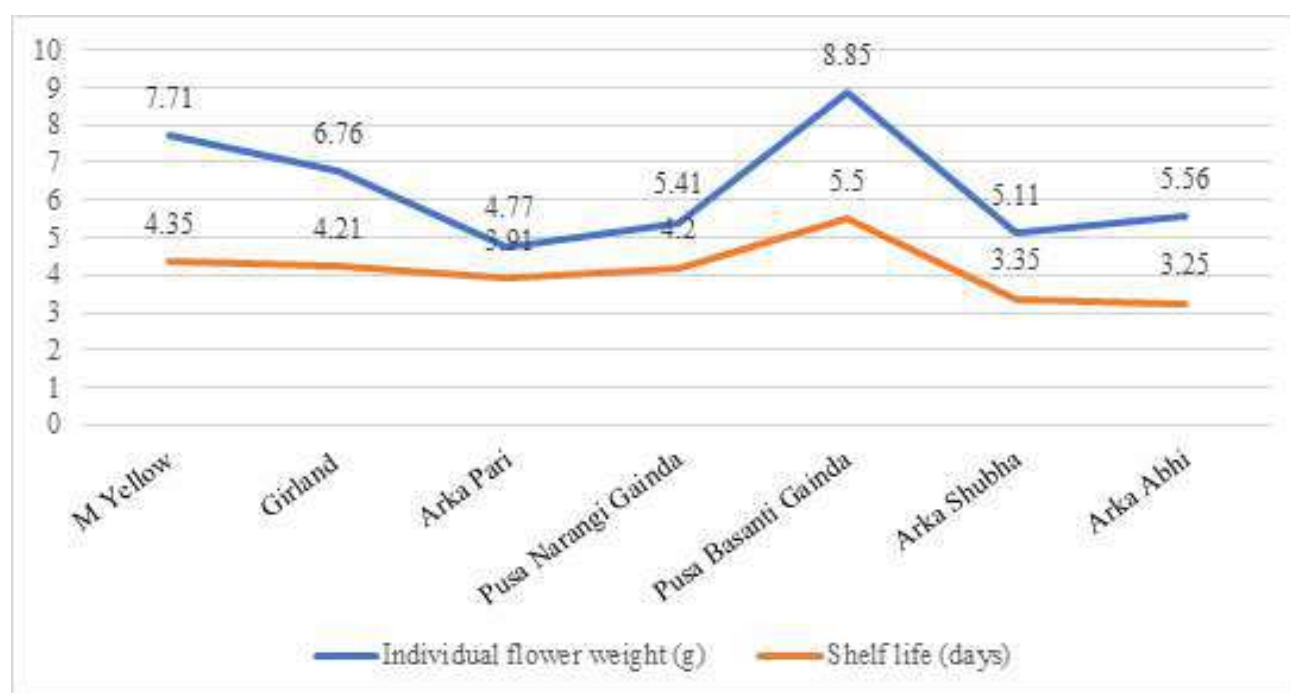


Fig 2. Individual flower weight and shelf life of different varieties of marigold

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Evaluation of New Alternatives of Neonicotinoid Insecticides Against Sucking Pests of Okra

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ABSTRACT

A field experiment was conducted during 2023-24 at RHREC, Dharwad, Karnataka to study the bio-efficacy and effectiveness of new alternatives of neonicotinoid insecticide molecules. Among the treatments, Flupyrifidifurone 200 SL @ 2.5 ml/l and Flonicamid 50 WG @ 0.4g/l proved highly effective in managing leaf hopper population by registering lowest mean number of leaf hoppers per 3 leaves (1.71 and 2.53, respectively) on 10 days after treatment imposition with highest percent suppression in population over control (84.29 and 76.75, respectively). With respect to whiteflies, among the treatments, Flupyrifidifurone 200 SL @ 2.5 ml/l and Flonicamid 50 WG @ 0.4g/l proved highly effective in managing whiteflies population by registering lowest mean number of whiteflies per 3 leaves (1.53 and 1.74, respectively) on 10 days after treatment imposition with highest reduction in population in terms of percent over control (83.45 and 81.24, respectively). Further because of lower pest load in Flupyrifidifurone 200 SL @ 2.5 ml/l and Flonicamid 50 WG @ 0.4 g/l treatment, which led to lesser damage with higher mean economic yield (11.08 t/ha and 10.76 t/ha respectively). Overall, chemical management by Flupyrifidifurone 200 SL @ 2.5 ml/l also Flonicamid 50 WG @0.4 g/l were most effective against leafhopper and whiteflies management with highest cost: benefit ratio of 2.60 and 2.90 respectively. The outcomes suggested that the present neonicotinoid insecticide were effective alternatives over conventional insecticides in formulating improved pest management strategy against sucking pests in okra.

Keywords: Leaf Hopper, Neonicotinoids, Okra, Pest Management, Whiteflies.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is cultivated as green vegetable commonly round the year in India and worldwide (Manu *et al*, 2021; Joshi *et al*, 2025). Fruits or pods of okra are highly valuable being highly nutritious, rich in vitamins, calcium, potassium, several minerals also having high medicinal, industrial and export potential (Joshi *et al*, 2021). Globally, India leads in okra production, contributing approximately 62 per cent to the total output. Okra grown with an area of 5.09 lakh hectares, annual production 60.95 lakh metric tons, with a productivity of 12 metric tons per hectare (Anonymous, 2018; Joshi *et al*, 2020). Okra is susceptible highly to damage caused by insect pests, approximately 72 species of insect pests and mites are limiting the okra crop growth (Rao and Rajendra, 2002). Among the various insect pests, sucking pests

like leafhopper and whitefly responsible for the major threat that limit the okra production. The okra fruit yield loss is 94.0 % by whiteflies and 54.04 % by aphids (Meenambigai *et al*, 2017). The whitefly noted as most notorious pest among top insect pests showing a pandemic distribution and infesting various important crops including vegetables, fiber crops, tubers and ornamentals (Abdel-Baky and Al-Deghairi, 2008). Whiteflies cause direct damage by sucking plant sap and it is also noted for the vector for deadly virus that is yellow vein mosaic. Due to whiteflies fast movement from plant to another plant, living habitat and its high reproductive potential make management of the pest is very difficult (Fouly *et al*, 2011). Farmers depend on conventional insecticides like organophosphate, synthetic pyrethroids and carbamates for sucking pest management (Patel *et al*, 1997). The frequent use of systemic insecticides resulted in the insecticide

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Treatment Details with dose followed in the experiment were as follows

Treatment	Dose (ml/L)
Flonicamid 50WG	0.2g/l
Flonicamid 50WG	0.3g/l
Flonicamid 50WG	0.4g/l
Flupyrifurone 200SL	1.5 ml/l
Flupyrifurone 200SL	2.0 ml/l
Flupyrifurone 200SL	2.5 ml/l
Imidacloprid 17.8 SL	0.35ml/l
Untreated Control	-

resistance development in the insect pest and causes disturbance in the agroecology by disturbing the non-targets (Dittrich *et al*, 1990). So, the present study intended to evaluate the effectiveness of newer neonicotinoid molecules with novel mode of action to identify a viable option for sustainable management of okra sucking insect pest.

MATERIALS AND METHODS

The seeds of okra cv. Arka Anamika were sown by line sowing method during *Kharif* 2023-24 at the AICRP (Vegetable crops) experimental farm, Regional Horticultural Research and Extension Centre, Dharwad. After fifteen days of sowing, the thinning of seedling was carried out by maintaining the spacing of 60 cm x 40 cm and following standard agronomic practices. The layout of experiment was in a RBD (Randomized Block Design) with seven insecticidal treatments and an untreated check and all treatments replicated thrice. Two insecticidal sprays at fifteen days interval were imposed during growing season and five plants were tagged randomly in each plot for recording the insect population before and after treatment imposition. The survival insect population were observed and recorded from three leaves per plant (top, middle and bottom). The population of survival leafhopper, whitefly and coccinellid were recorded one day earlier to treatment imposition and three, five, seven and ten days after treatment imposition (DATI). The recorded data were subjected to suitable statistical analysis with the help of SAS 9.2 programme (Sandra and Ramon, 1987).

RESULTS AND DISCUSSION

Efficacy of new insecticides against leafhopper population

The data on the population of leafhoppers (Table 1) for 2023-24 revealed that the leafhopper started appearing from early August, but their

population was meager. Hence, evaluation of these novel neonicotinoids was done at more than one month stage of the crop growth *i.e.* from August, when the pests started building up. Pre-count of leafhopper population was non-significant among the treatments. After 10 days of both sprays, all the seven neonicotinoids were statistically superior over the other treatment including control with respect to reduction in leafhopper population count. The average leafhopper population count after the first treatment imposition was lowest in the Flupyrifurone 200 SL @ 2.5ml/L treated plots (1.71) followed by Flonicamid 50 WG @ 0.4g/L (2.53) with per cent population reduction over control of 84.29 and 76.75 respectively. The present findings corroborate with Ghosal *et al* (2013) and Sujay Anand *et al* (2013) who also observed the superiority of newer neonicotinoids among different treatments tested. The next best treatments were Flupyrifurone 200 SL @ 2.0ml/L (2.86) and Flonicamid 50 WG @ 0.3g/L (3.04) which were in line with each other. This was in parallel with the findings of Raghuraman and Birah (2011) who found that the Imidacloprid @ 80 g ai/ha statistically suppressed leafhopper populations coupled with increase in yield. The superior yield was observed in imidacloprid (80 g a.i./ha) followed by its next lower dose of about 40 g a.i./ha and was superior in controlling leafhopper population in okra. The current findings were matching with findings of Begum and Patil (2016), who reported that imidacloprid (17.8 SL) was effective in reduction in leafhoppers and whiteflies population. Ahmad *et al* (2023) reported similar data, which supports our results, indicating that imidacloprid (17.8 SL) was effective in reducing the leafhoppers population and both of which are systemic neonicotinoids.

Efficacy of new insecticides against whitefly

The effect of insecticide treatments is presented in table 2. The data on the whiteflies population for 2023-24 revealed that the whiteflies started appearing from early August, but their population was meager. Hence, evaluation of these novel neonicotinoids were done at more than one month stage of the crop growth *i.e.* from August, when the pests started building up. Pre count of whiteflies population was non-significant among the treatments. After 10 days of both sprays, all the seven neonicotinoids were statistically superior over other treatments with respect to reduction in whiteflies population count. The average whiteflies population after the first treatment imposition was lowest in the Flupyrifurone 200 SL @ 2.5 ml/L treated plots (1.53)

Evaluation of New Alternatives of Neonicotinoid Insecticides Against Sucking Pests of Okra

Table 1: Number of leaf hoppers per 3 leaves after spray in okra for the year 2023-24.

Treatment	Dose (ml/L)	No. of leaf hoppers per 3 leaves after 1 st spray					No. of leaf hoppers per 3 leaves after 2 nd spray				Average	Suppression (%)
		1 DBTI	3 DATI	5 DATI	7 DATI	10 DATI	3 DATI	5 DATI	7 DATI	10 DATI		
Flonicamid 50WG	0.2g/l	9.22	7.25 (2.77)	5.66 (2.48)	5.31 (2.41)	5.18 (2.38)	5.84 (2.51)	5.45 (2.44)	4.40 (2.20)	6.01 (2.55)	5.63	48.08
Flonicamid 50WG	0.3g/l	7.64	5.67 (2.48)	4.08 (2.13)	2.50 (1.68)	1.88 (1.53)	3.66 (2.03)	2.50 (1.72)	2.08 (1.56)	1.97 (1.56)	3.04	72.00
Flonicamid 50WG	0.4g/l	9.27	5.15 (2.37)	3.20 (1.92)	1.84 (1.52)	1.70 (1.48)	2.91 (1.83)	2.38 (1.69)	1.73 (1.47)	1.30 (1.33)	2.53	76.75
Flupyrifidifurone 200SL	1.5 ml/l	8.53	6.09 (2.55)	4.21 (2.16)	2.77 (1.79)	2.14 (1.62)	3.85 (2.07)	2.95 (1.85)	2.79 (1.81)	2.34 (1.68)	3.39	68.78
Flupyrifidifurone 200SL	2.0 ml/l	9.06	5.53 (2.44)	3.43 (1.98)	2.22 (1.65)	1.86 (1.52)	3.54 (2.00)	2.51 (1.71)	1.94 (1.56)	1.83 (1.52)	2.86	73.68
Flupyrifidifurone 200SL	2.5 ml/l	8.65	4.06 (2.13)	2.33 (1.67)	1.09 (1.26)	0.85 (1.16)	1.87 (1.52)	1.62 (1.44)	0.98 (1.21)	0.86 (1.16)	1.71	84.29
Imidacloprid 17.8 SL	0.35ml/l	9.04	7.62 (2.84)	6.69 (2.68)	5.14 (2.37)	5.33 (2.41)	5.80 (2.49)	5.51 (2.42)	5.45 (2.43)	6.37 (2.62)	5.99	44.85
Untreated Control	-	8.86	9.46 (3.55)	9.88 (3.22)	10.22 (3.26)	10.80 (3.35)	10.94 (3.38)	11.32 (3.43)	11.89 (3.51)	12.36 (3.58)	10.86	-
SEm±		NS	0.16	0.12	0.16	0.12	0.15	0.14	0.15	0.09	-	-
CD @ 5%			0.45	0.34	0.48	0.34	0.45	0.41	0.45	0.26	-	-

* - Values in the brackets indicate square root transformed; DATI: Days after treatment imposition

followed by Flonicamid 50 WG @ 0.4g/L (1.74) (Table 2) with percent population suppression over control of 83.45 and 81.24 respectively. The present finding corroborates with Ghosal *et al* (2013) and Sujay Anand *et al* (2013) also observed the superiority of newer neonicotinoids among different treatments tested in their experiment. The next best treatments were Flupyrifidifurone 200 SL @ 2.0ml/L (2.65) and Flonicamid 50 WG @ 0.3g/L (3.54) which were in line with each other. This is in accordance with the observations of Raghuraman and Birah (2011) who found that the Imidacloprid @ 80g ai/ha statistically suppressed leafhopper populations simultaneously increased the yield. The maximum yield was observed in imidacloprid (80g ai/ha) followed by its next lower dose 40g a.i./ha was superior in managing leafhopper population in okra. The current findings were in accordance with Begum and Patil (2016)'s results, indicated that imidacloprid (17.8 SL) was effective in managing population of leafhoppers and whiteflies. Ahmad *et al* (2023) reported same findings, which supports present results, indicating that imidacloprid (17.8 SL) was effective in reducing the leafhoppers and whiteflies population both of which are systemic neonicotinoids.

Economic analysis of the insecticides

Economic analysis of different insecticides against leafhoppers and whiteflies was done and presented in table 3. It was evident that all the treatments recorded significantly maximum net returns

compared to the treatments. Among different tested treatments highest economic yield was recorded in Flupyrifidifurone 200 SL @ 2.5ml/L treated plots (11.08) followed by Flonicamid 50 WG @ 0.4g/L (10.76) (Table 3) with highest Benefit: Cost ratio of 2.8 in both the treatments. Similarly Ahmad *et al* (2023) got similar results, which supports present results wherein they observed that imidacloprid insecticide sprayed plot showed maximum economic return (1: 15.80) followed by acetamiprid (1: 13.25) both of which are systemic neonicotinoids.

CONCLUSION

The outcomes suggest that the present neonicotinoid insecticide were effective alternatives over conventional insecticides in formulating improved pest management strategy against sucking pests in okra leading to better crop protection and increased yields. Their systemic action ensured prolonged protection, reducing the frequency of applications, thereby lowering labour and input costs while minimizing environmental impact and enhancing sustainability in integrated pest management programs.

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Table 2: Number of whiteflies per 3 leaves after spray in okra for the year 2023-24

Treatments	Dose (ml/L)	No. of leaf hoppers per 3 leaves after 1 st spray					No. of leaf hoppers per 3 leaves after 2 nd spray				Average	Suppression over control (%)
		1 DBTI	3 DATI	5 DATI	7 DATI	10 DATI	3 DATI	5 DATI	7 DATI	10 DATI		
Flonicamid 50WG	0.2g/l	7.44	5.52 (2.45)	4.20 (2.16)	4.60 (2.25)	4.22 (2.17)	6.27 (2.60)	5.29 (2.40)	3.58 (2.02)	2.82 (1.82)	4.56	50.67
Flonicamid 50WG	0.3g/l	8.26	4.73 (2.27)	3.25 (1.93)	2.56 (1.74)	1.93 (1.51)	5.52 (2.44)	4.51 (2.23)	3.29 (1.93)	2.51 (1.92)	3.54	61.76
Flonicamid 50WG	0.4g/l	9.19	2.35 (1.68)	1.81 (1.51)	1.40 (1.37)	0.93 (1.19)	2.92 (1.81)	2.02 (1.57)	1.50 (1.40)	0.96 (1.20)	1.74	81.24
Flupyrifurone 200SL	1.5 ml/l	10.01	5.21 (2.38)	3.56 (2.00)	3.08 (1.84)	2.65 (1.72)	6.09 (2.56)	4.85 (2.30)	4.11 (2.12)	2.60 (1.75)	4.02	56.55
Flupyrifurone 200SL	2.0 ml/l	7.97	3.35 (1.94)	2.67 (1.78)	2.01 (1.58)	1.33 (1.34)	4.26 (2.17)	3.24 (1.91)	2.40 (1.69)	1.90 (1.55)	2.65	71.39
Flupyrifurone 200SL	2.5 ml/l	9.63	2.27 (1.64)	1.48 (1.40)	1.11 (1.26)	0.80 (1.14)	2.83 (1.79)	1.85 (1.51)	1.09 (1.25)	0.81 (1.13)	1.53	83.45
Imidacloprid 17.8 SL	0.35ml/l	9.04	6.56 (2.65)	5.57 (2.46)	4.23 (2.16)	3.94 (2.10)	6.97 (2.73)	5.87 (2.52)	4.51 (2.22)	4.21 (2.16)	5.23	43.43
Untreated Control	-	8.35	8.51 (3.00)	8.64 (3.02)	8.79 (3.05)	8.90 (3.07)	9.19 (3.11)	9.81 (3.21)	10.03 (3.24)	10.16 (3.26)	9.25	-
SEm±		NS	0.15	0.12	0.16	0.17	0.17	0.14	0.16	0.12	-	-
CD @ 5%			0.43	0.36	0.48	0.51	0.49	0.42	0.46	0.35	-	-

* - Values in the brackets indicate square root transformed; DATI: Days after treatment imposition

Table 3: Economic yield of okra during 2023-24

Treatments	Dose (ml/L)	Yield (t/ha)	B: C Ratio
Flonicamid 50WG	0.2g/l	6.10	1.0
Flonicamid 50WG	0.3g/l	7.40	1.5
Flonicamid 50WG	0.4g/l	10.76	2.9
Flupyrifurone 200SL	1.5 ml/l	6.24	1.1
Flupyrifurone 200SL	2.0 ml/l	7.33	1.8
Flupyrifurone 200SL	2.5 ml/l	11.08	2.6
Imidacloprid 17.8 SL	0.35ml/l	6.19	1.0
Untreated Control	-	3.11	
SEm±		0.57	
CD @ 5%		1.67	
CV (%)		13.60	

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Farmers Field School – An Innovative Approach for Transfer of Technology to Dairy Farmers

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ABSTRACT

The present study was conducted during the year 2023-24 to evaluate the effects of a Farmer Field School (FFS) on scientific dairy farming. The findings of the study revealed that the mean knowledge and adoption index were 97.57 and 82.56 per cent, respectively for the trained dairy farmers under FFS, while the corresponding values for pre FFS were 46.36 and 31.31 per cent, respectively. The overall impact of the FFS was observed to be 51.23 per cent regarding the existing knowledge and adoption after attending the FFS indicating a significant enhancement compared to the pre-FFS for various dimensions of improved dairy farming practices following the intervention. The mean milk yield recorded for cows and buffalo was 13.49 ± 0.39 and 11.40 ± 0.34 kg per day, respectively, after technological interventions in the farmer field school. This represents an increase compared to traditional dairy farming, which yielded 10.88 ± 0.54 and 9.17 ± 0.41 kg per day, respectively. The increase in milk yield for cows and buffalo was found to be 23.99 and 24.32 percent, respectively, following the implementation of FFS over the traditional system. The study indicated that the FFS model was the most suitable extension tool for enhancing milk production. This approach is expected to contribute not only increase in quality milk production but also to the improvement of the socio-economic conditions of the dairy farmers.

Keywords: Adoption, Dairy farming, Impact, Knowledge, Respondents.

INTRODUCTION

Farmer Field Schools (FFS) are a participatory, group-based learning approach that empowers farmers to solve agricultural challenges through hands-on training and experimentation. The Farmer Field School is an interactive and collaborative approach of agricultural extension designed to facilitate shared learning between participants and trainers. Its purpose is to effectively communicate and refine production techniques with the ultimate goal of increasing the rate of adoption. The farmers' field school is an extensive, season-long training plan that incorporates participation exercises, practical analysis and decision-making. The primary goal of the field schools is to provide farmers with a chance to acquire knowledge and gain more mastery over the circumstances they encounter on a daily basis. They learn how to use new technologies to minimize dairy input costs, improve management, boost productivity, and raise profitability.

At least 78 countries are implementing the FFS approach, a classic example of a participatory

extension strategy (Braun *et al*, 2006). In order to successfully implement a field school, it is essential that the individuals responsible for its formation and management possess the appropriate mindset (attitude change) to effectively handle the difficulties and requirements of this strategy. Thus, a farmer field school was organised to focus on the benefits of improved low cost production technologies with special references to general management, healthcare and supplementary feeding to dairy animals.

MATERIALS AND METHODS

In this program, a random selection of 25 dairy farmers was conducted from the Khijrabad village located in the Majri block of the S.A.S. Nagar district in Punjab. The primary constraints encountered by the trainees in dairy production were gathered from the respondents and subsequently ranked in order of significance. The visit of trainers to FFS was held fortnightly at the farmers' farm, incorporating instructional sessions alongside front line demonstrations of enhanced dairy husbandry practices, facilitating the acquisition of new technologies through

a hands-on approach. The group was divided into five sub-groups each consisting of five individuals, to conduct field observations about data on production of the selected dairy bovines in both the technical interventions and traditional groups. A pre-evaluation test was conducted for each group on the chosen FFS activities. In each lesson, they were assigned group assignments independently. The livestock farms were chosen, and the Frontline Demonstrations on requiring operational skills were executed. The classes concluded upon the group's acceptance of the outcomes derived from the demonstrations. Field days/ exposure visits were organized to impart technological knowledge to farmers regarding new technologies through the Seeing is believing approach at various scientifically managed dairy farms. The assessment for FFS was performed after a six-month period with all trainees. An impact study was conducted to assess the knowledge and adoption levels of respondents regarding various management aspects of practices, including housing, feeding, health care, and techniques for producing clean and quality milk. The respondents' knowledge and adoption levels were assessed as per Rahman (2007).

The data concerning milk yield and fat percentage were collected from a sample of 20 animals (10 cattle and 10 buffalo) following scientific interventions, which included balanced rations, supplementation with area-specific mineral mixtures, common salt, bypass fat, and timely deworming. Twenty animals served as the control group, comprising ten cows and ten buffaloes, managed under traditional farming practices. The animals were chosen at comparable lactation stages, body weights, milk yields, and parities. Partial budget was employed to assess the items of expenditure and income (Khadda *et al*, 2014). Consequently, the expenses associated with roughage, concentrate, mineral mixture, common salt, and bypass fat have been taken into account. The labour cost was excluded from the computation since it was identical in both groups as family members managed the cattle. The input costs were determined based on the market rates existing during FFS. The collected data were organized and examined according to established statistical methods (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

The participants exhibited a strong preference for animal husbandry and maintain traditional practices of raising dairy animals such as cows and buffaloes. The findings of the study indicated that the farmer field

school significantly impacted the knowledge and adoption levels of dairy farmers regarding improved dairy husbandry practices.

Knowledge level of dairy farmers:

The analysis of data indicated that the mean knowledge index of respondents before and after the FFS was recorded at 46.36 and 97.57 percent, respectively. The findings of the study indicated that all respondents possessed very good knowledge of various improved practices for dairy farming, specifically including: ventilation in shed, proper space for each animal, cleaning of shed daily, bedding material use in shed, balance ration feeding, mineral mixture, bypass fat and common salt feeding, formulation of balance ration, not to feed fusty fodder, drinking clean and fresh water, timely vaccination, deworming regularly, dusting regularly, washing entire animal daily, teats and udder washing before milking, wipe teats and udder with dry cloth after washing, KMnO_4 use in water for washing of teats and udder, examine milk, udder and teats daily, dry, and clean utensils use for milking, dome-shaped milking pots use for milking, milking done by healthy being, hands wash with plain water before milking, transfer the milk to milk collection center after milking immediately, whereas, the corresponding knowledge level regarding the same practices for the respondents prior to FFS were 70.66, 32.00, 64.34, 24.38, 37.33, 61.37, 24.66, 52.00, 32.33, 16.00, 68.00, 76.00, 64.34, 48.00, 36.00, 68.00, 12.67, 6.34, 64.34, 52.33, 40.66, 62.00 and 80.00 per cent was recorded, respectively. The overall increased of 110.46% in knowledge level regarding various aspects of improved dairy farming practices after the FFS. Comparable findings were also documented by Mallikarjuna *et al* (2012), Khadda *et al* (2012), Singh *et al* (2014), Khadda *et al* (2014a) and Khadda *et al* (2020).

Adoption level of dairy farmers

The findings of the current study indicated that the average adoption index was significantly higher (82.56%) for the farmers who benefited from the Farmer Field School, in contrast to their adoption index before participating in the program (31.31%). The respondents implemented enhanced dairy management practices, including daily shed cleaning, providing mineral supplements, ensuring access to clean and fresh water for the animals, washing teats and udders prior to milking, and washing hands with plain water before milking (100%). This was followed

Farmers Field School – An Innovative Approach for Transfer of Technology to Dairy Farmers

Table 1. Knowledge and adoption indices of scientific dairy farming among the dairy farmers.

Sr. No.	Scientific dairy farming practices	Knowledge		Adoption	
		Pre	Post	Pre	Post
1.	Management of housing				
i	Ventilation	70.66	100.00	20.33	72.00
ii	Spacing	32.00	96.00	21.33	76.00
iii	Cleaning of shed daily	64.34	100.00	48.00	100.00
iv	Bedding material use in shed	24.38	100.00	16.67	72.33
2.	Feeding management of dairy animals				
i	Feeding of balance ration	37.33	88.00	21.33	80.00
ii	Mineral mixture supplementations	61.37	100.00	28.00	100.00
iii	Bypass fat f supplementations	24.66	100.00	12.00	68.67
iv	Common salt supplementations	52.00	100.00	28.00	92.00
v	Formulation of balance ration	32.33	100.00	12.00	64.34
vi	Not to feed fusty fodder	16.00	100.00	16.34	88.00
vii	Drinking clean and fresh water	68.00	100.00	40.00	100.00
3.	Health Care of dairy animal				
i	Timely vaccination	76.00	100.00	52.00	96.00
ii	Deworming regularly	64.34	100.00	41.33	80.00
iii	Dusting regularly	48.00	92.00	46.67	88.00
4.	Clean milk production tech.				
i	Washing entire animal daily	36.00	92.00	12.00	72.00
ii	Teats and udder washing before milking	68.00	100.00	56.00	100.00
iii	To wipe teats and udder with dry cloth after washing	12.67	100.00	8.34	60.33
iv	To use of kmno4 in water for washing of teats and udder	6.34	68.00	1.00	54.34
v	Regularly examine milk, udder and teats	64.34	100.00	54.33	92.00
vi	Use dry, clean and hygienic utensils for milking	52.33	100.00	40.67	96.00
vii	Use dome-shaped milking pots for milking	40.66	96.00	20.00	64.34
viii	Milking by healthy person	62.00	100.00	40.00	84.00
ix	Hand wash	80.00	100.00	60.00	100
x	Keep milk away from coughing and sneezing	72.00	100.00	64.34	84.33
xi	Full hand milking	16.33	100.00	12.00	80.00
xii	Complete milking time	36.00	100.00	36.00	88.00
xiii	Keep animal in standing position	8.00	100.00	8.00	76.00
xiv	Transfer the milk to milk collection center immediately after milking	72.00	100.00	60.00	84.00
	Mean Index	46.36	97.57	31.31	82.56

by timely vaccinations and the use of dry, clean, and hygienic utensils for milking (96.00%), supplementing with common salt and regularly examining milk, udder, and teats (92.00%), avoiding fusty fodder, regular dusting, and completing milking within 6-7

minutes (88.00%). Additionally, milking was performed by healthy individuals, keeping milk away from coughing and sneezing, and transferring the milk to the collection center immediately after milking (84.00%). The practices also included feeding a

Table 2. Effect of FFS on knowledge and adoption of scientific dairy farming practices.

Sr. No.	Particular	Pre	Post	Difference
1.	Knowledge Index	46.36	97.57	51.21
2.	Adoption Index	31.31	82.56	51.25
	Total	77.67	180.13	102.46

Table 3. Performance of milch cattle pre and post farmer school.

Sr. No.	Parameter	Trainees of FFS		Non- trainees of FFS	
		Cattle	Buffalo	Cattle	Buffalo
1.	Av. milk yield/ day (kg)	13.49±0.39	11.40±0.34	10.88±0.54	9.17±0.41
2.	Lactometer reading	29.56±2.09	30.96±1.61	27.79±1.92	29.81±2.10
3.	Fat %	4.17±0.21	7.16±0.17	3.63±0.14	6.86±0.12
4.	Feeding cost/ kg of milk production (Rs.)	17.86	18.59	22.05	22.90
5.	Gross income from milk (Rs./ day)	674.50	741	544	641.90
6.	Net return (Rs./ day)	433.50	529	304	431.90
7.	B: C ratio	2.80	3.50	2.27	3.06

balanced ration, regular deworming, and full hand milking (80.00%). Ensuring adequate space for dairy animals in the shed and maintaining them in a standing position for 15 minutes post-milking (76.00%), providing proper ventilation in the shed and washing the entire animal daily (72.00%), incorporating bypass fat supplementations (68.67%), utilizing dome-shaped milking pots during milking (64.34%), formulating a balanced ration (64.00), wiping teats and udder with a dry cloth after washing (60.33%), and using KMnO₄ in water for cleaning teats and udder (54.00%) after FFS. Comparable findings were also documented by Mallikarjuna *et al* (2012), Khadda *et al* (2012), Singh *et al* (2014a), Khadda *et al* (2014), Akila and Bharathi (2020) and Khadda *et al* (2020).

Impact of FFS on knowledge and adoption

The data (Table 2) revealed that the average knowledge and adoption index were 97.57 and 82.56 per cent, respectively, for the dairy farmer after FFS, while the relevant values prior to FFS were 46.36 and 31.31 per cent, respectively. The results clearly demonstrated that the respondents who received training under FFS exhibited advanced levels of knowledge and adoption compared to pre FFS. The analysis highlighted the comprehensive effects of the field school on dairy farming was 51.23 percent in terms of knowledge and adoption among the trained respondents, indicating a significant increase compared to pre FFS program. The respondents experienced a significant impact, particularly regarding their knowledge and adoption of scientific

dairy farming practices, as a result of attending the Farmer Field School.

Production performance of milch animals

The compiled data concerning the production of dairy bovines indicated that the mean milk yield for cows and buffaloes was recorded at 13.49±0.39 and 11.40±0.34 kg/ day, in that order, following scientific intervention in the FFS. This represented an increase compared to the traditional dairy farming system, where yields were 10.88±0.54 & 9.17±0.41 kg per day, correspondingly. The recorded milk yield increase for cows and buffalo was 23.99 and 24.32 percent, correspondingly, following scientific involvement under FFS as compared to the conventional system. The increased milk yield observed in cows and buffalo could be attributed to improved managerial practices, including enhanced housing environment, balanced feeding strategies such as the incorporation of uromin lick, supplementation with mineral mixtures and common salt, as well as superior health management techniques implemented by the cattle keepers following the FFS. The data concerning to economic aspects of milk production from cows and buffalo indicated that the farmers adopted a systematic approach in dairy after attending the FFS, resulting in more gross and net returns, along with a high profit ratio compared to conventional dairy farming methods. The findings indicated a decrease in the cost of milk production per liter for cows and buffaloes by 23.46% and 23.18%, respectively, attributed to the technological interventions implemented by FFS

Farmers Field School – An Innovative Approach for Transfer of Technology to Dairy Farmers

trainees in contrast to the non-trainees of FFS. Yadav *et al* (2013), Khadda *et al* (2014), Khadda *et al* (2014a), Khadda *et al* (2016), Akila and Bharathi (2020), Khadda *et al* (2020), and Yadav *et al* (2020) have indicated that the production performance of dairy cattle is significantly influenced by the implementation of scientific dairy farming practices.

CONCLUSION

From the findings of the study, it can be determined that the Farmer Field School (FFS) program has been found to enhance dairy farmers' knowledge and attitudes towards advanced farming technologies. The program has led to increased milk yields and improved attitudes towards scientific animal husbandry practices. Farmers take on the role of investigators, exploring different technological options and actively participating in sharing and refining production technology. This approach directly addresses farmers' needs, improving the exchange of technologies and information among farmers. FFS serves as an exemplary model for validating and disseminating agricultural technologies, fostering sustainable agriculture and improving socio-economic conditions.

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Fungal Endophytes from Chilli and their Antagonism against *Colletotrichum capsici*

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ABSTRACT

The *Colletotrichum capsici* incited anthracnose/fruit rot posing a serious threat to commercial chilli production in India. In the present study, the fungal endophytes from chilli were explored in effort to combat the pathogen. 19 endophytic fungal isolates isolated from leaf, stem and root of healthy chilli plant exhibited antagonistic activity against *C. capsici* in dual culture assay under *in vitro*. Among them endophyte, UHSFS5 demonstrated the highest pathogen mycelial inhibition (74.68 %). Based on the cultural and morphological characteristics UHSFS5 was identified to be belonged to *Aspergillus* genus. Upon its accurate molecular identification, pathogenicity and enumerating its efficacy in pot and field and accurate molecular identification it may be employed to combat the chilli anthracnose disease.

Keywords: Anthracnose, *Aspergillus*, Chilli, Fungal endophyte.

INTRODUCTION

India is larger consumer and exporter of chilli (*Capsicum annum* L.) globally, in addition to being its greatest producer with 1.98 Mt and contributes 43 per cent of world chilli production, followed by China, Ethiopia, Thailand, Pakistan and Bangladesh (Kiruthika *et al*, 2024). The commercial production of chilli is potentially hindered by numerous biotic constraints of which the anthracnose disease incited by *Colletotrichum capsici*, *C. gleosporoides*, *C. acutatum* and *C. scoville* poses a significant threat to chilli production, resulting in substantial yield loss. The symptoms of the disease appear on foliage as tiny circular dots that eventually merge into larger elliptical patches, potentially resulting in defoliation under severe circumstances (Jojoy *et al*, 2024). Primarily, the symptoms are seen in severe form on ripe fruits in the field and leads to the fruit quality deterioration. The chemical pesticides are indiscriminately applied to chilli in an effort to overcome these biotic constraints. Further, these strategies have detrimental effect on human health, environment and most important one is development of resistance in target populations (Martin and Loper, 1999).

Since not many alternatives to pesticides are available, the biological control by utilizing beneficial microorganisms has been extensively researched (Duffy *et al*, 1995). Early workers found difficulties in incorporating non-native microbial into established and adapted microbial communities, as well as the absence of specificity between microbes and their host plants. However, one potential strategy to address this limitation is to utilize selected communities of native endophytic microorganisms (Amaresan *et al*, 2012). Endophytic microorganisms are a unique group of microbes that inhabit the tissues and internal organs of terrestrial and some aquatic plants (Gao *et al*, 2010). Endophytes are found in all plant species and exhibit varying capacities to benefit their hosts (Sarmah *et al*, 2023). Endophytes are typically defined as microbes residing within the internal tissues of plants and are commonly isolated from these tissues following surface sterilization (Fadiji *et al*, 2020). The studies on endophytic fungi in chilli were attempted by few early researchers (Amaresan *et al*, 2014; Pavithra *et al*, 2021) to combat anthracnose disease but achieved limited success. Hence with this background information the present study was conducted to explore the fungal endophytes in chilli against anthracnose/Fruit rot pathogen *C. capsici*.

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Table 1: List of fungal endophytes isolated from chilli.

Sl. No.	Isolates	Plant Part	Place	GPS coordinates
1	UHSFL1	Leaf	Bagalkot (Karnataka)	16.1691° N 75.6615° E
2	UHSFL2	Leaf		
3	UHSFL3	Leaf		
4	UHSFL4	Leaf	Devihosur (Haveri, Karnataka)	14.7951° N 75.3310° E
5	UHSFL5	Leaf		
6	UHSFS1	Stem		
7	UHSFS2	Stem	Bagalkot (Karnataka)	16.1691° N 75.6615° E
8	UHSFS3	Stem		
9	UHSFS4	Stem		
10	UHSFS5	Stem		
11	UHSFR1	Root		
12	UHSFR2	Root		
13	UHSFR3	Root	Devihosur (Haveri, Karnataka)	14.7951° N 75.3310° E
14	UHSFR4	Root		
15	UHSFR5	Root		
16	UHSFR6	Root		
17	UHSFR7	Root		
18	UHSFR8	Root		
19	UHSFR9	Root		

Table 2: *In vitro* evaluation of fungal endophytic isolates against *C. capsici*

Sl. No.	Isolates	Mycelial growth of pathogen (cm)	Mycelial growth inhibition (%)
1	UHSFL1	4.20	47.50 (43.59)*
2	UHSFL2	5.37	32.81 (34.96)
3	UHSFL3	6.12	23.43 (28.96)
4	UHSFL4	5.57	30.31 (33.42)
5	UHSFL5	5.72	28.43 (32.24)
6	UHSFS1	5.57	30.31 (33.42)
7	UHSFS2	2.60	67.50 (55.27)
8	UHSFS3	5.77	27.81 (31.84)
9	UHSFS4	5.75	28.12 (32.04)
10	UHSFS5	2.02	74.68 (59.82)
11	UHSFR1	6.15	23.12 (28.75)
12	UHSFR2	6.00	25.31 (30.02)
13	UHSFR3	5.75	28.12 (32.04)
14	UHSFR4	6.15	23.12 (28.75)
15	UHSFR5	5.77	27.81 (31.84)
16	UHSFR6	5.77	27.81 (31.84)
17	UHSFR7	4.85	39.37 (38.88)
18	UHSFR8	2.65	66.87 (54.89)
19	UHSFR9	2.47	69.06 (56.23)
S. Em ±		0.42	1.78
CD (0.01)		1.36	6.03

Mycelial growth of pathogen in control (without endophyte) is 9 cm

*Arcsine transformed values

Fungal Endophytes from Chilli and their Antagonism against *Colletotrichum capsici*



Fig.1: Fungal endophytes isolated from different parts of chilli



Fig.2: Antagonistic activity of endophytic fungal isolates against *C. capsici*

MATERIALS AND METHODS

Sample collection

The healthy chilli plants were collected in sterile polythene bags from fields in the Bagalkot and Haveri districts of Karnataka and brought to the laboratory for isolation of endophytes during 2023. The samples were used for the isolation of endophytes within 48 hours of sampling to ensure freshness and minimize the contamination.

Media preparation

Potato dextrose agar (PDA) medium [potato extract (200 g/L), dextrose (20 g/L), agar (20 g/L), pH 7] was utilized for the isolation and purification of endophytic fungi. To prevent bacterial contamination, streptomycin was incorporated into the medium at a concentration of 250 mg/L.

Endophytic fungi isolation

Endophytic fungi from the collected samples were isolated using a sterile leaf technique (Schult and Boyle, 2005). Healthy leaves, stems and roots were washed in running tap water to remove soil and dirt, then cut into one cm bits. These bits were surface sterilized in 70 per cent ethanol for one minute, followed by 2 per cent sodium hypochlorite for two minutes. Afterward, the sections were rinsed three times with sterile distilled water and placed on nine cm Petri plates containing Potato Dextrose Agar (PDA) medium supplemented with streptomycin (250 mg/l) to inhibit bacterial growth. To verify the effectiveness of the surface sterilization and ensure that isolations

were from internal plant tissues, a 100 µl aliquot from the final rinse and a whole surface-sterilized leaf were separately inoculated on PDA plates. The absence of fungal growth on these plates confirmed the success of the surface sterilization. All plates were incubated at 27±1°C and observed for fungal growth every day up to 10 days. The total of 19 fungal isolates were recovered from the collected samples (Table 2).

Effect of fungal endophytes against *C. capsici* under *in vitro*

Fungal endophytic fungal isolates were screened for their antagonistic effects using the dual culture method. Each agar plate was inoculated with a five mm diameter agar disk of endophytic fungi on one side and a five mm diameter agar disk of *C. capsici* on the opposite side. Control plates with only the pathogen or only the endophytes were also maintained. Petri plates then incubated at 27±1 °C for 7 days durations and diameter of the pathogen colony growth was measured in both the control plates and the paired cultures. The percentage inhibition of the pathogen was calculated using the formula; $I = (C - T / C) * 100$, Where I = per cent inhibition of pathogen, C = Growth of pathogen in absence of Endophyte, T = Growth of pathogen in presence of endophyte.

Cultural and morphological characterization of fungal endophytes

The isolates were cultured for seven days on Potato Dextrose Agar (PDA) medium and incubated at 25°C. Microscopic observations were conducted by preparing slides stained with lactophenol cotton blue.

A small tuft of the fungus, typically containing spores and spore-bearing structures was transferred onto a drop of stain using a flamed, cooled needle. The fungal material was carefully teased apart with two mounted needles and gently mixed with the stain to ensure even distribution. A cover slip was then placed over the sample, avoiding air bubbles in the preparation. Finally, the edges of the cover slip were sealed with fresh nail polish to secure the lactophenol mount for observation under the trinocular microscope.

RESULTS AND DISCUSSION

The endophytic microorganisms reside within the living plants tissues are promising, yet underexplored, sources of novel natural products for agricultural use. The presence of endophytes in plant parts, including leaves, stems, roots, flowers, seeds, and fruits of various plant species has been reported (Anjum and Chandra, 2015). In our study, healthy chilli samples (leaf, stem, flower bud and root) collected were subjected for isolation of endophytes. A total of 19 fungal endophytes were isolated from healthy chilli tissues: 5 from leaves, 5 from stems and 9 from roots. The isolates were designated as UHSFL1, UHSFL2, UHSFL3, UHSFL4, UHSFL5, UHSFS1, UHSFS2, UHSFS3, UHSFS4, UHSFS5, UHSFR1, UHSFR2, UHSFR3, UHSFR4, UHSFR5, UHSFR6, UHSFR7, UHSFR8 and UHSFR9 (Table 1; Fig. 1). All 19 isolates were tested against *C. capsici* to know the antagonistic activity through dual culture technique under *in vitro* condition. Among all tested isolates, UHSFS5 showed highest inhibition of 74.68 per cent (Table 2). It was identified based on macro and microscopic characters. The isolates exhibited a green colony colour with a colourless reverse, and its conidial head was greyish-green. The conidia were globose, smooth to finely rough, and displayed a yellow-green hue, as shown in Fig. 2. These distinctive morphological characteristics led to the identification of the isolate may be belonging to the genus *Aspergillus*.

The present results were in line with Pavithra *et al* (2021) who isolated various fungal endophytes from chilli and recorded highest mycelial growth inhibition of *Colletotrichum capsici* by *Aspergillus niger* to the tune of 90.74% under *in vitro* conditions. Further, Chowdary and Kumar (2022) found that of the 122 endophytic fungal isolates obtained from healthy chilli plants, the isolate ENRF 7 (*Trichoderma asperellum*) was found to be more promising against *Colletotrichum acutatum* with 61.45 % inhibition under *in vitro*. Endophytes reside in protected environments within plant tissues, providing them

with a competitive advantage over organisms in the rhizosphere and phyllosphere. They benefit from consistent nutrient flow, stable pH levels, and adequate moisture, while being shielded from high densities of competitors (Backman and Sikora, 2008). Additionally, they benefit the plant by suppressing pathogen access to the host system through the synthesis of bioactive compounds that act against phytopathogens (Singh *et al*, 2020).

CONCLUSION

The present study concluded that based on distinctive morphological characteristics the UHSFS5 isolate was identified belonging to genus *Aspergillus*. After confirming its identity at molecular level and testing its efficacy in field conditions, the fungal endophyte may be exploited as potent bio-control agent in managing the fruit rot disease of chilli.

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Genotypic and Phenotypic Correlation Analysis for Important Quantitative Characteristics in Okra Cultivars

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ABSTRACT

Okra is grown all over the world during spring-summer season. Estimations based on interrelations among yield related characters are crucial in order to understand the selection process ultimately improving yield during breeding programme. Therefore, the present research was undertaken during *Kharif* 2019 using 26 different cultivars to examine the degree to which various yields and its linked traits are related to one another at the H.N.B. Garhwal University Srinagar (Garhwal) Pauri Garhwal Uttarakhand. The data regarding correlation study revealed that the at both the phenotypic as well as genotypic levels, the average weight of fruit, fruits per plant, petiole length, diameter of fruit, seed index, length of fruit and moisture content were all significantly and positively associated with yield. Whereas, pedicel length, length of leaf, epicalyx segments, chlorophyll content, plant height, nodes at first flowering, internodal length, number of ridges per fruit, primary branches per plant, days taken to first fruit harvest, days taken to first flowering and days taken to first fruit set showed negative correlation. Finally, it might be summed up that the selections based on positively associated traits might prove to be more advantageous during mapping out the selection processes in crop improvement plans in okra.

Keywords: Cultivars, Crop improvement, Correlation, Okra, Vegetable, Yield.

INTRODUCTION

Okra [*Abelmoschus esculentus* L. (Moench.)] is a spring-summer season vegetable crop grown in varied climatic conditions all over the world for its tender fruits (Reddy *et al*, 2013; Ray *et al*, 2022). The fact that okra is considered to be a crop that is often cross-pollinated and has monoadelphous stamens, huge flowers that can be emasculated, and a high seed yield when pollinated by hand make it an intriguing crop for geneticists (Kumari *et al*, 2019; Joshi *et al*, 2021). Several commercial hybrids and varieties of okra crop are available in the local and international seed markets, however, most of them cannot be considered amenable for cultivation in each and every growing region which becomes a cause of difficulty for the farmers (Kumar and Joshi, 2024). In order to improve certain traits related to the yield and allied traits, the knowledge on the variability at genetic level along with the inter-relationship among various

parameters are very crucial (Sharma and Prasad, 2015; Joshi *et al*, 2020). For any selection strategy, it would be advantageous to consider the proportionate degree of association between various traits and yield (Raval *et al*, 2017). Hence, in the present research programme using the correlation studies, an investigation into the relationships between multiple attributes related to the several yield and allied traits and the final yield and productivity of fruits in the cultivars and genotypes under present investigation was undertaken.

MATERIALS AND METHODS

The current inquiry was conducted at the H.R.C., Horticulture Department, H.N.B.G.U., Srinagar (Garhwal), Uttarakhand, India for studying the relation between different quantitative characters during the summer season, 2019. During the experiment, 25 diverse genotypes of okra *viz.*, Arka Anamika (check), Varsha Uphar, Hisar Naveen, Lucky-666, Punjab-8, Kashi Pragati, Kashi Kranti,

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Table 1: Genotypic and phenotypic correlation coefficients among growth and yield parameters of okra.

Characters		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	26
1	G P	-	-0.203	-	-	-0.212	-0.118	0.371**	0.310**	0.148	-0.213	0.364**	-0.166	0.234*	-	0.078	-0.074
		0.372** -0.244*	-0.151	0.577** - 0.337**	0.252* -0.164	-0.190	0.002	-0.020	0.212	0.186	- 0.331**	0.237*	-0.102	0.068	0.377** -0.216	-0.058	-0.067
2	G P		0.128 0.125	0.616** 0.599**	0.183 0.167	-0.214 -0.136	-0.028 -0.032	-0.021 -0.015	-0.171 -0.161	0.053 0.033	0.284* 0.187	-0.214 -0.211	- 0.480** - 0.379**	- 0.517** - 0.428**	-0.122 -0.084	-0.238* -0.149	- 0.428** - 0.416**
3	G P			0.356** 0.330**	0.262* 0.252*	- 0.520** - 0.377**	0.021 0.044	0.074 0.033	0.030 0.033	0.764** 0.604**	0.684** 0.463**	0.120 0.110	-0.125 -0.100	-0.036 -0.031	- 0.305** -0.153	- 0.466** - 0.325**	-0.594** 0.567**
4	G P				-0.034 -0.032	-0.270* -0.175	0.097 0.055	0.052 -0.009	0.013 -0.006	0.224* 0.163	0.514** 0.319**	- 0.410** - 0.379**	- 0.597** - 0.477**	- 0.436** - 0.390**	-0.231* -0.184	-0.053 -0.038	0.514** - 0.496**
5	G P					0.163 0.123	0.079 0.073	0.208 0.007	- 0.358** - 0.327**	0.190 0.126	0.512** 0.283*	0.423** 0.389**	0.029 0.061	0.163 0.134	0.331** 0.163	-0.029 -0.042	0.113 0.093
6	G P						0.054 0.071	0.060 0.004	-0.088 -0.118	- 0.295** -0.231*	-0.015 -0.052	0.144 0.096	0.520** 0.274*	0.415** 0.204	0.443** 0.198	0.364** 0.218	0.253* 0.194
7	G P							0.164 -0.056	-0.285* -0.161	-0.123 -0.038	0.030 -0.041	0.174 0.137	-0.147 -0.143	0.364** 0.092	0.272* 0.083	-0.165 -0.169	0.023 -0.005
8	G P								0.076 0.004	0.241* 0.110	-0.095 0.141	0.277* 0.119	-0.139 -0.024	0.556** 0.150	-0.115 0.208	-0.140 -0.197	-0.244* -0.120
9	G P									-0.013 0.025	-0.279* -0.146	0.008 -0.006	-0.260* -0.186	-0.175 -0.105	- 0.563** -0.270*	-0.185 -0.093	-0.242* -0.212
10	G P										0.740** 0.496**	0.276* 0.205	-0.099 -0.087	-0.066 -0.100	-0.154 -0.068	- 0.328** -0.283*	- 0.695** - 0.558**
11	G P											-0.004 -0.023	- 0.327** -0.168	-0.136 -0.097	-0.081 0.183	-0.032 0.033	- 0.450** -0.280*
12	G P													0.518** 0.396**	0.185 0.089	-0.107 -0.058	0.073 0.068
13	G P													0.465** 0.350**	0.258* 0.161	0.311** 0.216	0.494** 0.395**
14	G P														0.261* 0.163	0.329** 0.266*	0.319** 0.257*
15	G P															0.010 0.079	0.496** 0.312**
16																	0.649** 0.482**

Kashi Vibhuti, Chanda, Hisar Unnat, LC-1, Kashi Mohini, LC-3, Kaveri, King Bhindi, LC-6, Parbhani Kranti, Pusa Sawani, Pusa A-4, LC-2, Super Anamika, VL Bhindi-2, LC-5, Vandana-241, LC-4 and Agri Bahar were evaluated. Three replications of each genotype were included in the Randomized Complete Block Design (RCBD) experiment setup. Each variety or cultivar or genotype every replication were evaluated (data collected) using five randomly selected and tagged plants. The observations noted were internodal length (cm), number of primary branches per plant, plant height (cm), days taken to first germination, stem girth (mm), petiole diameter (mm), petiole length (cm), flower diameter (cm), number of epicalyx segments, leaf length (cm), days taken to first flowering, number of fruits per plant, fruit length (cm), number of nodes at flowering, fruit diameter (mm), average fruit weight (g), number of ridges per fruit, pedicel diameter (mm), number of seeds per fruit,

pedicel length (cm), days taken to first fruit set, flesh thickness (mm), days taken to first fruit harvest, seed index, yield per hectare (q), yield per plot (kg), T.S.S (^oBrix), chlorophyll content (SPAD), ascorbic acid (mg/100g), ash content, moisture content and physiological loss (days). After collecting data, the mean was calculated, and the mean data was analyzed statistically by various methods. The ANOVA and C.D test at 5% and 1% level of significance was applied as given by Panse and Sukhatme (1967) for the study of the significance of variation among the treatments. Using formulas provided by Al-Jibouri *et al.* (1958) the phenotypic and genotypic correlation coefficient was calculated.

Genotypic and Phenotypic Correlation Analysis for Important Quantitative Characteristics

Table 2: Genotypic and phenotypic correlation coefficients among seed, yield and quality parameters of okra

Characters		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	G	0.496**	0.153	0.203	0.140	0.074	0.311*	-	0.380**	-0.074	-0.074	-0.043	0.066	0.837**	0.175	-0.137	0.037
	P	0.293**	0.136	0.037	0.159	0.142	* 0.154	0.295** -0.209	0.149	-0.068	-0.067	-0.024	0.049	0.120	0.159	-0.025	-0.009
2	G	-0.054	0.138	-	0.129	0.061	-	-	-	0.428*	-	-	0.409*	-	-	-	-
	P	-0.041	0.128	0.588** -0.458**	0.117	0.059	0.387* * -0.285*	-0.021 -0.027	-0.003 0.014	-	0.428* * 0.416* *	0.098 0.096	* 0.353* *	0.469** 0.230*	0.036 0.014	0.018 0.024	0.036 0.046
3	G	0.607**	0.408**	-0.217	0.763**	0.826**	0.056	0.543**	-	0.593*	0.594*	0.487*	-	-	-	-	-
	P	0.541**	0.380**	-0.182	0.675**	0.677**	0.032	0.497**	0.469** 0.343**	* 0.566* *	* 0.567* *	* 0.453* *	-0.077 -0.054	0.048 0.035	0.110 0.104	-0.102 -0.094	-0.274* -0.245*
4	G	0.024	0.214	-	0.223*	0.242*	-	-	-	0.513*	-	-	0.288*	-	-	-	-
	P	-0.003	0.193	0.297** -0.227*	0.197	0.186	0.373* * -0.252*	0.142 0.124	-0.024 -0.041	-	0.514* * 0.495* *	0.256* 0.256*	-0.019 -0.004	-0.030 -0.046	-0.290* -0.236*	-0.343** -0.252*	0.028 0.026
5	G	0.267*	0.634**	-0.249*	0.199	0.259*	0.129	0.314**	-0.104	0.113	0.113	0.173	0.132	0.226*	0.231*	0.000	-
	P	0.246*	0.557**	-0.132	0.163	0.188	0.082	0.281*	-0.060	0.093	0.093	0.160	0.103	0.128	0.181	0.011	0.306** -0.252*
6	G	-0.395**	-0.099	0.451**	-0.322**	-	0.309*	-0.055	0.108	0.252*	0.253*	0.556*	-	-	-	-	-
	P	-0.300**	-0.064	0.281*	-0.191	0.346** -0.182	* 0.222	-0.037	0.196	0.193	0.194	-	0.222 0.090	-0.344** -0.097	0.067 -0.051	-0.262* -0.054	-0.247* -0.105
7	G	0.231*	-0.103	0.362**	-0.168	-0.152	0.124	0.149	0.120	0.023	0.023	0.324*	-	-	-	-	-
	P	0.148	-0.043	0.130	-0.121	-0.068	0.062	0.091	0.087	-0.005	-0.005	* -0.241*	0.312* *	-0.192 -0.138	0.015 -0.010	-0.213 -0.167	0.195 0.153
8	G	0.233*	0.177	0.672**	0.305**	0.287*	0.311*	0.298**	0.274*	-0.243*	-0.244*	-	0.381*	0.288*	0.508**	0.058	-0.082
	P	0.006	0.026	0.215	0.111	0.060	* 0.015	0.144	0.056	-0.121	-0.120	-	* -0.141	0.152	0.360**	0.047	-0.084
9	G	0.006	-0.190	0.320**	0.099	0.137	0.166	0.032	-0.252*	-0.243*	-0.242*	-0.102	0.026	-0.277*	-0.041	0.163	0.030
	P	0.047	-0.171	0.182	0.049	0.064	0.150	0.024	-0.180	-0.213	-0.212	-0.087	0.055	-0.177	-0.044	0.092	-0.001
10	G	0.740**	0.498**	-0.066	1.002**	1.022**	-0.056	0.460**	-	0.695*	0.695*	0.476*	-	-	-	-	-
	P	0.514**	0.390**	-0.106	0.844**	0.822**	0.020	0.281*	0.291** -0.161	* *	* *	* 0.404*	-0.135 -0.046	0.251* 0.042	0.298** 0.209	-0.411** -0.257*	0.376** 0.308**
11	G	0.256*	0.472**	0.024	0.605**	0.698**	-0.133	0.472**	-0.187	0.449*	0.450*	0.549*	-	-	-	-	-
	P	0.092	0.328**	-0.013	0.361**	0.379**	-0.105	0.280*	-0.095	* -0.279*	* -0.280*	* 0.361*	0.144 0.050	0.028 -0.017	0.082 -0.036	0.380** -0.324**	0.454** 0.373**
12	G	0.463**	0.325**	0.097	0.282*	0.348**	0.185	0.540**	0.011	0.073	0.073	0.100	0.151	0.106	0.556**	0.119	-0.056
	P	0.410**	0.316**	0.077	0.272*	0.308**	0.113	0.501**	0.006	0.068	0.068	0.090	0.135	0.020	0.445**	0.068	-0.057
13	G	-0.176	-0.232*	0.033	-0.007	-0.058	0.323*	-0.053	0.066	-	-	-	-	-	-	-	-
	P	-0.150	-0.206	0.038	-0.035	-0.070	* 0.235*	-0.039	0.025	0.395*	0.395*	0.316* *	-0.285* -0.153	0.420** -0.167	0.273* 0.169	0.442** 0.265*	-0.174 -0.126
14	G	0.196	0.306**	0.549**	-0.105	-0.072	0.710*	0.189	0.319**	0.319*	0.319*	-0.229*	0.130	-0.096	0.222	0.092	-
	P	0.200	0.238*	0.375**	-0.124	-0.082	* 0.399*	0.125	0.167	* 0.257*	* 0.257*	-0.178	0.032	-0.036	0.107	0.089	0.338** -0.237*
15	G	-0.295**	-0.071	0.156	-0.174	-0.069	-0.124	0.414**	0.620**	0.496*	0.496*	0.210	0.191	-	0.192	0.336**	-0.221
	P	-0.247*	-0.100	0.086	-0.137	-0.106	-0.155	0.203	0.317**	* 0.312*	* 0.312*	0.162	0.014	0.458** 0.128	0.053	0.002	-0.170
16	G	-0.535**	0.057	-0.080	-0.352**	-	-	-	0.372**	0.649*	0.649*	-	-	-	-	-	-
	P	-0.306**	0.021	-0.001	-0.323**	0.381** -0.273*	-0.004 0.060	0.300** -0.184	0.228*	* 0.482*	* 0.482*	-0.096 -0.040	-0.134 -0.092	0.343** -0.126	-0.023 -0.018	-0.001 -0.035	0.025 0.034
17	G		0.586**	-0.012	0.673**	0.697**	0.212	0.230*	-0.247*	0.545*	0.545*	0.211	-0.183	0.229*	0.150	-	-
	P		0.510**	0.018	0.540**	0.475**	0.084	0.184	-0.132	* -0.474*	* 0.475*	0.162	-0.148	0.110	0.130	0.427** -0.268*	-0.223* -0.154
18	G			-0.203	0.447**	0.498**	0.304*	0.221	0.084	-0.269*	-0.269*	0.489*	0.213	0.468**	0.143	-0.283*	-
	P			-0.216	0.404**	0.422**	* 0.232*	0.180	0.029	-0.244*	-0.244*	* 0.428*	0.170	0.146	0.127	-0.215	0.440** -0.418**
19	G				-0.263*	-0.229*	0.465*	0.005	0.010	0.042	0.042	-0.447*	-0.030	-	-0.180	-	-
	P				-0.166	-0.132	* 0.209	0.033	0.027	0.034	0.034	-	-0.046	0.541** -0.034	-0.137 -0.160	0.336** -0.160	-0.215 -0.110
20	G					1.002**	-0.015	0.392**	-0.238*	-	-	-	-	-	-	-	-
	P					0.937**	-0.025	0.323**	-0.158	0.666* * 0.614* *	0.666* * 0.614* *	0.424* * 0.380* *	-0.011 -0.013	0.396** 0.107	0.305** 0.245*	-0.267* -0.155	0.343** -0.277*

Characters		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
21	G P						-0.006 0.001	0.536** 0.388**	-0.260* -0.139	- 0.654* * - 0.566* *	- 0.654* * - 0.566* *	0.551* * 0.461* *	0.004 -0.006	0.364** 0.046	0.378** 0.252*	-0.248* -0.087	- 0.347** -0.269*
22	G P							0.054 0.116	0.085 0.030	0.003 -0.013	0.004 -0.013	- 0.340* * -0.242*	0.019 0.060	0.062 -0.087	0.208 0.209	0.332** 0.130	-0.186 -0.168
23	G P								-0.240* -0.194	-0.198 -0.166	-0.198 -0.167	0.399* * 0.343* *	0.098 0.120	-0.262* -0.127	0.373** 0.352**	0.140 0.078	0.015 0.029
24	G P									0.265* 0.252*	0.265* 0.252*	0.107 0.080	0.250* 0.148	0.498** 0.130	0.004 -0.039	0.242* 0.169	- 0.320** -0.183
25	G P										1.000* * 1.000* *	-0.195 -0.190	-0.174 -0.157	- 0.381** -0.204	-0.098 -0.065	0.383** 0.292**	0.180 0.162
26	G P											-0.195 -0.190	-0.175 -0.157	- 0.382** -0.204	-0.098 -0.064	0.383** 0.292**	0.180 0.163
27	G P												0.200 0.151	0.133 0.110	0.173 0.106	0.066 0.061	-0.246* -0.184
28	G P													0.777** 0.225*	0.260* 0.254*	0.288* 0.164	-0.109 -0.099
29	G P														0.049 -0.050	0.011 -0.002	-0.097 -0.036
30	G P															0.493** 0.215	0.103 0.088
31	G P																0.087 0.038
32	G P																1.000 1.000

1- Days taken to first germination, 2- Plant height, 3- Number of primary branches per plant, 4- Internodal length, 5- Stem girth, 6- Petiole length, 7- Petiole diameter, 8- Leaf length, 9- Number of epicalyx segments, 10- Days taken to first flowering, 11- Number of nodes at first flowering, 12- flower diameter, 13- Fruit length, 14- Fruit diameter, 15- Average fruit weight, 16- Number of fruits per plant, 17- Number of ridges per fruit, 18- Pedicel length, 19- Pedicel diameter, 20- Days taken to first fruit set, 21- Days taken to first fruit harvest, 22- Flesh thickness, 23- Number of seeds per fruit, 24- Seed index, 25- Yield per plot, 26- Yield per hectare, 27- Total soluble solids, 28- Ascorbic acid, 29- Chlorophyll content, 30- Ash content, 31- Moisture content and 32- Physiological loss.

RESULTS AND DISCUSSION

Determination of the correlation coefficient at genotypic and phenotypic levels

The data (Tables 1 and 2) showed the correlation coefficients for 32 distinct traits that were calculated at the genotypic and phenotypic levels for all potential combinations of yield and the corresponding attributing characters. In the current study, the genotypic level correlation coefficient had a larger magnitude than the phenotypic level correlation coefficient. Differences between their magnitudes were less in value, which was likewise highlighted by Nwangburuka *et al* (2012), Reddy *et al* (2013), Nirosha *et al* (2014), Umrao *et al* (2015) and Kumar and Joshi (2024) in their research on okra crop.

Correlation of yield with other traits

The present investigation revealed that yield per plot possesses a strong positive correlation with the

number of fruits per plant (0.649 and 0.482), fruit weight (0.496 and 0.257), fruit length (0.494 and 0.395), moisture content (0.383 and 0.292) and fruit diameter (0.319 and 0.257) at 1% level of significance while, seed index (0.265 and 0.252) and petiole length (0.252 and 0.193) were positively significant at both the genotypic and phenotypic levels at the 5% level of significance. It had non-significant positive correlation with physiological loss (0.180 and 0.162), stem girth (0.113 and 0.093), flower diameter (0.073 and 0.068), pedicel diameter (0.042 and 0.034), petiole diameter (0.023 and -0.005) and flesh thickness (0.003 and -0.013) which was similar to the results of Koundinya *et al* (2013), Balai *et al* (2014), Prajna and Gasti (2015), Ahamad *et al* (2015) and Raval *et al* (2019) in okra. Days taken to first germination (-0.074 and -0.067), ash content (-0.098 and -0.065), ascorbic acid (-0.174 and -0.157), total soluble solids (-0.195 and -0.190) and the number of seeds per fruit (-0.918 and -0.166) showed a negative correlation with yield per plot that was not statistically significant. Pedicel length (-0.269

Genotypic and Phenotypic Correlation Analysis for Important Quantitative Characteristics

and -0.244), leaf length (-0.244 and -0.120) and number of epicalyx segments (-0.242 and -0.120) had a highly significant negative correlation with yield per plot at 5% level of significance while, chlorophyll content (-0.381 and -0.204) had negative correlation with yield which is opposite to the findings of Nagre *et al* (2011) and Sawant *et al* (2014) in okra which might be explained by the fact that in the present investigation, data for chlorophyll content was taken in later stages of plant growth and findings shows that the negative correlation between chlorophyll content and yield indicated towards reduced metabolic activity of plant as it grows older. Plant height (-0.428 and -0.416), number of nodes at first flowering (-0.449 and -0.279), internodal length (-0.513 and -0.495), number of ridges per fruit (-0.545 and -0.244), number of primary branches per plant (-0.593 and -0.566), days taken to first fruit harvest (-0.654 and -0.566), days taken to first flowering (-0.695 and -0.558) and days taken to first fruit set (-0.666 and -0.614) showed a strong negative connection, both at the genotypic and phenotypic levels, with yield per plot at the 1% threshold of significance the outcomes were consistent with the conclusions of Nagre *et al* (2011), Koundinya *et al* (2013), Reddy *et al* (2013), Sawant *et al* (2014) and Pithiya *et al* (2017) in okra.

Inter association among important yield components

The information about inter-relation among yield components can be beneficial in the selection programme. According to Reddy *et al* (2013) and Deepanshu and Shamd (2017), inter-relation between yield traits should be estimated in the selection process.

Plant height

The plant height, at genotypic level was highly significant and positively associated with internodal length (0.616), chlorophyll content (0.469) and ascorbic acid (0.409) at 1% level of significance and number of nodes at first flowering (0.284) was positively significant at 5% level of significance. It had a non-significant positive correlation with stem girth (0.183), pedicel length (0.138), days taken to first fruit set (0.129), number of primary branches per plant (0.128), total soluble solids (0.098), days taken to first fruit harvest (0.061), days taken to first flowering (0.053), ash content (0.036), Physiological loss (0.036), and moisture content (0.018). Plant height had a non-significant negative correlation with seed index (-0.003), leaf length (-0.021), number of seeds per fruit (-0.021), petiole diameter (-0.028), number of ridges

per fruit (-0.054), average fruit weight (-0.122), number of epicalyx segments (-0.171), petiole length (-0.214) and flower diameter (-0.214). highly significant negative correlation at 5% level of significance with the number of fruits per plant (-0.238) and 1% level of significance with flesh thickness (-0.387), yield per plot (-0.428), yield per hectare (-0.428), fruit length (-0.480), fruit diameter (-0.517) and pedicel diameter (-0.588) which was following the findings of Deepanshu and Shamd (2017) and Jonah and Kwaga (2019) in okra.

Number of fruits per plant

Genotypic correlation revealed that the number of fruits per plant was highly significant and positively correlated with yield per plot (0.649), yield per hectare (0.649) and seed index (0.372) at 1% level of significance, while a positive non-significant correlation was observed with physiological loss (0.025) and pedicel length (0.057). It had a negative non-significant correlation with moisture content (-0.001), flesh thickness (-0.004), ash content (-0.023), pedicel diameter (-0.080), total soluble solids (-0.096) and ascorbic acid (-0.134). The number of fruits per plant had highly significant negative correlation at 1% level of significance with the number of seeds per fruit (-0.300), chlorophyll content (-0.343), days taken to first fruit set (-0.352), days taken to first fruit harvest (-0.381) and the number of ridges per fruit (-0.535), which was following the findings of Adiger *et al* (2011), Nagre *et al* (2011), Koundinya *et al* (2013) and Nirosha *et al* (2014) in okra.

Yield

Yield per hectare, at genotypic level was highly significantly and positively correlated with moisture content (0.383) while it was non-significantly and positively correlated with physiological loss (0.180). which was similar with the findings of Balai *et al* (2014), Prajna and Gasti (2015) and Pithiya *et al* (2017) in okra. Yield per hectare, at phenotypic level was highly significantly and positively correlated with moisture content (0.292) while it was non-significantly and positively correlated with physiological loss (0.163). It was non-significantly and negatively associated with ash content (-0.064), ascorbic acid (-0.157), total soluble solids (-0.190) and chlorophyll content (-0.204), which was following the findings of Nirosha *et al* (2014), Sawant *et al* (2014) and Thulasiram *et al* (2017) in okra.

Ascorbic acid

Studies on ascorbic acid's genotypic correlation analysis indicated that it was highly significant and positively associated with chlorophyll content (0.777) at 1% level of significance and 5% level of significance with moisture content (0.288) and ash content (0.260). Ascorbic acid, at phenotypic level was highly significant and positively associated with chlorophyll content (0.225) and ash content (0.254) at 5% level of significance while the positive non-significant correlation with moisture content (0.164). Ascorbic acid had a non-significant negative correlation with physiological loss (-0.099). Earlier, workers like Nagre *et al* (2011), Balai *et al* (2014) and Nirosha *et al* (2014) also recorded similar observations for ascorbic acid in okra.

CONCLUSION

According to the results of the current study, the environment had less of an effect on phenotypic expression since the genotypic correlation coefficients were higher than the phenotypic correlation coefficients. The fruit length, fruit diameter, number of fruits per plant, seed index, fruit weight, moisture content and petiole length all were significantly correlated with the yield per plot at phenotypic and genotypic levels. This suggests that these traits are important for genetically improving the yield of okra through selection while pedicel length, leaf length, chlorophyll content, number of epicalyx segments, number of nodes at first flowering, plant height, internodal length, number of primary branches per plant, number of ridges per fruit, days taken to first flowering, days taken to first fruit harvest and days taken to first fruit set shown a highly significant negative association with yield per plot, suggesting that these attributes are not as important in the selection process for okra's yield-related genetic modification. Therefore, it might be concluded that the traits *viz.*, fruit weight, number of fruits per plant, fruit length, fruit diameter, moisture content, seed index and petiole length can be considered while designing breeding and selection processes for strong selection process.

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Impact of Controlled Environment on Growth and Flowering of Gerbera (*Gerbera jamesonii* Bolus)

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ABSTRACT

Gerbera (*Gerbera jamesonii* Bolus) a popular cut flower from the Asteraceae family, whose cultivation in semi-arid regions diversifies income and offers profitable market opportunities, enabling scientists develop techniques suited to these conditions. Although, flower production in northern part is limited compared to southern parts of the state, it still contributes to the sector, especially as floriculture gaining traction. The present study was conducted to assess vegetative and flower characteristics of seven gerbera varieties (Intense, Chique, Camilla, Sam Dom, Ritmo, Beaker and Ankur) with three replications using Randomized block design (RBD) at the College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka under polyhouse conditions. Results showed that vegetative characters like plant spread (63.89 cm), leaf length (30.03 cm) and leaf breadth (16.40 cm) was highest in the variety Intense. Plant height (54.20) was highest in Chique, maximum no of leaves per plant was produced by Beaker (28.17). Pertaining to flower characters, the maximum number of flowers per plant per month (3.93), stalk girth (6.30 mm) and flower diameter (11.3 cm) was highest in Intense. Stalk length (58.5 cm) was greater in Chique and maximum flower weight in Sam Dom (10.83 g). Hence, it was observed that the variety Intense performed best for most of the characters followed by Chique, Ankur, Ritmo, Camilla, Sam Dom and least by Beaker. In conclusion, the study identifies 'Intense' as the most promising gerbera variety for semi-arid polyhouse conditions in northern Karnataka, demonstrating superior vegetative and floral traits compared to the other varieties tested.

Keywords: Bagalkot, Environment, Flower, Gerbera,

INTRODUCTION

Gerbera (*Gerbera jamesonii* Bolus) is a bright and striking perennial belonging to the family Asteraceae, renowned for its daisy flowers, which convey happiness and positivity. The striking and colourful blooms come in numerous shades, rendering them a favourite in gardens as well as floral arrangements because of their optimistic vibe (Kankana and Talukdar, 2015). Gerbera plants are relatively drought-tolerant and thrive in regions with moderate rainfall and well-drained soil. Semi-arid environments, characterized by dry weather, are best suited for the cultivation of Gerbera, providing farmers with a lucrative venture, as it is one of the most sought-after cut flowers in the international floral market (Kumar *et al*, 2013). Floriculture is an important contributor to employment generation through job

opportunities in different sectors of cultivation, packaging, transport and sale (Rahul *et al*, 2021; Kumar and Singh, 2022). To agricultural communities, floriculture provides a means to diversify their income sources and reduce reliance on traditional crops such as cotton and grains (Shivani and Tamrakar, 2022). The advent of high-tech farming practices, such as greenhouse farming, has enabled flower cultivation in Northern Karnataka to be carried out throughout the year, thus enhancing both quality and output. Flowers produced in this area, especially Gerberas, are slowly finding their way into markets all over the country. The increasing demand for these flowers is opening up new business prospects (Maitra *et al*, 2024). Moreover, studies on how these plants and varieties accommodate local climates can result in the creation of specialized cultivation methods suited to the area, supporting

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Table 1: Mean performance of gerbera cultivars for vegetative growth parameters.

Name of variety	Plant spread (cm)	Number of leaves	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)
Intense	63.89	21.97	53.09	30.03	16.40
Chique	57.30	20.97	54.20	23.87	11.03
Camilla	51.73	20.20	46.61	23.30	9.40
Sam Dom	44.50	16.73	37.37	21.00	8.60
Ritmo	55.63	13.73	44.30	23.27	12.47
Beaker	37.97	22.37	27.63	20.93	7.87
Ankur	50.85	28.17	39.3	26.30	11.07
CD at (5%)	4.89	4.27	4.84	1.54	1.52
SEm	1.59	1.39	1.57	0.50	0.49

healthier growth and improved yields for commercial and ornamental purposes. Hence, the present study was conducted to study the performance of different gerbera varieties under protected cultivation practices.

MATERIALS AND METHODS

The study was done at College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, during 2024-25 in a naturally ventilated polyhouse for assessment of different Gerbera cultivars for performance. Planting was initiated in October 2024. Meteorological observations made from the UHS Bagalkot MHREC station during the growing period of the crop revealed that the average maximum temperatures varied from 31.9°C to 28°C and the average minimum temperatures varied from 20°C to 17°C. The highest relative humidity varied from 84% to 62% and the lowest relative humidity varied from 69% to 33%. There were seven Gerbera cultivars, *viz.*, Intense, Chique, Camilla, Sam Dom, Ritmo, Beaker and Ankur, obtained from Kumar Florist (K.F. Bio Plants), Pune. A three replication Randomized Block Design (RBD) was used. Raised beds with dimensions 18 meters in length, 1 meter in width and 0.30 meters in height were prepared and amended with basal application of farmyard manure (FYM), biofertilizers and di-ammonium phosphate (DAP). Gerbera seedlings were tissue-cultured and transplanted at a distance of 30 cm × 20 cm and normal agronomic practices were maintained during the course of cultivation. Vegetative parameters such as plant height, plant spread, leaf number, leaf length and leaf breadth were collected through data. Floral characteristics like flower stalk length, stalk girth, number of flowers/plant/month, flower weight and flower diameter were measured 120 days after planting (DAP). The data collected were analyzed statistically using analysis of variance (ANOVA), standard error of the mean (S.Em ±) and critical difference (CD) at 5% level of significance to determine the performance of

the cultivars under naturally ventilated polyhouse conditions.

RESULTS AND DISCUSSION

Vegetative parameters

The findings of the current research, as presented in the table 1, demonstrated noteworthy differences between the different Gerbera cultivars for several vegetative characteristics. Statistical analysis reported that the cultivar 'Chique' achieved the highest plant height at 54.20 cm, followed very closely by 'Intense' with 53.09 cm, while 'Beaker' had the lowest height at 27.63 cm. These plant height differences concur with the findings documented by Reddy *et al* (2003). Leaf number varied between 13.73 and 28.17, with 'Ankur' having the largest number and 'Ritmo' having the least, supported by Kumar *et al* (2013). Leaf length was maximum in 'Intense' (30.03 cm) followed by 'Ankur' (26.30 cm) and 'Chique' (23.87 cm). Leaf breadth was dominated by 'Intense' at 16.40 cm followed by 'Ritmo' (12.47 cm) and 'Ankur' (11.07 cm). In plant spread, 'Intense' recorded the widest spread of 63.89 cm, followed by 'Chique', while that of 'Beaker' was the narrowest at 37.97 cm. These differences are based on the natural genetic composition of the cultivars, in addition to their corresponding leaf sizes, supporting Deka *et al* (2015). Moreover, the plant height of 'Intense' (53.09 cm) and 'Ankur' (39.3 cm) recorded during this research were different from that reported in Odisha (44.7 cm and 46.3 cm respectively), according to Maitra *et al* (2024), reflecting the influence of local climatic conditions on the growth of the cultivars.

Flower characters

Data analysis from the table 2 shows that flower characteristics were quite different for the various Gerbera varieties. In the single-type flowers, the maximum diameters were for the flowers of

Impact of Controlled Environment on Growth and Flowering of Gerbera

Table 2: Mean performance of gerbera cultivars for floral growth parameters.

Name of variety	Number of flowers/plant/month	Flower weight (g)	Flower diameter (cm)	Stalk length (cm)	Stalk girth (mm)	Flower colour	Flower type
Intense	3.93	9.52	11.33	57.63	6.30	Dark Pink	Single
Chique	3.23	7.23	6.73	58.50	4.91	Purple	Double
Camilla	2.73	10.62	6.75	50.20	4.23	Light Pink	Double
Sam Dom	2.00	10.83	7.80	40.83	4.61	White	Double
Ritmo	2.20	7.72	9.30	46.17	5.80	Yellow	Single
Beaker	3.90	8.32	5.94	32.50	4.97	Orange-Yellow	Double
Ankur	2.00	10.18	10.29	50.50	4.35	Bright Red	Single
CD at (5%)	0.60	0.21	0.65	4.96	0.46	-	-
SEm	0.19	0.07	0.21	1.61	0.15	-	-



Intense



Chique



Beaker



Ankur



Sam Dom



Ritmo



Camilla



'Intense' (11.3 cm), followed by 'Ankur' (10.29 cm) and 'Ritmo' (9.30 cm). For double-type flowers, the largest flower diameter was recorded in 'Sam Dom' (7.80 cm), followed by 'Camilla' (6.75 cm), whereas the smallest diameters were recorded in 'Chique' (6.73 cm) and 'Beaker' (5.94 cm). The greater flower diameters in single-type flowers can be due to their longer ray florets compared to double-type flowers. The larger flower size of 'Intense' is attributed to the genetic makeup of the cultivar. These findings are consistent with the reports of Gotz (1983) and Mahmood *et al* (2013) who also

reported extreme variation in flower diameter among Gerbera cultivars under greenhouse conditions. As for flower yields, the largest number of flowers per plant in 'Intense' (3.93), followed closely by 'Beaker' (3.90), then 'Camilla' (2.73) and 'Chique' (2.33), but the lowest flower yield was 'Sam Dom' (2.00). This augmented flower production in some cultivars can be attributed to characteristics like an increased leaf area, leaf number and plant spread, all of which improve the storage and production of photosynthates, hence leading to flower growth, as justified by Deka *et al* (2015). The longest

stalks of flowers were observed in 'Chique' (58.5 cm), then 'Intense' (57.63 cm) and 'Ankur' (50.5 cm), while 'Beaker' had the shortest (32.5 cm). Since stalk length is primarily controlled by genes, its difference between cultivars is not unexpected, according to Sarkar and Ghimaray (2004). In *Gerbera*, stalk length is an important quality factor of cut flowers, as longer stalks contain greater reserves that are responsible for flower longevity, something also highlighted by Mahmood *et al* (2013). In stalk girth, the maximum was in 'Intense' (6.30 mm), then 'Ritmo' (5.80 mm), while minimum was recorded in 'Camilla' (4.23 mm). Rajiv Kumar *et al.* (2012) had reported previously variations in stalk thickness among ten *Gerbera* genotypes in polyhouse conditions. For flower weight, 'Sam Dom' yielded the most massive flowers (10.83 g), while 'Chique' yielded the lightest (7.23 g). This difference in flower weight correlates with flower size, as confirmed by Vijayalaxmi *et al* (2021), with bigger flowers naturally having more mass.

CONCLUSION

Vegetative growth and floral traits of *Gerbera* were significantly impacted by the selection of cultivar. The differences noticed among the seven cultivars can be credited primarily to their unique genetic attributes, as they were all grown under identical and favourable polyhouse conditions. Out of them, the cultivar 'Intense' performed the best in both vegetative and floral traits. Cultivars like 'Chique', 'Ankur' and 'Ritmo' also exhibited satisfactory results. On the basis of the findings of this study, the cultivation of 'Intense', 'Chique', 'Ankur' and 'Ritmo' is suggested in naturally ventilated polyhouses in semi-arid areas to attain maximum growth and flower production.

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Impact of Pre-Harvest Fruit Bunch Bagging on Yield and Quality of Different Litchi (*Litchi chinensis* Sonn.) Cultivars

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ABSTRACT

Pre-harvest bagging practice enhances harvest timing, minimizes insect infestations, reduces chemical residues, and supports organic cultivation. A study was carried out at the Instructional Farm of UBKV, Pundibari to evaluate the effects of bagging on three litchi cultivars (Calcuttia, Elaichi, and China) using six coloured bags (transparent, yellow, green, blue, red, and black with 5% perforations) and an un-bagged control in a factorial randomized block design with four replications. The Elaichi cultivar showed the best performance with reduced fruit drop (27.71%) and maximum fruit retention (64.70%). Un-bagged fruits had the highest cracking rate (5.47%) and infestation (10.76%), while bagged fruits were free from these issues. Blue-coloured bags yielded the best results, achieving maximum fruit weight (17.38 g), diameter (3.11 cm), length (3.78 cm), juice yield (7.73 ml), TSS (21.04 °B), total sugar (16.31%), reducing sugar (13.74%), ascorbic acid (32.01 mg/100 g), and anthocyanin content (29.22 mg/100 g). Bagging proved effective in improving fruit quality and reducing losses, particularly during the rainy season.

Keywords: Bagging, Cracking, Fruit, Insect, Infestation, Litchi, Pre-Harvest, .

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.), the queen of subtropical fruit is a member of the Sapindaceae family, prized for its flavour, quality and vivid red hue. Bihar, West Bengal, and Jharkhand account for 66% of the overall output making them the major production centers (Sahni *et al*, 2020). Poor fruit set, low retention, fruit cracking, and pest infestations all contribute to its low average output, despite its potential (Das and Rahman, 2018). The leathery-rinded fruit usually produced in clusters comes in a variety of shapes and colours usually ranging from pink to red flowers (Malotra *et al*, 2018). The 24 Parganas of West Bengal, Murshidabad, Malda, and Nadia are important agricultural locations for popular cultivars like Shahi, Bombai, and Bedana. Proteins, minerals (calcium, phosphorus), vitamins (B1, C), and bioactive substances with anti-cancer and antioxidant qualities are all abundant in litchi (Singh *et al*, 2019). Its pulp comprises 60% juice, contributing to its high nutritional and commercial value (Nath *et al*, 2016).

Yield and financial returns are severely constrained by the fruit's short shelf life, erratic

flowering, excessive fruit loss, and temperature sensitivity. To reduce these problems, novel approaches have been investigated such as pre-harvest fruit bagging. Fruit bagging, a physical protection technique, has demonstrated encouraging outcomes in terms of improving litchi quality and output. Bagging enhances internal quality (nutritional retention) and outward appearance (coloration and blemish reduction) by changing the microenvironment (Fan and Mattheis, 1998). Fruits are also shielded against pests, illnesses, mechanical harm, and pesticide residues by it. Fruit has improved in size and weight and matured 12 days earlier thanks to bagging procedures that use biodegradable cellophane paper bags (Debnath and Mitra, 2008).

Bagging contributes to quality improvement by increases the colour of the peel and lessens cracking, encourages organic farming and reduces pesticide residues. Harvesting is spaced out and handling is made easier, provides protection from sunburn, insect damage, and other environmental dangers (Fan and Mattheis, 1998; Shah *et al*, 2020). Bagging of the fruits is a labour-intensive method that has been successful in resolving important agricultural issues, making it a

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Table 1: Effect of fruit bunch bagging on fruit drop and fruit retention in litchi.

Bagging (B)	Fruit Drop (%)			Mean	Fruit Retention (%)			Mean
	Cultivars (C)				Cultivars (C)			
	Calcuttia	Elaichi	China		Calcuttia	Elaichi	China	
B ₀ (Control)	36.83 (37.35)	38.83 (38.54)	35.30 (36.43)	36.99 (37.44)*	63.17 [7.89]	61.17 [7.85]	64.70 [8.07]	63.01 [7.97]#
B ₁ (Transparent)	21.15 (27.32)	23.74 (29.13)	20.92 (27.20)	21.94 (27.89)	78.85 [8.91]	76.26 [8.76]	79.08 [8.92]	78.06 [8.86]
B ₂ (Yellow)	23.41 (28.94)	28.38 (32.10)	21.83 (27.84)	24.54 (29.62)	76.59 [8.78]	71.62 [8.49]	78.17 [8.87]	75.46 [8.71]
B ₃ (Green)	21.18 (27.37)	25.33 (30.20)	18.85 (25.73)	21.79 (27.77)	78.82 [8.91]	74.67 [8.67]	81.15 [9.04]	78.21 [8.87]
B ₄ (Blue)	18.06 (25.14)	22.62 (28.39)	17.37 (24.57)	19.35 (26.03)	81.94 [9.08]	77.38 [8.82]	82.63 [9.12]	80.65 [9.01]
B ₅ (Red)	26.15 (30.74)	29.02 (32.57)	26.59 (31.04)	27.25 (31.45)	73.85 [8.62]	70.98 [8.45]	73.41 [8.60]	72.75 [8.56]
B ₆ (Black)	22.69 (28.42)	26.06 (30.68)	23.83 (29.13)	24.20 (29.41)	77.31 [8.82]	73.94 [8.63]	76.17 [8.75]	75.80 [8.73]
Mean	24.21 (29.32)	27.71 (31.66)	23.53 (28.85)	25.15 (37.44)	63.17 [8.73]	61.17 [8.52]	64.70 [8.77]	74.85 [8.67]
	Bagging (B)		Cultivars (C)	B × C	Bagging (B)		Cultivars (C)	B × C
SEm±	0.55		0.36	0.95	0.05		0.03	0.08
CD at 5.0 %	1.55		1.01	NS	0.14		0.09	NS

*Figures in parentheses indicates arc sign transformed values.

#Figures in parentheses indicates square root transformed values.

feasible strategy for raising litchi quality and productivity in India. The current experiment was conducted with the aim of examining the impact of fruit bunch bagging with various coloured bags on the fruit yield and quality of different litchi cultivars, taking into account its significance and cultivation bottleneck.

MATERIALS AND METHODS

Experimental set-up

The experiment was carried out at the Uttar Banga Krishi Viswavidyalaya's Department of Pomology and Post Harvest Technology's Instructional Farm, located in Pundibari, Cooch Behar, West Bengal-736165, Faculty of Horticulture. The area is 43 meters above mean sea level and falls within the Terai agro-climatic zone of West Bengal. It is situated at 26°39'83" N latitude and 89°38'64" E longitude (according to the geographic coordinate system). High humidity and a lot of rainfall are characteristics of the subtropical humid climate found in this area.

Methodology

Three cultivars (Calcuttia, Elaichi, and China) were examined using 21 treatment combinations of six different coloured bags (transparent, yellow, green,

blue, red, and black bags with 5% perforations) and one unbagged control. A factorial randomized block design was used to arrange these possibilities, which were replicated four times. Each replication featured two bunches that were bagged. Seven days after the fruit set, the litchi panicles were packed in a variety of coloured cellophane paper bags. In order to provide the appropriate ventilation required for fruit development, 5% of each bag was perforated by creating holes (4 mm) in each bag. Using the necessary precautions to prevent shock to the young fruitlets and panicle breakage during bag tying, fruits were gathered from several treatments at the proper stage of development.

Observations Recorded

The observations were recorded by randomly selected fruits from each bag. During the course of the experiment, the observations like fruit drop (%), fruit cracking (%), fruit retention (%), number of infested fruits by fruit borer (*Conopomorpha sinensis*) per panicle (%), fruit weight (g), weight of aril (g), weight of seed (g), fruit length and diameter (cm), total soluble solids (TSS) content (°Brix), total sugar (%), reducing sugars (%), non-reducing sugars (%), titratable acidity (%), ascorbic acid (mg/100) and anthocyanin content of fruit peel (mg/100ml) were taken.

Impact of Pre-Harvest Fruit Bunch Bagging on Yield and Quality of Different Litchi

Table 2: Effect of fruit bunch bagging on fruit cracking and infestation in litchi

Bagging (B)	Fruit Cracking (%)			Mean	Infested fruits (%)			Mean
	Cultivars (C)				Cultivars (C)			
	Calcuttia	Elaichi	China		Calcuttia	Elaichi	China	
B ₀ (Open)	0.00 [0.71]	16.40 [3.98]	0.00 [0.71]	5.47 [1.80]#	16.82 (17.68)	0.00 (0.00)	15.48 (16.89)	10.76 (11.52)*
B ₁ (Transparent)	0.00 [0.71]	0.00 [0.71]	0.00 [0.71]	0.00 [0.71]	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
B ₂ (Yellow)	0.00 [0.71]	0.00 [0.71]	0.00 [0.71]	0.00 [0.71]	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
B ₃ (Green)	0.00 [0.71]	0.00 [0.71]	0.00 [0.71]	0.00 [0.71]	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
B ₄ (Blue)	0.00 [0.71]	0.00 [0.71]	0.00 [0.71]	0.00 [0.71]	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
B ₅ (Red)	0.00 [0.71]	4.36 [1.87]	0.00 [0.71]	1.45 [1.10]	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
B ₆ (Black)	0.00 [0.71]	7.88 [2.89]	0.00 [0.71]	2.63 [1.44]	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Mean	0.00 [0.71]	4.09 [1.65]	0.00 [0.71]	1.36 [1.02]	2.40 (2.53)	0.00 (0.00)	2.21 (2.41)	1.54 (1.65)
	Bagging (B)		Cultivars (C)	B × C	Bagging (B)		Cultivars (C)	B × C
SEm±	0.17		0.08	0.20	1.79		1.17	3.10
CD at 5.0 %	0.33		0.23	0.57	5.06		NS	NS

*Figures in parentheses indicates arc sign transformed values.

#Figures in parentheses indicates square root transformed values.

Table 3: Effect of fruit bunch bagging on weight of fruit, fruit length and fruit diameter in litchi

Bagging (B)	Weight of Fruit (g)			Mean	Fruit Length (cm)			Mean	Fruit Diameter (cm)			
	Cultivars (C)				Cultivars (C)				Cultivars (C)			Mean
	Calcuttia	Elaichi	Calcuttia		China	Elaichi	Calcuttia		China	Elaichi	China	
B ₀ (Open)	17.84	13.75	3.20	3.68	3.43	3.44	3.20	3.68	3.43	3.44	3.39	3.36
B ₁ (Transparent)	20.34	15.68	3.45	3.65	3.74	3.61	3.45	3.65	3.74	3.61	3.27	3.13
B ₂ (Yellow)	20.03	15.39	3.39	3.53	3.68	3.53	3.39	3.53	3.68	3.53	3.29	3.19
B ₃ (Green)	20.62	16.04	3.48	3.79	3.76	3.67	3.48	3.79	3.76	3.67	3.26	3.11
B ₄ (Blue)	21.10	16.57	3.68	3.86	3.81	3.78	3.68	3.86	3.81	3.78	3.22	3.06
B ₅ (Red)	18.55	14.48	3.35	3.47	3.58	3.46	3.35	3.47	3.58	3.46	3.33	3.30
B ₆ (Black)	19.06	14.72	3.42	3.53	3.68	3.54	3.42	3.53	3.68	3.54	3.32	3.23
Mean	19.65	15.23	3.42	3.64	3.67	3.58	3.42	3.64	3.67	3.58	3.30	3.20
	Bagging (B)		Cultivars (C)	Bagging (B)	Cultivars (C)		B × C	Bagging (B)	Bagging (B)	Cultivars (C)	B × C	
SEm±	0.08		0.12	0.03	0.04		0.07	0.04	0.03	0.04	0.07	
CD at 5.0 %	0.22		0.33	0.08	0.12		NS	0.11	0.08	0.12	NS	

Table 4: Effect of fruit bunch bagging on total soluble solid and total sugar in litchi

Bagging (B)	Totals Soluble Solid (°Brix)			Mean	Total Sugar (%)			Mean
	Cultivars (C)				Cultivars (C)			
	Calcuttia	Elaichi	China		Calcuttia	Elaichi	China	
B ₀ (Open)	17.50	17.53	17.50	17.51	14.27	14.11	14.25	14.21
B ₁ (Transparen)	20.06	18.58	19.19	19.27	15.73	15.25	15.16	15.38
B ₂ (Yellow)	19.01	19.00	18.10	18.70	15.51	15.22	15.07	15.27
B ₃ (Green)	21.00	20.43	20.38	20.60	16.05	15.80	16.05	15.97
B ₄ (Blue)	21.01	21.04	21.07	21.04	16.36	16.34	16.22	16.31
B ₅ (Red)	17.98	17.70	17.68	17.78	14.39	14.39	14.53	14.44
B ₆ (Black)	18.15	18.10	18.01	18.09	14.92	14.61	14.76	14.76
Mean	19.24	18.91	18.85	19.00	15.32	15.10	15.15	15.19
	Bagging (B)	Cultivars (C)	B × C		Bagging (B)	Cultivars (C)		B × C
SEm±	0.09	0.13	0.23		0.05	0.07		0.13
CD at 5.0 %	0.25	0.38	0.65		0.14	0.21		NS

Table 5: Effect of fruit bunch bagging on reducing sugar and non-reducing sugar in litchi

Bagging (B)	Reducing Sugar (%)			Mean	Non-Reducing Sugar (%)			Mean
	Cultivars (C)				Cultivars (C)			
	Calcuttia	Elaichi	China		Calcuttia	Elaichi	China	
B ₀ (Open)	10.95	10.76	10.92	10.88	3.32	3.35	3.33	3.33
B ₁ (Transparent)	12.71	12.27	12.16	12.38	3.01	2.98	3.00	3.00
B ₂ (Yellow)	12.42	12.15	12.01	12.19	3.09	3.07	3.06	3.08
B ₃ (Green)	13.15	12.92	13.16	13.08	2.91	2.89	2.89	2.89
B ₄ (Blue)	13.53	13.51	13.37	13.47	2.83	2.83	2.85	2.84
B ₅ (Red)	11.13	11.21	11.31	11.22	3.25	3.19	3.22	3.22
B ₆ (Black)	11.76	11.49	11.58	11.61	3.17	3.12	3.18	3.16
Mean	12.23	12.04	12.07	12.12	3.08	3.06	3.08	3.07
	Bagging (B)		Cultivars (C)	B × C	Bagging (B)		Cultivars (C)	B × C
SEm±	0.05		0.07	0.13	0.01		0.01	0.02
CD at 5.0 %	0.14		0.21	NS	NS		0.03	NS

RESULTS AND DISCUSSION

Fruit drop and retention

The different colour bags showed positive effect on fruit drop and retention in litchi (Table 1). Among the different colour bags, the lowest fruit drop and the highest fruit retention were recorded when fruit bunches were bagged with blue colour bags. The litchi cultivars also exhibited significant variations on fruit drop and retention of litchi. The highest fruit drop and the maximum fruit retention were recorded in litchi cultivar Elaichi (27.71 %) and China (64.70 %), respectively. In comparison to the unbagged fruits, Son and Kim (2010) discovered that bunch bagging grapes 7 to 9 weeks after full bloom decreased the rate of fruit drop (breaking). According to Shah *et al* (2020), in litchi cv. Rose, fruit that was packaged using white

polypropylene bags with 5% perforation, 30 days prior to harvest had the best fruit retention. Debnath and Mitra (2008) found that bagging the fruits a week after fruit set greatly enhanced the amount of litchi fruit retained per panicle. Additionally, bagging improved fruit retention in off-season longan cv. Chuliang, according to Yang *et al* (2008).

Fruit cracking (%) and infested fruit (%)

It was evident from the data (Table 2) that no fruit cracking as well as no infested fruit were recorded in most of the bagged fruit, only in control 5.47 % cracked fruit and 10.76 % infested fruits were seen. The litchi cultivars also exhibited significant variations on cracked fruit percentage and non-significant variation on infested fruit percentage of litchi. Lal (2019) stated that fruit bunch bagging prior to

Impact of Pre-Harvest Fruit Bunch Bagging on Yield and Quality of Different Litchi

Table 6: Effect of fruit bunch bagging on titratable acidity and ascorbic acid in litchi

Bagging (B)	Titratable Acidity (%)			Mean	Ascorbic Acid (mg/100g)			Mean
	Cultivars (C)				Cultivars (C)			
	Calcuttia	Elaichi	China		Calcuttia	Elaichi	China	
B ₀ (Open)	0.52	0.52	0.52	0.52	23.10	23.03	23.00	23.04
B ₁ (Transpare)	0.45	0.45	0.44	0.45	30.25	30.68	30.53	30.48
B ₂ (Yellow)	0.47	0.47	0.46	0.46	29.98	29.78	29.75	29.83
B ₃ (Green)	0.44	0.44	0.43	0.44	31.23	31.68	30.63	31.18
B ₄ (Blue)	0.42	0.42	0.42	0.42	32.00	32.03	32.00	32.01
B ₅ (Red)	0.50	0.45	0.46	0.47	25.58	25.35	25.25	25.39
B ₆ (Black)	0.49	0.48	0.47	0.48	26.50	26.20	28.40	27.03
Mean	0.47	0.46	0.46	0.46	28.37	28.39	28.51	28.42
	Bagging (B)	Cultivars (C)	B × C		Bagging (B)	Cultivars (C)	B × C	
SEm±	0.01	0.01	0.01		0.11	0.16	0.28	
CD at 5.0 %	NS	0.02	NS		NS	0.46	0.79	

Table 7: Effect of fruit bunch bagging on anthocyanin content of fruit peel in litchi

Bagging (B)	Anthocyanin Content (mg/100ml)			Mean
	Cultivars (C)			
	Calcuttia	Elaichi	China	
B ₀ (Open)	13.11	14.57	20.68	16.12
B ₁ (Transparent)	26.86	26.19	23.36	25.47
B ₂ (Yellow)	24.60	25.33	22.28	24.07
B ₃ (Green)	28.83	28.23	23.84	26.96
B ₄ (Blue)	30.74	30.01	26.92	29.22
B ₅ (Red)	21.13	23.04	21.10	21.76
B ₆ (Black)	23.01	24.57	21.86	23.15
Mean	24.04	24.56	22.86	23.82
	Bagging (B)		Cultivars (C)	B × C
SEm±	1.55		2.37	4.10
CD at 5.0 %	NS		6.69	NS

harvesting produced high-quality litchi fruit with minimal cracking and borer infestation. Shah *et al* (2020) also obtained similar results. They found that using a white polypropylene bag with a 5% perforation to bag a bunch of litchi fruit decreased fruit cracking by 93.93% and borer infestation by 92.81%. Fruit cracking ranged from a minimum of 7.69% in a white polypropylene bag with 5% perforation to a maximum of 12.79% when the fruit was not bagged. Yang *et al* (2008) also found similar patterns of fruit cracking in fruit bagging in Longan.

Weight of fruit, fruit length and fruit diameter

The different colour of bags showed a significant effect on weight of fruit, fruit length and fruit diameter in litchi (Table 3). Among the different colour bags, the maximum weight of fruit, fruit length and fruit diameter were recorded when fruit bunches were bagged with blue colour bags (B₄). The maximum

weight of fruit was recorded in Calcuttia (C₁) 19.65 g and minimum weight of fruit (14.45 g) was obtained in open condition. The maximum fruit length and diameter were recorded in litchi cultivar China (3.67) and (3.18), respectively. According to Lal (2019), bagging increased the weight of litchi fruit by 14.49%. Similar findings were made by Abdel *et al* (2017) who found that unbagged fruits had the lowest weight and that fruits bagged with agril blue bags had the greatest fruit weight in mango cv. Keitt, followed by agril green bags. Additionally, fruit length was increased by bagging, with fruits bagged with agril white bags showing the largest increase, followed by those bagged with red bags. Furthermore, mangoes bagged using agril green bags first, then blue bags, showed an improvement in fruit diameter. Shah *et al* (2020) also discovered that fruits bagged with white polypropylene bags with 5% perforation had a maximum weight of 21.53 g, whereas unbagged fruits

had a minimum weight of 19.95 g. When litchi was packed in pink polypropylene bags with no holes, the largest fruit diameter (3.45 cm) was measured. Yang *et al* (2008) reported that bagging in longan increased the size of the fruit.

Total soluble solid and total sugar

The different colour bags showed a significant effect on total soluble solid and total sugar content in litchi (Table 4). Among the different bags, the highest total soluble solid and the total sugar were recorded from the fruit bunches which were bagged with blue colour bags. The highest totals soluble solid and total sugar was recorded in litchi cultivar Calcuttia as 19.24 and 15.32, respectively. The maximum TSS was recorded on C₃B₄ (21.07 °B) followed by C₂B₄ (21.04 °B). The TSS was significantly altered by bagging Litchi berries claimed Kholiya *et al* (2019). Fruit that was not bagged had the lowest TSS (18.75 °B) followed by fruit that was bagged in double parchment paper bags (20.96 °B) and fruit that was packed in triple parchment paper bags (21.03 °B). They also reported that fruits that were not bagged had the lowest total sugar content (20.99%), while fruits that were packaged in a single parchment paper bag had the highest (21.99%), followed by fruits that were bagged in double parchment (21.75%). Litchi fruit packed in white polypropylene bags with 10% perforation had the highest TSS (18.76°B), whereas pink polypropylene bags without perforation had the lowest (17.72°B) Shah *et al* (2020). They also found that the fruits with the greatest total sugar (13.25%) were those that were wrapped in white polypropylene bags with 5% perforation whereas the fruits without bags had the lowest (11.92%). Pre-harvest bagging in litchi, increased TSS value was also reported by Debnath and Mitra (2008) and Lal (2020).

Reducing sugar and non-reducing sugar

The different bags showed a significant effect on reducing sugar but non-significant on non-reducing sugar of litchi fruit (Table 5). Among the different colour bags, the highest reducing and non-reducing were recorded from fruit bunches which were bagged with blue colour bags and green colour bags respectively. The highest reducing sugar (12.23) and non-reducing sugar (3.08) were recorded in litchi cultivar Calcuttia. The maximum reducing sugar value were recorded on C₁B₄ (13.53 %) followed by C₂B₄ (13.51 %). According to Shah *et al* (2020), litchi fruits that are bagged with white polypropylene bags (5% perforation) had the highest amount of reducing sugar (11.41%) and non-reducing sugar (1.84%), while

unbagged fruit had the lowest amount for the same parameter (10.14%). The litchi fruit coated with a single piece of parchment paper had the highest decreasing sugar (20.49%), whereas the fruit that was not bagged had the lowest (18.86%). Additionally, they stated that fruits packaged with brown paper bags had the highest non-reducing sugar content (8.16%), while fruits bagged with triple parchment paper had the lowest (6.75%).

Titrateable acidity and ascorbic acid

The perusal of the data on titrateable acidity and ascorbic acid content of litchi fruit with bunch bagging by different colour bags in different cultivar are presented in (Table 6). Among the different colour bags, the lowest titrateable acidity and highest ascorbic acid were recorded when fruit bunches were bagged with blue colour bags followed by green colour. The lowest titrateable acidity was recorded in both litchi cultivar Elaichi and China (0.46 %), whereas highest ascorbic acid content was found in China (28.51 mg). The maximum ascorbic acid content was recorded in C₂B₄ (32.03 mg). The highest levels of ascorbic acid (57.26 mg/100 g) and acidity (0.48 %) were found in bagged litchi fruits, whereas the lowest levels were found in unbagged fruits (48.62 mg/100 g) and acidity (0.35 %), according to Lal (2020). Shah *et al* (2020) found that among the different bagging materials, fruits bagged with white polypropylene bags with 0% perforation had the highest ascorbic acid (22.59 mg/100 g) and the lowest acidity (0.38%), while fruits that were not bagged had the highest acidity (0.53%) and the lowest ascorbic acid (20.76 mg/100 g). Abdel *et al* (2017) found that when mango fruit cv. Keitt was bagged using different materials, the fruits bagged with agrail red bags had the highest vitamin content in their fruit juice (48.07 mg/100 ml and 49.14 mg/100 ml), while the fruits that were not bagged had the lowest levels (47.96 mg/100 ml and 48.05 mg/100 ml).

Anthocyanin content of fruit peel

The different colour bags showed non-significant effect on anthocyanin content of the peels of litchi fruit (Table 7). Among the different colour bags, the highest anthocyanin content was recorded when fruit bunches were bagged with blue colour bags (29.22 mg/100 ml). The highest anthocyanin content was recorded in litchi cultivar Elaichi (24.56 mg/100 ml) followed by Calcuttia (24.04 mg/100 ml). The maximum anthocyanin content in fruit peel was recorded in C₁B₄ (30.74 mg/100 ml). In line with Debnath and Mitra's (2008) findings on litchi, Shah *et al* (2020) found that the peel has the highest

Impact of Pre-Harvest Fruit Bunch Bagging on Yield and Quality of Different Litchi

anthocyanin content (23.66 mg/100 g), and that the anthocyanin concentration was highest in litchi fruits bagged with a white polypropylene bag with 5% perforation and lowest in unbagged fruits (21.59 mg/100 g).

CONCLUSION

Fruit bunch bagging is an easy, safe, and environmentally friendly technique that has various advantages, including a lower frequency of insect pests and physiological illnesses (fruit cracking, sun burn). Pre-harvest fruit bagging enhanced the physical and biochemical characteristics of the fruit as well as its retention. One effective way to keep the environment and the fruits physically apart is to bag them. Bagging alters the micro environment for fruit growth and lessens the direct involvement of light. Compared to fruits that were unbagged or open due to early development, the microclimate within the CP (cellophane paper) bag (which has a different colour) produced an earlier buildup of the necessary heat unit. The anthocyanin synthesis may have been accelerated by the altered microclimate inside the bag, resulting in a greater anthocyanin concentration at maturity compared to the fruits that were not bagged. Pre-harvest fruit bagging (7 days after fruit set) in litchi with blue bags with 5% perforation may be advised to improve the physical and biochemical qualities for high-quality fruit production and reduce the use of pesticides in the sub-Himalayan Terai region of West Bengal, according to the current study.

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Impact of Rootstock Selection and Cane Regulation on the Organoleptic Characteristics of Wine

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ABSTRACT

An investigation was conducted to assess the impact of rootstock selection and cane regulation on the organoleptic characteristics of wine in the semi-arid region of Karnataka. The study was carried out during 2022-2024 at the Main Horticultural Research and Extension Centre, Bagalkot, using a split-split plot design with two rootstocks (R₁: Dogridge and R₂: 110 R), five grape varieties (V₁: Cabernet Sauvignon, V₂: Medica, V₃: Shiraz, V₄: Sauvignon Blanc and V₅: Chenin Blanc), and three cane regulation levels (C₁: control, C₂: 36 canes/vine and C₃: 24 canes/vine). Organoleptic properties, including appearance, aroma, taste, and overall acceptability, were evaluated using a 20-point hedonic scale over two years and pooled data. Results revealed significant differences among treatments. Rootstock R₂ consistently recorded higher scores across all organoleptic parameters, with pooled appearance and aroma scores of 17.90 and 18.16, respectively, compared to R₁. Among varieties, V₂ exhibited superior performance, with the highest pooled appearance (17.47) and aroma (17.31) scores, followed by V₃ and V₁. Cane regulation influenced appearance but had a non-significant effect on aroma, with C₃ recording the highest pooled scores for appearance (15.78) and aroma (16.13). Interaction effects were significant, with the combination R₂V₂C₃ achieving the highest scores for both appearance (20.68) and aroma (20.05). The findings demonstrate that rootstock 110 R, Medica variety, and a 24-cane regulation approach significantly enhance the sensory quality of wine in semi-arid conditions. These results emphasize the importance of integrating rootstock selection and cane regulation to optimize wine quality. The study provided valuable insights for viticultural practices in similar agro-climatic regions, contributing to sustainable and high-quality wine production systems.

Keywords: Cane regulation, Organoleptic characteristics, Rootstock, Selection, Wine quality.

INTRODUCTION

Grape cultivation is considered to be an economic venture for the farmers due to its high monetary returns both from its fruits and processed products like wine (Kaur *et al*, 2021). The production of wine from fruits of grape is an intricate process, where the quality and sensory attributes of the final product are greatly influenced by viticultural practices. Organoleptic evaluation, encompassing the sensory parameters of appearance, aroma, taste, and mouthfeel, plays a crucial role in determining the acceptability and market value of wine. Factors such as rootstock selection and cane regulation are pivotal in shaping these sensory characteristics, as they influence the

growth, yield, and chemical composition of grape berries, which, in turn, impact the wine's quality and sensory profile. Rootstocks contribute to the vine's tolerance to biotic and abiotic stresses, nutrient uptake, and overall vine vigor (Singh *et al*, 2025), which directly affect the accumulation of phenolic compounds, organic acids, and sugars in the grape berries which are the key determinants of wine's organoleptic properties. Cane regulation, primarily through pruning intensity, alters the vine's canopy structure, light interception, and the balance between vegetative and reproductive growth. This influences the development of flavour precursors and secondary metabolites that enhance wine aroma, taste, and mouthfeel. (Kiran *et al*, 2019). This study was

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undertaken to assess the organoleptic properties of wine produced from five grape varieties grown on two rootstocks and subjected to three levels of cane regulation. By evaluating the appearance, aroma, taste, and overall acceptability of wine over two years and pooled data, the study aimed to identify significant differences and interactions among the treatments and determine the most favourable combinations for enhancing wine quality. The research holds immense relevance for viticulture practices in regions like Karnataka's northern dry zone, where managing environmental and climatic challenges is critical for producing high-quality wine. The findings are expected to provide valuable insights into optimizing rootstock selection and cane regulation to improve the sensory attributes of wine, contributing to the advancement of sustainable and high-quality wine production systems.

MATERIALS AND METHODS

The investigation on “Influence of rootstock and cane regulation on growth, yield, and quality of wine grapes” was conducted during 2022-2024 at MHREC, Block J1, UHS, Bagalkot (16° 9' N, 75° 37' E, 542 m MSL) in the northern dry zone of Karnataka. The experiment used a split-split plot design with 30 treatments replicated three times. Spacing was 9 ft × 4 ft. The main treatments were rootstocks (Dogridge and 110 R), sub-treatments were cultivars (Cabernet Sauvignon, Medica, Shiraz, Sauvignon Blanc and Chenin Blanc), and sub-sub treatments were cane regulation levels (C₁: Control, C₂: 36 canes/vine and C₃: 24 canes/vine). Data were recorded on randomly selected plants. Wine samples were organoleptically analyzed using a 20-point hedonic scale (appearance, aroma, taste, colour, overall acceptability) by 10 panel members, following standard wine-tasting procedures (Veena *et al*, 2015).

Hedonic scale:

18-20 excellent	15-17 good	12-14 fair	
9-11 ordinary	6-8 poor	3-5 bad	1-2 very bad

RESULTS AND DISCUSSION

Organoleptic evaluation of appearance

The organoleptic evaluation of appearance in 2023, 2024, and in pooled data showed significant differences due to rootstocks (Table 1). In pooled data, rootstock R₂ recorded significantly higher appearance scores (17.90) compared to rootstock R₁ (12.94). The variation in appearance scores due to varieties was significant as well. Variety V₂ exhibited the highest

appearance score (17.47), followed by V₃ (16.46) and V₁ (15.55). The lowest appearance score was recorded by variety V₅ (12.91). Cane regulation also had a significant effect on appearance. In pooled data, cane C₃ showed the highest appearance score (15.78), followed by C₂ (15.40), and the control C₁ (15.09). The interaction between rootstocks, varieties, and cane regulation influenced the organoleptic evaluation of appearance significantly. In pooled data, the treatment combination R₂V₂C₃ recorded the highest appearance score (20.68), followed by R₂V₂C₂ (20.15) and R₂V₃C₃ (19.23).

Organoleptic evaluation of aroma

The aroma evaluation in 2023, 2024, and in pooled data showed significant differences due to rootstocks (Table 1). In pooled data, rootstock R₂ recorded significantly higher aroma scores (18.16) compared to rootstock R₁ (13.42). The variation in aroma scores due to varieties was significant. Variety V₂ had the highest aroma score (17.31), followed by V₃ (16.63) and V₁ (16.05). The lowest aroma score was recorded by variety V₅ (13.62). Cane regulation had a non-significant effect on aroma during 2023, 2024, and in pooled data. In pooled data, cane C₃ exhibited the highest aroma score (16.13), followed by C₂ (15.79) and control C₁ (15.44). The interaction between rootstocks, varieties, and cane regulation significantly influenced the aroma evaluation. In pooled data, the treatment combination R₂V₂C₃ recorded the highest aroma score (20.05), followed by R₂V₂C₂ (19.73) and R₂V₃C₃ (19.15).

Organoleptic evaluation of taste

The taste evaluation in 2023, 2024, and in pooled data revealed significant differences due to rootstocks (Table 2). In pooled data, rootstock R₂ recorded significantly higher taste scores (19.54) compared to rootstock R₁ (14.84). The variation in taste scores due to varieties was also significant. Variety V₂ had the highest taste score (18.35), followed by V₃ (17.59) and V₁ (17.22). The lowest taste score was recorded by variety V₅ (16.07). Cane regulation had a non-significant effect on taste during 2023, 2024, and in pooled data. In pooled data, cane C₃ exhibited the highest taste score (17.48), followed by C₂ (17.16) and control C₁ (16.93). The interaction between rootstocks, varieties, and cane regulation significantly influenced the taste evaluation. In pooled data, the treatment combination R₂V₂C₃ recorded the highest taste score (21.47), followed by R₂V₂C₂ (20.54) and R₂V₃C₃ (20.04).

Impact of Rootstock Selection and Cane Regulation on the Organoleptic Characteristics of Wine

Table 1: Organoleptic evaluation for appearance and aroma.

Treatment	Appearance			Aroma		
	2023	2024	Pooled	2023	2024	Pooled
Root Stocks (R)						
R ₁	13.51	12.38	12.94	14.10	12.74	13.42
R ₂	18.59	17.22	17.90	19.19	17.13	18.16
S.E. M±	0.02	0.04	0.01	0.04	0.04	0.02
CD AT 5%	0.14	0.27	0.06	0.25	0.25	0.10
Varieties (V)						
V ₁	16.41	14.69	15.55	17.11	14.99	16.05
V ₂	18.06	16.89	17.47	18.13	16.48	17.31
V ₃	17.12	15.80	16.46	17.44	15.82	16.63
V ₄	15.29	14.16	14.72	16.22	14.48	15.35
V ₅	13.36	12.47	12.91	14.32	12.92	13.62
S.E. M±	0.44	0.30	0.29	0.22	0.23	0.15
CD AT 5%	1.32	0.89	0.86	0.65	0.70	0.46
Canes (C)						
C ₁	15.71	14.47	15.09	16.23	14.66	15.44
C ₂	16.00	14.80	15.40	16.66	14.93	15.79
C ₃	16.43	15.13	15.78	17.04	15.22	16.13
S.E. M±	0.26	0.24	0.19	0.29	0.28	0.21
CD AT 5%	0.73NS	0.69NS	0.55	0.82NS	0.8NS	0.59NS
Root Stocks (R) x Canes (C) x Varieties (V)						
R ₁ V ₁ C ₁	13.84	11.89	12.86	14.51	12.66	13.59
R ₁ V ₁ C ₂	13.96	12.52	13.24	14.70	12.68	13.69
R ₁ V ₁ C ₃	14.10	13.02	13.56	14.80	12.90	13.85
R ₁ V ₂ C ₁	14.96	13.89	14.43	15.03	13.97	14.50
R ₁ V ₂ C ₂	15.06	14.52	14.79	15.59	14.29	14.94
R ₁ V ₂ C ₃	15.55	14.62	15.09	15.79	14.45	15.12
R ₁ V ₃ C ₁	14.46	13.38	13.92	14.82	13.60	14.21
R ₁ V ₃ C ₂	14.59	13.63	14.11	14.91	13.69	14.30
R ₁ V ₃ C ₃	14.86	13.82	14.34	14.93	13.78	14.36
R ₁ V ₄ C ₁	12.67	11.59	12.13	13.50	11.98	12.74
R ₁ V ₄ C ₂	12.89	11.64	12.27	13.58	12.57	13.07
R ₁ V ₄ C ₃	13.59	11.81	12.70	13.89	12.59	13.24
R ₁ V ₅ C ₁	10.37	9.11	9.74	10.38	10.10	10.24
R ₁ V ₅ C ₂	10.76	9.55	10.16	11.76	10.72	11.24
R ₁ V ₅ C ₃	10.93	10.72	10.82	13.32	11.16	12.24
R ₂ V ₁ C ₁	18.33	16.71	17.52	19.27	17.11	18.19
R ₂ V ₁ C ₂	18.91	16.97	17.94	19.61	17.27	18.44
R ₂ V ₁ C ₃	19.29	17.01	18.15	19.77	17.33	18.55
R ₂ V ₂ C ₁	20.18	19.22	19.70	20.55	18.44	19.50
R ₂ V ₂ C ₂	20.94	19.36	20.15	20.70	18.76	19.73
R ₂ V ₂ C ₃	21.66	19.70	20.68	21.13	18.97	20.05
R ₂ V ₃ C ₁	19.44	17.44	18.44	19.91	17.75	18.83
R ₂ V ₃ C ₂	19.52	17.94	18.73	19.95	17.93	18.94
R ₂ V ₃ C ₃	19.87	18.59	19.23	20.12	18.18	19.15
R ₂ V ₄ C ₁	17.20	16.55	16.87	18.44	16.41	17.43
R ₂ V ₄ C ₂	17.22	16.66	16.94	18.70	16.61	17.65
R ₂ V ₄ C ₃	18.17	16.68	17.43	19.18	16.70	17.94
R ₂ V ₅ C ₁	15.65	14.93	15.29	15.88	14.55	15.22
R ₂ V ₅ C ₂	16.19	15.23	15.71	17.09	14.79	15.94
R ₂ V ₅ C ₃	16.25	15.29	15.77	17.47	16.18	16.83
S.E. M±	0.81	0.76	0.61	0.91	0.88	0.66
CD AT 5%	2.31	2.17	1.74	2.60	2.52	1.88

Table 2: Organoleptic evaluation for taste and colour.

Treatment	Taste			Colour		
	2023	2024	Pooled	2023	2024	Pooled
Root Stocks (R)						
R ₁	15.49	14.19	14.84	16.30	15.11	15.70
R ₂	20.52	18.56	19.54	21.16	19.64	20.40
S.E. M±	0.05	0.04	0.02	0.05	0.04	0.04
CD AT 5%	0.30	0.26	0.14	0.32	0.25	0.24
Varieties (V)						
V ₁	17.88	16.55	17.22	18.57	17.23	17.90
V ₂	19.20	17.50	18.35	20.10	19.18	19.64
V ₃	18.31	16.88	17.59	19.48	17.69	18.59
V ₄	17.51	15.92	16.72	18.01	16.78	17.39
V ₅	17.11	15.04	16.07	17.48	16.02	16.75
S.E. M±	0.29	0.30	0.19	0.35	0.39	0.27
CD AT 5%	0.88	0.91	0.58	1.04	1.17	0.80
Canes (C)						
C ₁	17.75	16.11	16.93	18.49	17.05	17.77
C ₂	17.99	16.32	17.16	18.76	17.32	18.04
C ₃	18.27	16.70	17.48	18.94	17.76	18.35
S.E. M±	0.28	0.27	0.20	0.30	0.25	0.21
CD AT 5%	0.8NS	0.78NS	0.57NS	0.84NS	0.72NS	0.6NS
Root Stocks (R) x Canes (C) x Varieties (V)						
R ₁ V ₁ C ₁	15.10	14.30	14.70	16.00	14.70	15.35
R ₁ V ₁ C ₂	15.29	14.33	14.81	16.20	14.76	15.48
R ₁ V ₁ C ₃	15.56	14.38	14.97	16.67	14.76	15.72
R ₁ V ₂ C ₁	16.28	14.68	15.48	17.14	16.64	16.89
R ₁ V ₂ C ₂	16.49	14.99	15.74	17.55	16.99	17.27
R ₁ V ₂ C ₃	17.15	16.20	16.68	17.86	17.68	17.77
R ₁ V ₃ C ₁	15.62	14.38	15.00	16.77	14.87	15.82
R ₁ V ₃ C ₂	16.10	14.41	15.26	16.78	15.40	16.09
R ₁ V ₃ C ₃	16.18	14.67	15.42	16.90	15.77	16.33
R ₁ V ₄ C ₁	14.81	13.86	14.34	15.78	14.42	15.10
R ₁ V ₄ C ₂	14.97	13.92	14.45	15.84	14.54	15.19
R ₁ V ₄ C ₃	15.07	14.10	14.58	15.87	14.67	15.27
R ₁ V ₅ C ₁	14.38	12.51	13.45	14.47	13.03	13.75
R ₁ V ₅ C ₂	14.48	13.00	13.74	15.12	14.07	14.60
R ₁ V ₅ C ₃	14.80	13.19	14.00	15.51	14.34	14.93
R ₂ V ₁ C ₁	20.30	18.32	19.31	20.48	19.66	20.07
R ₂ V ₁ C ₂	20.50	18.93	19.72	20.98	19.71	20.34
R ₂ V ₁ C ₃	20.55	19.06	19.80	21.10	19.77	20.44
R ₂ V ₂ C ₁	21.06	19.33	20.20	22.29	20.65	21.47
R ₂ V ₂ C ₂	21.64	19.43	20.54	22.85	20.99	21.92
R ₂ V ₂ C ₃	22.56	20.38	21.47	22.95	22.09	22.52
R ₂ V ₃ C ₁	20.56	19.24	19.90	22.09	19.81	20.95
R ₂ V ₃ C ₂	20.64	19.24	19.94	22.12	19.82	20.97
R ₂ V ₃ C ₃	20.76	19.32	20.04	22.23	20.46	21.35
R ₂ V ₄ C ₁	19.95	17.68	18.81	20.13	18.85	19.49
R ₂ V ₄ C ₂	20.09	17.82	18.96	20.17	18.96	19.56
R ₂ V ₄ C ₃	20.20	18.12	19.16	20.28	19.22	19.75
R ₂ V ₅ C ₁	19.45	16.79	18.12	19.72	17.88	18.80
R ₂ V ₅ C ₂	19.72	17.16	18.44	19.99	17.95	18.97
R ₂ V ₅ C ₃	19.82	17.58	18.70	20.06	18.84	19.45
S.E. M±	0.89	0.86	0.63	0.93	0.79	0.66
CD AT 5%	2.54	2.47	1.81	2.67	2.27	1.88

Impact of Rootstock Selection and Cane Regulation on the Organoleptic Characteristics of Wine

Table 3: Overall organoleptic evaluation

Treatment	Overall organoleptic evaluation		
	2023	2024	Pooled
Root Stocks (R)			
R ₁	15.77	14.11	14.94
R ₂	20.41	18.87	19.64
S.E. M±	0.04	0.02	0.01
CD AT 5%	0.22	0.13	0.06
Varieties (V)			
V ₁	18.11	16.36	17.23
V ₂	19.58	17.60	18.59
V ₃	18.50	16.99	17.75
V ₄	17.47	15.99	16.73
V ₅	16.79	15.51	16.15
S.E. M±	0.28	0.27	0.22
CD AT 5%	0.84	0.81	0.65
Canes (C)			
C ₁	17.86	16.33	17.10
C ₂	18.06	16.50	17.28
C ₃	18.35	16.64	17.50
S.E. M±	0.25	0.28	0.21
CD AT 5%	0.71NS	0.81NS	0.6NS
Root Stocks (R) x Canes (C) x Varieties (V)			
R ₁ V ₁ C ₁	15.60	13.88	14.74
R ₁ V ₁ C ₂	15.80	13.91	14.85
R ₁ V ₁ C ₃	16.03	14.16	15.10
R ₁ V ₂ C ₁	16.80	15.21	16.00
R ₁ V ₂ C ₂	16.86	15.35	16.10
R ₁ V ₂ C ₃	17.27	15.40	16.34
R ₁ V ₃ C ₁	16.08	14.62	15.35
R ₁ V ₃ C ₂	16.13	14.68	15.41
R ₁ V ₃ C ₃	16.57	14.73	15.65
R ₁ V ₄ C ₁	14.88	13.45	14.16
R ₁ V ₄ C ₂	15.32	13.68	14.50
R ₁ V ₄ C ₃	15.39	13.75	14.57
R ₁ V ₅ C ₁	14.40	12.60	13.50
R ₁ V ₅ C ₂	14.73	13.08	13.91
R ₁ V ₅ C ₃	14.75	13.09	13.92
R ₂ V ₁ C ₁	20.23	18.65	19.44
R ₂ V ₁ C ₂	20.46	18.70	19.58
R ₂ V ₁ C ₃	20.53	18.86	19.69
R ₂ V ₂ C ₁	22.02	19.53	20.78
R ₂ V ₂ C ₂	22.18	19.76	20.97
R ₂ V ₂ C ₃	22.35	20.34	21.34
R ₂ V ₃ C ₁	20.54	19.14	19.84
R ₂ V ₃ C ₂	20.58	19.35	19.96
R ₂ V ₃ C ₃	21.12	19.42	20.27
R ₂ V ₄ C ₁	19.53	18.31	18.92
R ₂ V ₄ C ₂	19.74	18.35	19.04
R ₂ V ₄ C ₃	19.97	18.38	19.18
R ₂ V ₅ C ₁	18.57	17.91	18.24
R ₂ V ₅ C ₂	18.78	18.10	18.44
R ₂ V ₅ C ₃	19.50	18.30	18.90
S.E. M±	0.79	0.89	0.66
CD AT 5%	2.25	2.55	1.89

Organoleptic evaluation of colour

The colour evaluation in 2023, 2024, and pooled data revealed significant differences due to rootstocks (Table 2). In pooled data, rootstock R₂ recorded significantly higher colour scores (20.40) compared to rootstock R₁ (15.70). The variation in colour scores due to varieties was also significant. Variety V₂ had the highest colour score (19.64), followed by V₃ (18.59) and V₁ (17.90). The lowest colour score was recorded by variety V₅ (16.75). Cane regulation had a non-significant effect on colour during 2023, 2024, and in pooled data. In pooled data, cane C₃ exhibited the highest colour score (18.35), followed by C₂ (18.04) and control C₁ (17.77). The interaction between rootstocks, varieties, and cane regulation significantly influenced the colour evaluation. In pooled data, the treatment combination R₂V₂C₃ recorded the highest colour score (22.52), followed by R₂V₂C₂ (21.92) and R₂V₃C₃ (21.35).

Overall organoleptic evaluation

The overall organoleptic evaluation in 2023, 2024, and pooled data revealed significant differences influenced by rootstocks (Table 3). In pooled data, rootstock R₂ had a higher overall evaluation score (19.64) compared to R₁ (14.94), showing a notable difference in the quality of the treatments. For varieties, V₂ scored the highest in pooled data (18.59), followed by V₃ (17.75) and V₁ (17.23), with V₅ showing the lowest score (16.15). The effect of cane regulation on the overall evaluation was non-significant across all years and pooled data, as canes C₁, C₂, and C₃ displayed similar scores. In pooled data, C₃ had the highest score (17.50), followed by C₂ (17.28) and C₁ (17.10). The interaction between rootstocks, varieties, and cane regulation significantly affected the overall evaluation. In pooled data, the highest scores were observed in the combinations of R₂V₂C₃ (21.34), R₂V₂C₂ (20.97), and R₂V₂C₁ (20.78), with the lowest scores coming from combinations involving R₁, such as R₁V₃C₁ (13.50) and R₁V₄C₁ (14.16).

The pooled data demonstrated significant differences in organoleptic evaluations across rootstocks, varieties, and their interactions, showcasing their influence on grape quality parameters such as appearance, aroma, taste, and colour. Rootstock R₂ consistently outperformed R₁ in all parameters, ascribing its superior performance to enhanced nutrient uptake and better compatibility with scion varieties, corroborating findings by Tarricone *et al* (2023) who reported improved berry appearance and sensory quality in grapes grafted onto vigorous rootstocks. Similarly, the significant variation among

varieties highlights the influence of genetic factors, with variety V₂ excelling in appearance, aroma, taste, and colour. These results align with the studies of Singh *et al* (2022), where *Vitis vinifera* cultivars exhibited varietal differences in sensory traits due to variations in biochemical composition. The non-significant effects of cane regulation on aroma, taste, colour, and overall evaluation suggest that cane numbers alone may not have a direct influence on organoleptic properties. However, the superior scores observed in treatments involving C₃ could be attributed to its optimized canopy structure, leading to better light interception and photosynthetic efficiency, as discussed by Mian *et al* (2024). The interaction effects revealed that the highest scores in all organoleptic parameters were recorded for the R₂V₂C₃ combination, emphasizing the synergistic impact of selecting suitable rootstock-variety combinations alongside appropriate cane regulation. This finding aligns with reports by Blank *et al* (2022), who demonstrated that rootstock-scion interactions coupled with optimal cultural practices could significantly enhance grape quality.

CONCLUSION

The study highlighted the critical role of rootstocks and varietal characteristics in enhancing the organoleptic qualities of grapes, with R₂ and V₂ emerging as the most promising treatments. Additionally, while cane regulation had a limited direct impact, its interaction with rootstock and variety contributed significantly to the overall quality. These findings underline the importance of adopting an integrated approach combining rootstock selection, variety choice, and cultural practices to optimize grape production and sensory quality in the northern dry zone of Karnataka.

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Impact of Spacing and Fertilizer Levels on Quality Attributes of Pinwheel Flower (*Tabernaemontana Divaricata* L.)

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ABSTRACT

The present experiment was carried out at the Department of Floriculture and Landscaping, College of Horticulture, Bagalkot during the year 2023–2024. The study tested three fertilizer levels (F₁: 20:40:40 g NPK/plant/year, F₂: 30:60:60 g NPK/plant/year and F₃: 40:80:80 g NPK/plant/year) and three spacing configurations (S₁: 1.5 x 1.2 m, S₂: 2.0 x 1.5 m and S₃: 2.5 x 1.8 m), resulting in nine treatment combinations, each replicated thrice in a Factorial Randomized Complete Block Design (RCBD). Fertilizers were applied at four intervals (May, July, September and November) using urea, di-ammonium phosphate and muriate of potash as sources of nitrogen, phosphorus and potash respectively. Quality attributes were measured at 240 days after treatment imposition. The results indicated that the combination of S₂ and F₃ (spacing of 2.0 x 1.5 m and fertilizer level of 40:80:80 g NPK/plant/year) resulted in the highest flower diameter (17.00 mm), bud diameter (11.32 mm), corolla tube length (2.44 cm), single (1.10 g), ten (11.0 g), fifty (50.0 g) and 100-flower bud weight (100.01 g) and flower bud shelf life (2.90 days). On the other hand, the lowest values for these traits were observed in the S₁ F₁ treatment combination (spacing of 1.5 x 1.2 m and fertilizer level of 20:40:40 g NPK/plant/year), with flower diameter (13.41 mm), bud diameter (7.98 mm), corolla tube length (1.94 cm), single (0.79 g), ten (7.9 g), fifty (46.1 g) and 100-flower bud weight (92.11 g) and flower bud shelf life (1.70 days). The study concluded that the ideal combination of spacing S₂ and F₃ proved to be highly beneficial for producing top-quality flower buds in Pinwheel flowers. Hence, can be recommended to the growers for ensuring superior flower quality.

Keywords: Pinwheel flower, Spacing, Fertilizer, Quality.

INTRODUCTION

Tabernaemontana divaricata (L.) R. Br. ex Roem. & Schult., commonly known as Pinwheel flower is a perennial shrub native to India and widely cultivated across Southeast Asia and other tropical regions, belongs to the Apocynaceae family. The plant is known for its striking white flowers, and approximately 120 species of *Tabernaemontana* are found in tropical regions such as Brazil, Egypt, India, Sri Lanka, Vietnam, Malaysia and Thailand (Samanta *et al*, 2015). It is referred to by various names, including East Indian rosebay, Pinwheel flower, and Moonbeam

in English, and by different vernacular names in India. Pinwheel flower typically grows to a height of 5–6 feet, with glossy dark green leaves. The flowers, arranged in pinwheel-shaped clusters, vary in form, with both single and double-flowered types. While the single-flowered variety is unscented, the double-flowered form carries a pleasant fragrance. These flowers primarily bloom in spring but can flower sporadically year-round. The plant is widely used in religious rituals in India and is a popular choice for gardens due to its year-round blooms and low maintenance needs.

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Table 1: Impact of different spacing and fertilizer levels on quality attributes of Pinwheel flower.

Treatment	Flower diameter (mm)	Bud diameter (mm)	Corolla tube length (cm)	Single flower bud weight (g)	Ten bud flower weight (g)	Fifty flower bud weight (g)	Hundred flower bud weight (g)	Shelf life of flower buds (days)
Spacing (S)								
S ₁	14.44	8.60	2.10	0.89	8.90	46.01	92.02	2.03
S ₂	15.75	10.30	2.37	1.03	10.30	47.83	95.66	2.57
S ₃	15.54	10.14	2.34	0.99	9.90	46.96	93.91	2.47
S.E.m ±	0.09	0.07	0.01	0.01	0.0746	0.3264	0.65	0.02
C.D. at 5%	0.28	0.22	0.04	0.02	0.224	0.979	1.96	0.06
Fertilizer levels (F)								
F ₁	14.33	9.05	2.20	0.90	8.97	46.28	92.55	1.93
F ₂	15.20	9.74	2.25	0.97	9.67	46.60	93.19	2.40
F ₃	16.19	10.24	2.37	1.05	10.47	47.92	95.84	2.73
S.E.m ±	0.09	0.07	0.01	0.01	0.0746	0.3264	0.65	0.02
C.D. at 5%	0.28	0.22	0.04	0.02	0.224	0.979	1.96	0.06
Interaction s								
S ₁ F ₁	13.41	7.98	1.94	0.79	7.9	46.1	92.11	1.70
S ₁ F ₂	14.64	8.81	2.07	0.89	8.9	46.1	92.17	1.90
S ₁ F ₃	15.27	9.00	2.30	0.99	9.9	45.9	91.79	2.50
S ₂ F ₁	14.88	9.32	2.33	0.98	9.8	46.5	93.01	2.10
S ₂ F ₂	15.36	10.27	2.35	1.01	10.1	47.0	93.95	2.70
S ₂ F ₃	17.00	11.32	2.44	1.10	11.0	50.0	100.01	2.90
S ₃ F ₁	14.69	9.85	2.33	0.92	9.2	46.3	92.53	2.00
S ₃ F ₂	15.62	10.16	2.34	1.00	10.0	46.7	93.47	2.60
S ₃ F ₃	16.31	10.40	2.36	1.05	10.5	47.9	95.73	2.80
S.E.m ±	0.16	0.12	0.02	0.01	0.1291	0.5654	1.13	0.03
C.D. at 5%	0.48	0.37	0.07	0.03	0.387	1.695	3.39	0.10

F₁ - 20:40:40 g NPK/plant/year
S₁ - 1.5 x 1.2 m

F₂ - 30:60:60 g NPK/plant/year
S₂ - 2.0 x 1.5 m

F₃ - 40:80:80 g NPK/plant/year
S₃ - 2.5 X 1.8 m

Pinwheel flower thrives in well-drained sandy loam soil with an acidic to neutral pH and prefers sunny locations in tropical and subtropical climates. It is often propagated through stem cuttings and requires moderate watering throughout the year, along with occasional light pruning to maintain its size and shape. The plant plays an important role in landscaping, serving as an evergreen ornamental shrub with its abundant white flowers, often referred to as Moonbeam

due to their beauty under moonlight. To improve its growth and flowering, proper nutrient management is essential, particularly the supply of nitrogen, phosphorus and potassium. Enhancing the plant's nutritional needs has the potential to increase both its production and the quality of its flowers. This study aims to study the impact of spacing on quality attributes and to optimize NPK dosage for quality flower production of Pinwheel flower.

Impact of Spacing and Fertilizer Levels on Quality Attributes of Pinwheel Flower

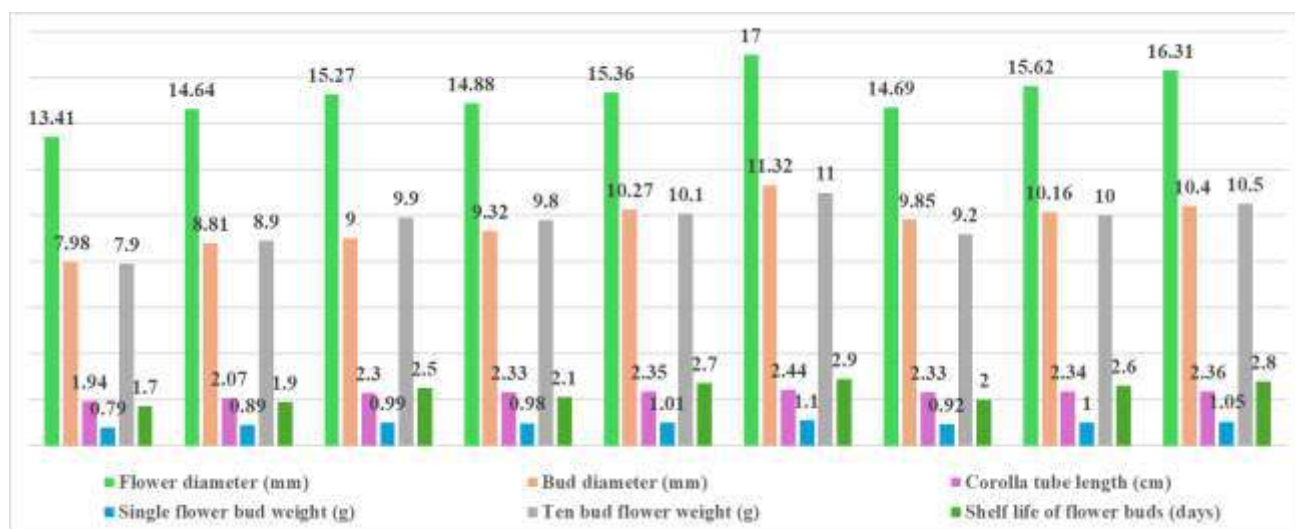


Fig. 1: Quality attributes of Pinwheel flower as influenced by spacing and fertilizer levels



T₆ (S₂F₃): S₂ (2.0 x 1.5 m) + F₃ (40:80:80 g NPK/plant/year)

Fig.2: Flower & bud diameter (mm) (a&b), corolla tube length (cm) (c), single & 100 flower bud weight (g) (d&e) of Pinwheel flower as influenced by spacing and fertilizer levels

MATERIALS AND METHODS

A field experiment was conducted during the year 2023-24 at Floriculture block, MHREC (Main Horticultural Research and Extension Centre), College of Horticulture, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India. For this experiment 5-month-old Pinwheel flower plot was selected. The treatment comprised of 3 levels of

fertilizer (F₁: 20:40:40, F₂: 30:60:60 and F₃: 40:80:80 g of NPK/plant/year) and 3 different spacing (S₁: 1.5 x 1.2 m, S₂: 2.0 x 1.5 m and S₃: 2.5 X 1.8 m) in 9 treatment combinations. These treatment combinations were replicated thrice and laid out in a Factorial RCB design. Nitrogen, phosphorus and potash were applied in the form of urea, di ammonium phosphate and muriate of potash, respectively. Fertilizer distribution occurred in

four stages at two-month intervals (during month of May, July, September and November). Other cultural operations were carried out as per recommendations. All quality attributes such as diameter of flower and flower bud, corolla tube length, shelf life of flower buds, single, ten, fifty and hundred flower bud weight were recorded at 240 DAT (days after treatment imposition).

RESULTS AND DISCUSSION

Impact of different spacing and fertilizer levels on quality attributes

The plant spacing had a significant impact on the quality attributes of the Pinwheel flower (Table 1). The largest flower bud diameter (10.30 mm) and flower diameter (15.75 mm), corolla tube length (2.37 cm), and the weight of single, ten, fifty and hundred flower buds (1.03 g, 10.30 g, 47.83 g and 95.66 g, respectively) as well as the flower shelf life (2.57 days) were observed at a plant spacing of S_2 (2.0 X 1.5 m). These values were statistically at par with S_3 (2.5 X 1.8 m), except for the weight of single and ten buds and the shelf life of flowers. In contrast, the lowest measurements (8.60 mm, 14.44 mm, 2.10 cm, 0.89 g, 8.90 g, 46.01 g, 92.02 g and 2.03 days, respectively) were recorded at the closest spacing of S_1 (1.5 X 1.2 m) (Table. 1). The optimal spacing allowed the plants to access more nutrients compared to the tighter spacing, despite the same nutrient availability in the soil, resulting in improved quality attributes of the flowers. Similar findings were reported by Sumangala *et al* (2013) in Jasmine, Kavya *et al* (2022) in lupin, and Dali *et al* (2023) in chrysanthemum.

The different levels of fertilizer (N, P_2O_5 and K_2O) had a significant impact on the quality attributes of the Pinwheel flower (Table 1). The application of 40:80:80 g of NPK per plant per year under the F_3 treatment resulted in the highest flower bud and flower diameters (10.24 mm and 16.19 mm, respectively), corolla tube length (2.37 cm), and the weight of single, ten, fifty and hundred flower buds (1.05 g, 10.47 g, 47.92 g and 95.84 g, respectively), as well as the longest shelf life (2.73 days). In contrast, the lowest values (9.05 mm, 14.33 mm, 2.20 cm, 0.90 g, 8.97 g, 46.28 g, 95.55 g and 1.93 days, respectively) were observed in the F_1 (20:40:40 g of NPK per plant per year) (Table. 1). An increase in nutrient doses led to improvements in the quality parameters of the flowers. These results align with the findings of Quasim *et al* (2008), Shoram *et al* (2012) and Bilji *et al* (2022) in Jasmine.

The combined effect of different plant spacing and fertilizer levels significantly influenced the quality parameters of the Pinwheel flower (Table 1). The highest flower bud and flower diameters (11.32 mm and 17.00 mm, respectively), corolla tube length (2.44 cm), and the weight of single, ten, fifty and hundred flower buds (1.10 g, 11.0 g, 50.0 g and 100.01 g, respectively), along with the longest shelf life (2.90 days), were observed in the treatment combination of S_2F_3 (2.5 X 1.8 m spacing and 40:80:80 g of NPK/plant/year). On the other hand, the lowest values (7.98 mm, 13.41 mm, 1.94 cm, 0.79 g, 7.90 g, 46.10 g, 92.11 g and 1.70 days) were recorded in the S_1F_1 treatment. The optimal spacing allowed for better nutrient supply to the plants and reduced competition for resources such as food, water and light. Similar findings were reported by Divyashree *et al* (2016) in Gaillardia, Manjula *et al* (2023) in Nerium and Paramagoudar (2015) in Spider Lily.

CONCLUSION

The experimental study concluded that the ideal combination of spacing S_2 (2.0 x 1.5 m) and 40:80:80 g NPK/plant/year (F_3) proved to be highly beneficial for producing top-quality flower buds in Pinwheel flowers. This combination resulted in the highest values for key quality attributes such as flower and bud diameter, corolla tube length, shelf life of flower buds, and the weight of single, ten, fifty and hundred flower buds. Hence can be recommended to the flower growers for ensuring superior flower quality in case of pinwheel flower.

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Impact of Spacing and Fertilizer Levels on Quality Attributes of Pinwheel Flower

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In Vitro Shoot Induction of Highbush Blueberry (*Vaccinium corymbosum* L.)

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ABSTRACT

The highbush blueberry (*Vaccinium corymbosum* L.) fruits has experienced a substantial rise, largely due to their nutritional and medicinal qualities. Propagation through *in vitro* culture has been considered the most effective method for a rapid increase of disease-free propagules on a year-round basis. This study was focused on the establishment of a high-efficiency *in vitro* tissue culture and rapid propagation technology system by using blueberry leaves and nodal segment. The experiment included a comparative analysis of WPM (Woody Plant Medium) with different growth hormones. For callus induction, leaf explants were cultured on WPM enriched with different combinations of BAP (0.0, 0.5 and 1.0 mg/l) and/or 2,4-D (1.0, 1.5 and 2.0 mg/l), as well as WPM with Zeatin (ZT) (0.1 to 0.5 mg/l.) alone. The comparative analysis for callus induction was ranged from 50 to 100 per cent. The formulation of WPM with 0.5 mg/L BAP and 1 mg/L 2,4-D achieved a full callus formation (100 %). For shoot induction, these Calli were transferred to a shoot induction medium provided with BAP (0.0, 0.5 and 1.0 mg/l) and/or 2,4-D (1.0, 1.5 and 2.0 mg/l), as well as WPM with Zeatin (ZT) (0.1 to 0.5 mg/l) separately. The nodal explants were also used for the shoot induction by culturing them on WPM provided with ZT (0.1 to 0.5 mg/l). Successful shoot formation (93.3 %) was observed on WPM with ZT at 0.5 mg/l.

Keywords: Highbush Blueberry, *Vaccinium corymbosum*, *In vitro*, Woody Plant Medium etc.

INTRODUCTION

The highbush blueberry (*Vaccinium corymbosum* L.) is a member of the Ericaceae family (Monika *et al*, 2022). As a tetraploid, rhizomatous shrub that undergoes cross-pollination, the blueberry holds considerable commercial value on a global scale, with Chile being a prominent nation in both production and exportation (Ariel *et al*, 2013). Blueberries are divided into five major categories: 1) northern highbush (*Vaccinium corymbosum* L.); 2) southern highbush, which arises from the hybridization of *V. corymbosum*, *Vaccinium darrowii* Camp, and other blueberry species; 3) lowbush, which comprises *Vaccinium angustifolium* Ait, *Vaccinium myrtilloides* Michx, and *Vaccinium boreale* Hall and Aald.; 4) half-high, a hybrid resulting from the crossing of highbush and lowbush types; and 5) rabbiteye (*Vaccinium virgatum* Ait.) (Dongliang *et al*, 2018). Based on information from the International Blueberry Organization (IBO), the total area registered for blueberry production in 2023 reached 267,000 ha.

Numerous research investigations have demonstrated that blueberries possess therapeutic potential for a variety of health conditions, including

diabetes management, the prevention of diabetic retinopathy, neuroprotection, the treatment of malignant tumours, chronic disease mitigation, cardiovascular disease prevention, antimicrobial properties, enhancement of memory, and protection against Alzheimer's disease (Abou El-Dis *et al*, 2021). Traditionally, blueberry propagation has been carried out using cuttings from coniferous, semi-coniferous, and deciduous species, as well as rhizomatous cuttings from specific clones. However, this method presents several challenges, including a notably low success rate for rooting in many genotypes, extended timeframes for propagating and bringing newly developed plants to market, and various phytosanitary issues (Monika *et al*, 2022). Traditional techniques for propagation are often marked by their slow progress, intensive labour demands, and a pronounced dependence on environmental conditions and seasonal cycles (Correia *et al*, 2024). Micropropagation is an extremely efficient technique for propagating new blueberry cultivars, enabling the quick production of many plants. As a result, the practice of micro propagating blueberries has significantly increased over the last thirty years (Testsumura *et al*, 2012). Techniques of tissue culture propagation serve as an effective method to produce virus-free plants (Monika *et al*, 2022). The propagation

Table 1. Combinations of growth hormones (BAP and 2,4-D) for callus induction from the leaves of Blueberry.

Sr. No.	Treatment	Treatment combination
1	T ₁	Control
2	T ₂	WPM + 0.0 mg/L BAP + 1.0 mg/L 2,4-D
3	T ₃	WPM + 0.5 mg/L BAP + 1.0 mg/L 2,4-D
4	T ₄	WPM + 1.0 mg/L BAP + 1.0 mg/L 2,4-D
5	T ₅	WPM + 0.0 mg/L BAP + 1.5 mg/L 2,4-D
6	T ₆	WPM + 0.5 mg/L BAP + 1.5 mg/L 2,4-D
7	T ₇	WPM + 1.0 mg/L BAP + 1.5 mg/L 2,4-D
8	T ₈	WPM + 0.0 mg/L BAP + 2.0 mg/L 2,4-D
9	T ₉	WPM + 0.5 mg/L BAP + 2.0 mg/L 2,4-D
10	T ₁₀	WPM + 0.5 mg/L BAP + 2.0 mg/L 2,4-D

Table 2. Concentrations of zeatin for callus induction and shoot initiation of blueberry

Sr. No.	Treatment	Concentrations
1	T ₁	WPM + 0.1 mg/L Zeatin
2	T ₂	WPM + 0.2 mg/L Zeatin
3	T ₃	WPM + 0.3 mg/L Zeatin
4	T ₄	WPM + 0.4 mg/L Zeatin
5	T ₅	WPM + 0.5 mg/L Zeatin

of blueberries through tissue culture is associated with a more extensive plant spread, leading to an increased bearing area and, as a result, higher yields compared to those obtained from conventional propagation methods utilizing softwood, single-node cuttings (Djurdjina *et al*, 2012)

MATERIALS AND METHODS

Plant Material and Sterilization

For shoot regeneration, nodal segment as well as leaf Explant material was used. The nodal segments were taken from one year old disease-free highbush blueberry plant. The segments were thoroughly rinsed with running tap water for 15-20 min. and then soaked in a solution of 2-3 drops of Tween 20 diluted in sterile distilled water for 15 minutes. After this, the segments were washed with sterile distilled water. Under a laminar flow hood, nodal segments were treated with a 0.1% HgCl₂ solution for 5 minutes, followed by three rinses with sterile distilled water. The nodal segments were then exposed to 70% ethanol for 30 seconds, after which they were washed again with sterile distilled water. Explants measuring between 1 and 1.5 cm in length were excised from single node of *V. corymbosum* and subsequently transferred to a culture medium.

For shoot regeneration from the leaf explant, young, actively growing leaves were harvested from

highbush blueberry plants. Initially, the leaves were thoroughly rinsed under running tap water. Subsequently, leaves were immersed in a solution of 2-3 drops of Tween 20 mixed with sterile distilled water for a duration of 5 minutes, followed by a wash with sterile distilled water. The leaves were then exposed to a 0.1% solution of HgCl₂ for 2 minutes and rinsed three times with sterile distilled water. Finally, the leaves were treated with 70% ethanol for 10 seconds and washed again with sterile distilled water before applying a fungicide treatment (M45/Bavistin).

Media Preparation

The basal culture medium designated for shoot induction is the WPM (McCown Woody Plant Medium), as referenced by Lloyd and McCown (1980). This medium is supplemented with 30g/l sucrose, 10g/l agar and pH maintained at 4.8 along with different concentrations of the growth hormones like zeatin, BAP and 2, 4-D for callus induction and shoot initiation (Table No. 1, 2).

Establishment and maintenance of Cultures

The establishment of callus culture induced from leaves

Sterilized leaves subjected to 2 to 3 diagonal cuts that were perpendicular to the main vein. The upper side of the leaves was positioned facing upward

In Vitro Shoot Induction of Highbush Blueberry (*Vaccinium corymbosum* L.)

Table 3. Percentage of callus induced from leaf explant supplemented with different concentration of BAP and 2,4-D after 30-45 days.

Treatment	Treatment combination	No. of Explants inoculated	No. of explants responded	Per cent (%) Response
T ₁	WPM medium (Cultured)	120	0	0.00
T ₂	WPM+ 0.0mg/L BAP + 1.0mg/L 2,4-D	120	90	75.00
T ₃	WPM+ 0.5mg/L BAP + 1.0mg/L 2,4-D	120	120	100.00
T ₄	WPM+ 1.0mg/L BAP + 1.0mg/L 2,4-D	120	90	75.00
T ₅	WPM+ 0.0mg/L BAP + 1.5mg/L 2,4-D	120	100	83.30
T ₆	WPM+ 0.5mg/L BAP + 1.5mg/L 2,4-D	120	70	58.30
T ₇	WPM+ 1.0mg/L BAP + 1.5mg/L 2,4-D	120	100	83.30
T ₈	WPM+ 0.0mg/L BAP + 2.0mg/L 2,4-D	120	60	50.00
T ₉	WPM+ 0.5mg/L BAP + 2.0mg/L 2,4-D	120	70	58.50
T ₁₀	WPM+ 0.5mg/L BAP + 2.0mg/L 2,4-D	120	80	66.60

Table 4. Percentage of callus induced from leaf supplemented with different concentration of zeatin explant after 30-45 days.

Treatment	Treatment combination	No. of. Explants	No. of explants responded	Per cent (%) Response
T ₁	WPM medium (Cultured)	40	7	17.50
T ₂	WPM+ 0.1 mg/L Zeatin	40	23	57.50
T ₃	WPM+ 0.2 mg/L Zeatin	40	35	87.50
T ₄	WPM+ 0.3 mg/L Zeatin	40	20	50.00
T ₅	WPM+ 0.4 mg/L Zeatin	40	30	75.00
T ₆	WPM+ 0.5 mg/L Zeatin	40	20	50.00

Table 5. Percentage of shoot initiation from nodal explant supplemented with different concentration of zeatin explant after 45-50 days.

Treatment	Treatment combination	No. of. Explants	Avg. no. of shoots initiated	Per cent (%) Response
T ₁	WPM medium (Cultured)	60	0	0
T ₂	WPM+ 0.1 mg/L Zeatin	60	25	41.60
T ₃	WPM+ 0.2 mg/L Zeatin	60	47	78.30
T ₄	WPM+ 0.3 mg/L Zeatin	60	52	86.60
T ₅	WPM+ 0.4 mg/L Zeatin	60	38	63.30
T ₆	WPM+ 0.5 mg/L Zeatin	60	56	93.30

on the medium provided with different combinations of growth hormones (Table No. 1 and 2), while the lower side was ensured to be in full contact with the medium. The petri plates were then sealed and placed in a dark culture chamber maintained at 24°C for a period ranging from 28 to 30 d. Following this incubation, the dishes were removed and incubated at 24°C under a 16-hour light and 8-hour dark cycle for another 14 to 28 d. Cultures were maintained in the replicated manner.

Initiation of shoots through callus derived from leaves

After complete callus development, the Calli were transferred to a shoot induction medium provided with BAP (0.0, 0.5 and 1.0 mg/l) and/or 2,4-D (1.0, 1.5 and 2.0 mg/l), as well as WPM with Zeatin (ZT) (0.1 to 0.5 mg/l) separately. These cultures were maintained in a growth chamber at a regulated temperature of 24±1 °C, with a light exposure duration of 16 hours. After

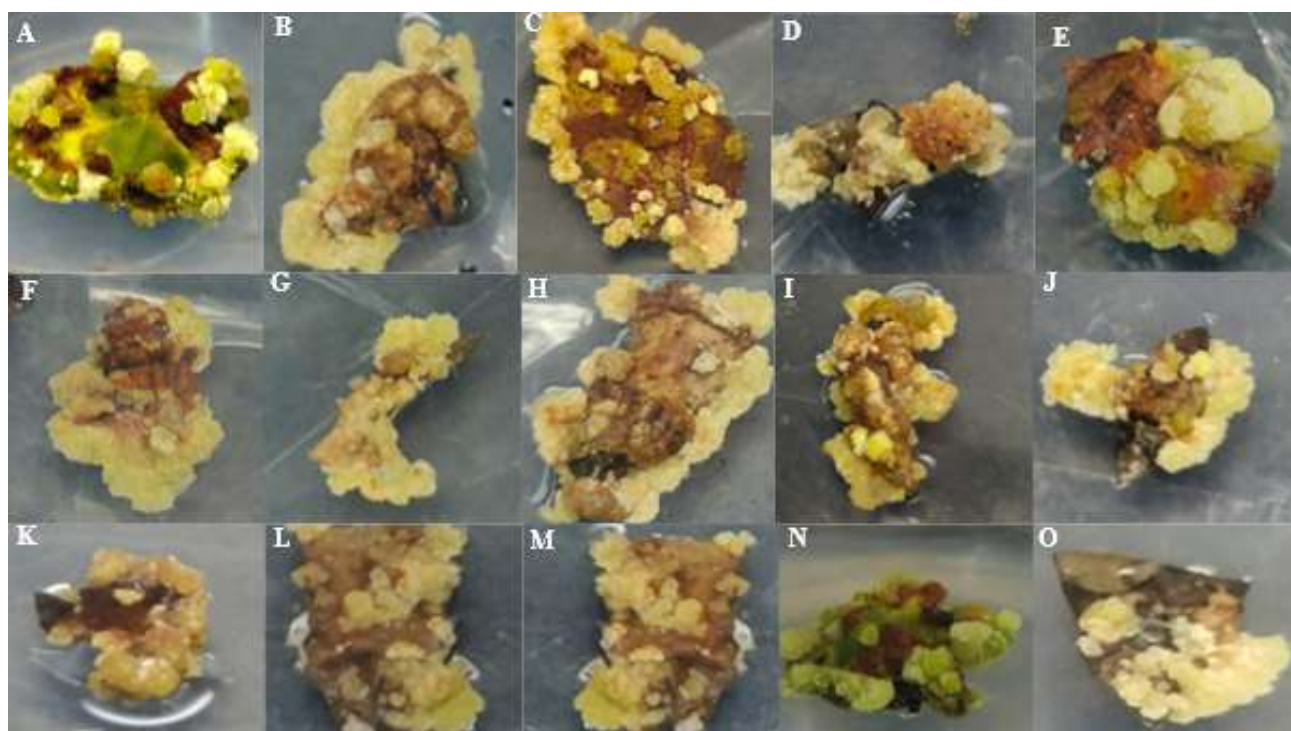


Plate No.1 Callus induced from leaf explants at different concentrations of PGRs (A) 0.1 mg/L Zeatin (B) 0.2 mg/L Zeatin (C) 0.3 mg/L Zeatin (D) 0.4 mg/L Zeatin (E) 0.5 mg/L Zeatin (F) 0.0 mg/L BAP + 1.0 mg/L 2,4-D (G) Control (H) 0.5 mg/L BAP + 1.0 mg/L 2,4-D (I) 1.0 mg/L BAP + 1.0 mg/L 2,4-D (J) 0.0 mg/L BAP + 1.5 mg/L 2,4-D (K) 0.5 mg/L BAP + 1.5 mg/L 2,4-D (L) 1.0 mg/L BAP + 1.5 mg/L 2,4-D (M) 0.0 mg/L BAP + 2.0 mg/L 2,4-D (N) 0.5 mg/L BAP + 2.0 mg/L 2,4-D and (O) 0.5 mg/L BAP + 2.0 mg/L 2,4-D.

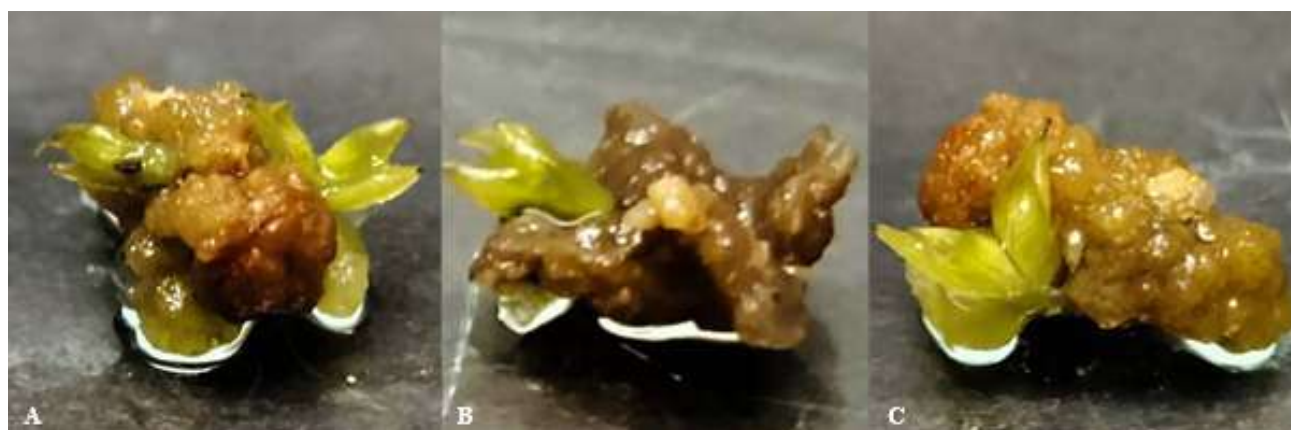


Plate No.2 Shoots initiated from callus at different concentration of Zeatin (A) 0.5 mg/L (B) 0.4 mg/L (C) 0.3 mg/L

15-20 days the shoot initiation through was observed on 0.5mg/l zeatin.

The establishment of shoots initials from nodal explant

The disinfected stem segments were aseptically segmented into single-nodal sections and

cultured to initiate shoot development on WPM medium containing (0.1, 0.2, 0.3, 0.4, and 0.5 mg/l) zeatin with replications. After the inoculation, the culture bottles were incubated in a growth room at a controlled temperature of 24 ± 1 °C, under a 16-hour light exposure.

In Vitro Shoot Induction of Highbush Blueberry (*Vaccinium corymbosum* L.)

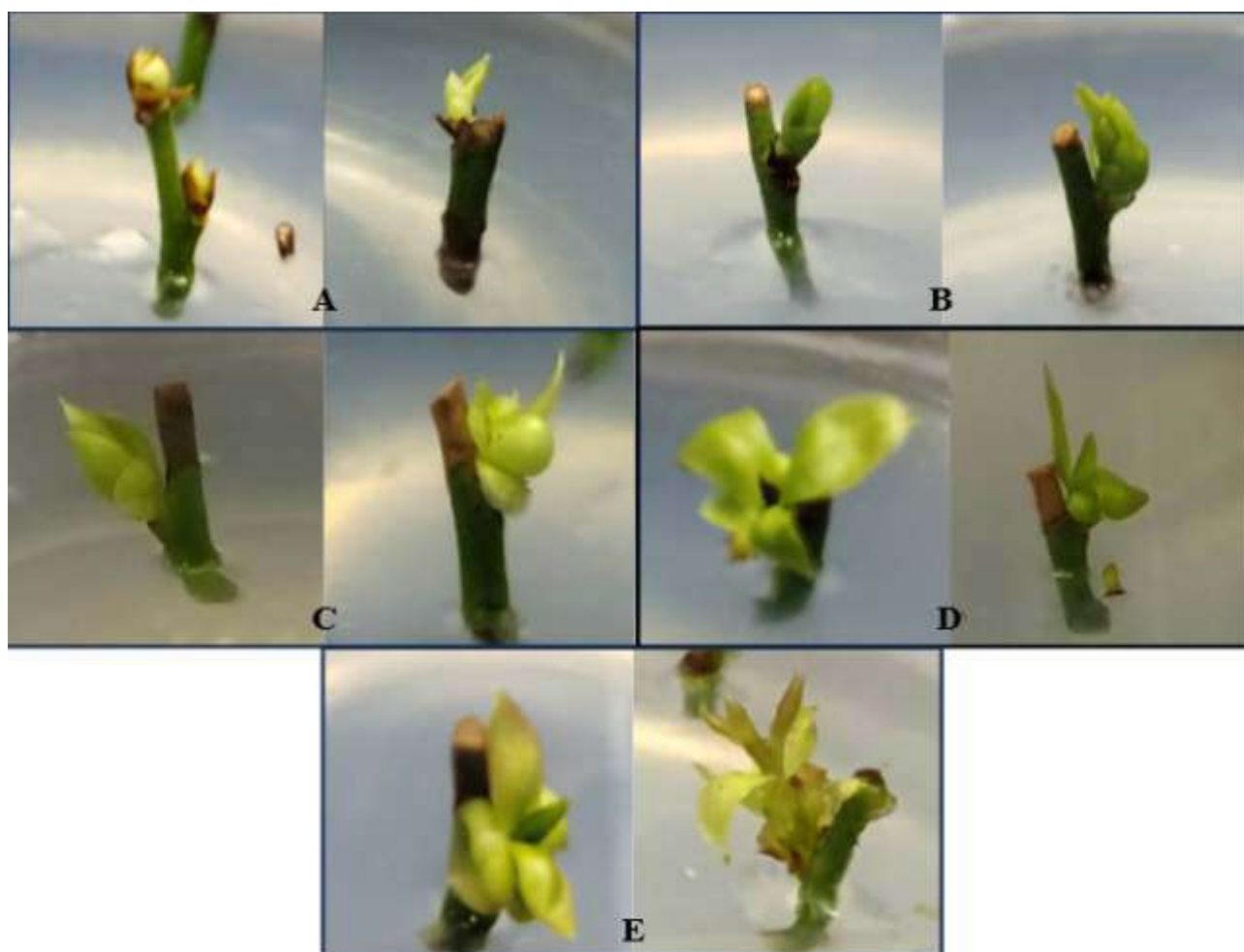


Plate No. 3. Shoot initiation from nodal explants at different concentration of Zeatin

(A) 0.1 mg/L Zeatin (B) 0.2 mg/L Zeatin (C) 0.3 mg/L Zeatin (D) 0.4 mg/L Zeatin (E) 0.5 mg/L Zeatin

RESULTS AND DISCUSSION

This investigation outlines a comprehensive protocol for initiating shoots from nodal segments and callus derived from leaves *in vitro*. The results indicated that highbush blueberry can be successfully micro propagated through plant tissue culture using nodal segments as well as leaves as an explant. The sterilization procedure applied to leaves and nodal segments demonstrated high efficacy, resulting in a minimal contamination rate. The duration of exposure to 70% ethanol and 0.1% HgCl_2 is critical for the viability of the explants. Prolonged exposure to these sterilizing agents may lead to browning and subsequent death of the explants.

The results indicated that a concentration of 0.2 mg/L zeatin led to an 87.5% callus formation rate

(Table No. 4). Additionally, the use of Woody Plant Medium (WPM) supplemented with 0.5 mg/L BAP and 1 mg/L 2,4-D resulted in complete callus formation (100 %) (Table No. 3) (Plate No. 1). The subculture of callus was executed on a shoot initiation medium containing zeatin from 0.1 to 0.5 mg/L (Table No. 2). After a period of 15 to 20 days of subculturing, shoot initiation was observed at concentrations of 0.3, 0.4, and 0.5 mg/l of zeatin (Plate No. 2).

Single-node segments cultured on WPM supplemented with zeatin at different concentrations (0.1 to 0.5 mg/L) demonstrated node proliferation. Zeatin at 0.5 mg/L showed optimal shoot formation (93.3 %) after 45-50 days of incubation period in growth room (Table No. 5 and Plate No. 3). The Woody Plant Medium (WPM) has been recognized as the most effective medium for the induction of callus and the

initiation of shoots from explants of blueberry leaves and stems, respectively. Cytokinin's such as zeatin, BAP and 2,4-D have been shown to promote callus development. Young leaves were cultured on a basal medium enriched with various plant growth regulators (PGRs), specifically the combination of 2,4-D and BAP, alongside the sole application of zeatin. Callus formation was observed after a 30- 45 d incubation period for each hormone combination. In prior research, WPM medium has proven to be an effective tool for inducing shoots across a range of *Vaccinium* species. In prior research, WPM medium has proven to be an effective tool for inducing shoots across a range of *Vaccinium* species. (Debnath *et al*, 2020). Research conducted in the past has also focused on the similar combinations of BAP and 2,4-D (Abou El-Dis *et al*, 2021).

CONCLUSION

The role of plant tissue culture in the vegetative propagation of blueberries is of great importance. This study successfully formulated an efficient protocol for the rapid micropropagation of highbush blueberry. The research involved experiments aimed at establishing callus cultures from leaves and initiating shoots from both callus and nodal segments. The results of this study confirm the successful in vitro regeneration of highbush blueberry, *Vaccinium corymbosum* L. The regeneration protocol developed here provides a framework that could improve shoot propagation systems for various other species in the *Vaccinium* genus. Furthermore, the implications of this research go beyond propagation techniques, as the established protocol can be utilized for biotechnological applications. By enabling the production of high-quality plant material, this work supports the broader objectives of sustainable agriculture and the conservation of genetic resources within the *Vaccinium* species. This innovative approach not only holds promise for improving propagation efficiency but also serves as a valuable resource for generating certified vegetative material. Such advancements are particularly significant in the context of horticultural practices and the commercial production of highbush blueberries.

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Influence of dwarf interstock on inter-stock grafting in Cashew (*Anacardium occidentale*)

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ABSTRACT

Cashew (*Anacardium occidentale*) is a perennial nut crop, extensively cross-pollinated and heterozygous, therefore seedlings cannot be utilized for commercial planting. However, rootstock can be generated from seednuts and used for grafting by a preferred cashew variety. Because of its perennial nature, this crop will require a lengthy breeding cycle to produce any unique features. As a result, inter-stock grafting technology represents a fresh way to grafting success and producing unique features in cashews. With this background, we conducted a study on inter-stock grafting with various dwarfing scion materials as inter-stock scions with a desirable variety in nursery trials across two seasons (October and April) to determine the survival percentage for future research. Three different inter-stock scions (Nethra Vaman, Taliparamba, and V-7) were employed with two commercial types (V-4 and Bhaskara), and dwarf trait and other growth parameters were measured. Grafting success rates ranged from 40 to 96.67 percent during 2022-23 and 63.33 to 100 percent during 2023-24. Across various grafting seasons. Grafting in April had a better survival rate than grafting in October, and V4 variety had a higher success rate than Bhaskara among different interstock grafting.

Keywords: Bhaskara, Cashew, Graft, Interstock, Vengurla 4

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is a perennial nut crop, extensively cross-pollinated and heterozygous in nature, therefore seedlings cannot be used for commercial planting. However, rootstock can be raised by seednut and used for grafting by desirable cashew varieties. Because of its perennial nature, inducing any specific features in this crop will require a lengthy breeding cycle. According to 2023 data, Maharashtra has a high production of 1145 kg/ha. It is grown in 34 countries with an area of 6.85 million ha and an output of 3.85 million MT. The average productivity is 564 kg/ha, with the highest productivity in Mexico (2489 kg/ha) and Vietnam (1123 kg/ha). The current low productivity is attributed to several factors, such as the establishment of a plantation with seedlings of nondescript origin, due to poor and irregular flowering due to adverse environmental conditions (Parameswaran *et al*, 1984), poor fruit set and excessive premature fruit drop (Patnaik *et al*, 1985), low hermaphrodite flowers, nutritional deficiency (Subbaiah, 1983), inefficient pollination (Heard *et al*, 1990) and irregular and prolonged flowering (Aliyu, 2005).

Cashew is an evergreen, dicotyledonous, woody, tropical tree with a medium canopy size. On average, the plant attains a height of 5-8 m. The leaves are alternate, simple, globous, oblong, leathery, and often notched at the apex. The size of the leaf varies from 6 to 24 cm in length and 4 to 15 cm in width based on species and variety. The root system of a completely grown cashew tree consists of a taproot surrounded by a well-developed and extensive network of lateral roots, 90% of which lie at a soil depth of 15–32 cm. The growth pattern of the cashew tree alternates between vegetative and reproductive phases. There are two types of branching in cashew: intensive and extensive types (Damodaran, 1965). An intensive type of growth pattern tends to give the bushy appearance to trees, whereas an extensive type results in a spreading tree habit. Annually, two or three peak periods of growth are observed in bearing cashew trees with the development of stray shoot growth. In bearing trees, from flower flush, many shoots develop that give rise to terminal inflorescence/panicle. The other vegetative flush gives rise to lateral shoots that develop soon after the main crop has matured.

Dwarf traits in cashew are important to reduce the height of cashew trees for ease of harvesting, and



Fig. 1 Interstock grafting methodology

the availability of dwarf sources is scarce, and it is very difficult to multiply by grafting due to its low success rate. *Anacardium pumilum* was a dwarf species of cashew and tried with inter-stock grafting, and it was not successful or low success rate reported (Bhagya *et al*, 2022). Generally, dwarf species will have a low yield in nature, and this trait can be used in high-yielding varieties to reduce the tree height with a good yield. Thus, a preliminary nursery study was undertaken to know the success rate of grafting by interstock grafting technology

MATERIALS AND METHODS

The present research experiment was carried out during 2023-24 at the nursery of ICAR-Directorate of Cashew Research, Puttur, Karnataka, located at (latitude 12°46'36"N, longitude 75°16'08, and altitude 72 m above MSL) in the west coast region of India. The climate of this study site was tropical, with an annual rainfall of 3500 mm per year. The soil media used for the experiment was analyzed, and pH varies from 5.98, EC (0.198 ds/m), OC (0.86), available N (75.2 kg/ha), available P (45.32 kg/ha), and available K (178 kg/ha) in a two-set experiment (Table 1). Interstock grafting was carried out in different seasons (October 2023 and April 2024) by using the softwood grafting method

with 60-day-old rootstocks and different interstocks were used as shown in Table 2 viz. Nethra Vaaman, Taliparamba, V7, and two controls (without interstock grafting) to know the survival percentage of the graft and to induce dwarfness in cashew (Fig. 1). So, preliminarily, we have studied to know the success of interstock grafts in cashew, and the recorded survival percentage of grafts was recorded at monthly intervals after the grafting. Survival percentage was calculated by using the below-mentioned equation after the 180 days of grafting. This experiment was carried out with CRD with 3 replications, and 20 grafts per replication were done. Data was statistically analyzed with Excel and interpreted.

$$\text{Survival \%} = \frac{\text{no.of grafts survived}}{\text{Total no of grafts}} \times 100 \dots \dots \dots (1)$$

RESULT AND DISCUSSION

In any perennial crops with cross-pollinated crops, it's very difficult to induce desirable traits. Here we have taken dwarf nature cashew varieties for inducing dwarfness, and a preliminary study was taken up in the nursery. In this study we have tried interstock grafting in the nursery and evaluated the survival percentage of grafts (Fig 2 and Table 3). The grafting carried out during the month of October had a survival and success percentage that varied from 40 to 86.6 %

Influence of dwarf interstock on inter-stock grafting in Cashew (*Anacardium occidentale*)

Table 1. Soil properties of potting media used for grafting in nursery.

Content name	Values	Remark
pH	5.98	Acidic
EC (ds/m)	0.198	Normal
Organic carbon (%)	0.86	High
Available N(kg/ha)	75.2	Low
Available P(kg/ha)	45.32	High
Available K(kg/ha)	178	Medium
Fe (ppm)	10.42	Sufficient
Mn (ppm)	17.06	Sufficient
Zn (ppm)	4.42	Sufficient
Cu (ppm)	2.63	Sufficient
B (ppm)	20.92	Sufficient

Table 2. Treatment details used in interstock grafting technology.

Treatment	Interstock	Main scion
T ₁	Nethra vamaan	V4 (Vengurla 4)
T ₂	Nethra vamaan	Bhaskara
T ₃	Taliparamba	V4 (Vengurla 4)
T ₄	Taliparamba	Bhaskara
T ₅	V7 (Vengurla 7)	V4 (Vengurla 4)
T ₆	V7 (Vengurla 7)	Bhaskara
T ₇	Control	V4 (Vengurla 4)
T ₈	Control	Bhaskara

Table 3. Survival percentage of interstock grafts of different seasons in cashew.

Treatment	Survival % (October 2023 grafts)	Survival % (April 2024 grafts)
T1-Nethra vamaan+V4	83.33	71.67
T2-Nethra vamaan +Bhaskara	63.33	55.00
T3-Taliparamba+V4	86.66	40.00
T4-Taliparamba+Bhaskara	80.00	40.00
T5-V7+V4	100.00	40.00
T6-V7+Bhaskara	86.66	46.67
T7-V4	100.00	73.33
T8-Bhaskara	100.00	86.67

(Table 3). Among the different interstocks, the Taliparamba interstock had a lower survival percentage with the V4 and Bhaskara varieties and V7 as the interstock with the V4 variety (40 %) grafts. Nethra vamaan with V4 recorded 71.67 %, and Nethra

vamaan with the Bhaskara variety reported 55 %, and the control (no interstocks) reported the highest survival percentage in both V4 (73.33 %) and the Bhaskara variety (86.6 %) as compared to interstock grafts.

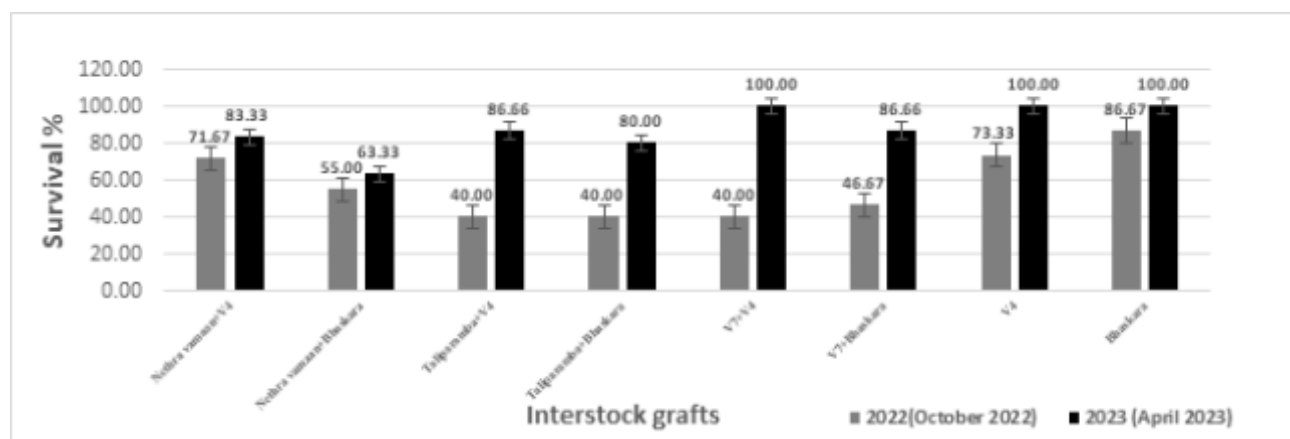


Fig. 2 Survival percentage of interstock grafting in cashew in different season

During April grafting interstocks, the survival percentage of grafts varies from 63.33 to 100 %. The highest survival percentage was reported in the control with no interstocks and was *on par* with interstock V7 with V4 (100 %), followed by V7 with Bhaskara (86.66 %), Taliparamba with V4 (86.66 %), Nethra Vamaan with V4 (83.33 %), Taliparamba with Bhaskara (80%), and the lowest survival percentage was observed in Nethra Vamaan with Bhaskara (Table 3). Among the different seasons of grafting, April grafts survival percentage is significantly higher as compared to October grafts except in Nethra vamaan as interstock which clearly indicated a seasonal influence on graft success. It was noticed that interstock grafting V4 is responded well in success rate as compared to Bhaskara. This success rate mainly depends on the compatibility of grafts (genotype), season, selection of scion sticks, skill of the graft man, and weather. These results were supported by Bhagya *et al* (2022). Higher success in the case of soft wood grafting is achieved in the seasons in which fluctuation in the day and night temperatures is minimum and high humidity is prevalent throughout the day (Swamy *et al*, 2010).

CONCLUSION

From this study, it was concluded that April month interstock grafting was better as compared to October grafting, and V4 variety interstock grafting had more success as compared to Bhaskara, and interstock grafting is possible in cashew and other dwarf-inducing species can be included in future studies. This study has shown that more scope is there to study on interstock grafting technology for speed breeding technique in cashew.

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Influence of dwarf interstock on inter-stock grafting in Cashew (*Anacardium occidentale*)

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Influence of Entomopathogenic Fungi *Beauveria bassiana* on Growth and Yield of Tomato (*Solanum lycopersicum* L.)

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ABSTRACT

Two experiments were conducted on the influence of entomopathogenic fungi *Beauveria bassiana* UHSB-END1 (University of Horticultural Sciences Bagalkot – Endophytic1) on growth and yield of tomato (*Solanum lycopersicum* L.) during December 2023 to May 2024 at the vegetable science block, University of Horticultural Sciences, Bagalkot. The experiment I was laid out in a completely randomized design having five treatments (T₁ - Soaking seeds for 2 hrs, T₂ - Soaking seeds for 6 hrs, T₃ - Soaking seeds for 12 hrs, T₄ - Soaking seeds for 24 hrs, T₅ – Control) with four replications. The experiment II was laid out in randomized complete block design having ten treatments (T₁ - Seed treatment, T₂ - Seedling root dip, T₃ - Soil drenching, T₄ - Foliar spray, T₅ - Seed treatment + Seedling root dip + Soil drenching, T₆ - Seed treatment + Seedling root dip + Foliar spray, T₇ - Seed treatment + Soil drenching + Foliar spray, T₈ - Seedling root dip + Soil drenching + Foliar spray, T₉ - Seed treatment + Seedling root dip + Soil drenching + Foliar spray, T₁₀ – Control) with three replications. The experiments were conducted to study the impact of *B. bassiana* UHSB-END1 on growth and development of tomato seedlings and fruit yield. The result showed that the seeds soaked with *B. bassiana* for 12 hrs (T₃) showed the best results. They had a 100 per cent germination rate and seedling survivability with desirable seedlings length and seedling dry matter in experiment I. The highest plant height (48.92, 57.30, 63.82 and 67.34 cm) and leaf chlorophyll (52.51, 50.52, 39.82 and 29.04 SPAD) content showed in the treatment T₇- seed treatment + soil drenching + foliar spray and total dry matter (3878.33 kg/ha) at final harvest, leaf area (29.75, 32.87, 35.04 and 35.50 cm²) in the treatment T₆ - seed treatment + seedling root dip treatment + foliar spray at 30, 60, 90 DAT and at final harvest of tomato respectively. The maximum yield attributes like fruit volume (67.34 cm³), fruit diameter (69.17 mm) and fruit weight (70.23 g), the highest yield per ha (56.32 t) showed notable results in the treatment T₆- seed treatment + seedling root dip treatment + foliar spray were observed in experiment II.

Keywords: *Beauveria bassiana*, Chlorophyll, Dry matter, Entomopathogenic, Fruit volume, Fruit diameter, Fruit weight, Leaf area, Survivability, Seed germination, Seedling length, Tomato, Yield.

INTRODUCTION

Beauveria bassiana, a fungus that generates an array of toxic secondary metabolites, including beauvericin, bassianin, bassianolide, beauverolides, tenellin, oosporein, and oxalic acid. These compounds play a key role in enabling the fungus to infect and ultimately eliminate its hosts (Wang *et al*, 2021). It also plays an important role in other aspects like colonizers of internal plant tissues (Wakil *et al*, 2020), as

colonizers of the rhizosphere (Nelly *et al*, 2019), as promoters of plant growth and plant fitness (Jaber and Enkerli, 2017), act as enhancers of tolerance to environmental challenges, like drought tolerance and promoting overall growth as biofertilizers (Vega *et al*, 2009).

Many plants maintain symbiotic relationships with endophytic fungi (Card *et al*, 2016), which inhabit plant tissues without causing any apparent harm

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Experiment I. Effect of *Beauveria bassiana* UHSB-END1 seed treatment on the growth characteristics of tomato seedlings in different hours.

Table 1. Treatment details of experiment 1

T ₁	Soaking seeds for 2 hrs duration with 5 g/L <i>Beauveria bassiana</i>
T ₂	Soaking seeds for 6 hrs duration with 5 g/L <i>Beauveria bassiana</i>
T ₃	Soaking seeds for 12 hrs duration with 5 g/L <i>Beauveria bassiana</i>
T ₄	Soaking seeds for 24 hrs duration with 5 g/L <i>Beauveria bassiana</i>
T ₅	Control (soaking seeds only with water)

Experiment – II Effect of *Beauveria bassiana* UHSB-END 1 on growth and yield of tomato.

Table 2. Treatment details of experiment 2

T ₁	Tomato seeds treated with 5 g/L <i>Beauveria bassiana</i> for 12 hrs duration
T ₂	Seedling root dip treatment with 5 g/L <i>B. bassiana</i> for 15 min. (While transplanting)
T ₃	Soil drenching with 10 g/L <i>B. bassiana</i> 15 days after transplanting of tomato seedlings
T ₄	Foliar spray with 4 g/L <i>B. bassiana</i> 30, 45, 60 days after transplanting of tomato seedlings.
T ₅	Seed treatment + Seedling root dip treatment + Soil drenching (T ₁ + T ₂ + T ₃)
T ₆	Seed treatment + Seedling root dip treatment + Foliar spray (T ₁ + T ₂ + T ₄)
T ₇	Seed treatment + Soil drenching + Foliar spray (T ₁ + T ₃ + T ₄)
T ₈	Seedling root dip treatment + Soil drenching + Foliar spray (T ₂ + T ₃ + T ₄)
T ₉	Seed treatment + Seedling root dip treatment + Soil drenching + Foliar spray (T ₁ + T ₂ + T ₃ + T ₄)
T ₁₀	Standard check (Control) – Untreated tomato seedlings.

(Bamisile *et al.*, 2018). Once established, these fungi form mutualistic partnerships with their hosts (Sasan and Bidochka, 2012) enhancing plant growth and increasing resilience to both biotic and abiotic stresses (Zimmermann, 2007). Endophytes are notable for their phylogenetic diversity and wide range of lifestyles, including variations in colonization patterns, transmission modes, host specificity, and tissue preference within plants (Behie *et al.*, 2015). There is growing interest in utilizing entomopathogenic fungi (EPFs) as endophytes due to their unique advantages over traditional applications. One such fungus, *Beauveria bassiana*, has demonstrated the ability to colonize numerous plant species, including wheat, soybean, rice, beans, onion, tomato, palm, grape, potato, and cotton (Vega, 2018). It can establish local or systemic presence within roots, stems, leaves, and internal plant tissues. Inoculation methods such as seed treatment, foliar spraying, and soil irrigation have been shown to successfully introduce endophytic fungi into plants (Akello and Sikora, 2012). For instance, applying *B. bassiana* and *Metarhizium anisopliae* to seeds led to effective colonization and significant plant growth improvements as indicated by increased stem height, root length, and biomass (Jaber, 2018 ; Shao-Fang *et al.*, 2017). In particular, soil and foliar applications of *B. bassiana* have been widely used to enhance corn seedling development (Yuhong *et al.*, 2017). This study aims to assess the effects of *B.*

bassiana UHSB-END1 on the growth and yield of tomato (*Solanum lycopersicum*), focusing on its potential as a growth-promoting endophytic fungus.

MATERIALS AND METHODS

The experiment - I was conducted using a completely randomized design with five treatments and four replications (Table 1). The crop used in the study was tomato (*Solanum lycopersicum* L.), specifically the hybrid variety Arka Rakshak from Indian Institute of Horticultural Research, Hesaragatta, Bangalore. The experiment - II was conducted using Randomized Complete Block Design with ten treatments and three replications (Table 2). The best tomato seedlings of experiment - 1 were used for experiment - II. The experiment - II was executed under irrigated conditions using a drip system, with planting gaps of 90 cm × 45 cm. Each plot contained 44 plants, with a total of 30 plots. The plot proportion was 10.16 m by 2 m, resulting in a net plot size of 610 m². The experiment took place during the spring-summer season. Seeds were sown in pro trays on December 12, 2023, and transplanted on January 13, 2024. The final harvest occurred on May 7, 2024. The recommended dose of fertilizers (RDF) for tomatoes was 120kg N, 80kg P₂O₅ and 50 kg K₂O per hectare. The experiment took place at the vegetable science block, College of Horticulture in Bagalkot, during the 2023-24 period. This location falls within the Northern Dry Zone of

Influence of Entomopathogenic Fungi on Growth and Yield of Tomato

Karnataka (Agroclimatic Zone-3), situated at a latitude of 16° 10' and a longitude of 74° 42' with an elevation of 542 meters above sea level. The experimental site featured a nearly flat topography with sufficient surface drainage. The data in respect of all the above parameters were tabulated and subjected to the statistical analysis by adopting Completely Randomized Design at critical difference values with 1% level of significance of the corresponding degree of freedom for experiment I and the Randomized Complete Block Design were analyzed at a 5% probability level using Fischer's method of variance analysis for experiment II. Whenever the 'F test' indicated significance, the critical difference at the same level was determined (Panse and Sukhatme, 1954).

Germination percentage (%) : Tomato seeds began to sprout within 3–4 days of sowing. The germination percentage was verified by dividing the number of seeds that successfully germinated by the total number of seeds sown, then multiplying the result by 100 to express it as a percentage

Radicle length (cm): Radicle is a plant tissue which grows from the micropyle of the seed and develops further down into the soil. The radicle length observation was carried in 3 to 4 days old tomato seedlings.

Plumule length (cm): Plumule is the part of seed embryo that grows into a shoot by the process of seed germination. Plumule length observation was carried in 3 to 4 days old tomato seedlings.

Seedling height (cm) : Five randomly chosen and tagged plants were measured for seedling height at 30 days post sowing using a scale from the ground to the tip of the main stem. The average height of five plants was computed and expressed in centimeters.

Plant height (cm): Five randomly chosen and tagged plants were measured at 30, 60, 90 and at the final harvest, after transplantation. It was measured by using a scale/tape from the ground to the tip of the main stem. The average height of five plants was computed and illustrated in centimeters.

Leaf area (cm²) : Five randomly chosen and tagged plants were evaluated at 30, 60, 90 and at the final harvest, after transplantation. It was measured by multiplying correction factors with length into breadth of base, bottom and top of the leaves of plant. The average of five plants was computed and expressed in centimeter square (cm²).

Leaf chlorophyll content (SPAD): Five randomly chosen and tagged plants were quantified at 30, 60, 90 and at the final harvest, after transplantation. It was measured by using SPAD meter from the base, bottom and top of the leaves of plant.

Seedling Survivability (%): The seedling survivability rate was determined by summing the number of healthy living seedlings, dividing that total by the overall number of seedlings planted and then multiplying the result by 100 to express it as a percentage.

Seedling dry matter (g): Seedling dry matter was calculated by subtraction of freshly weighed seedling by the oven dried weighed seedling. It was achieved by 30 days old seedlings.

Volume of fruit (cm³): Five fruits from each treatment were collected and examined in the laboratory, where volume was assessed by water displacement method and expressed in cubic centimeters (cm³). The average volume of these five fruits was calculated and used for statistical analysis.

Fruit diameter (mm) : Five fruits per treatment were collected and fruit diameter was recorded by using vernier caliper, then average value of five fruits was taken for statistical analysis.

Fruit weight (g) : The mean weight of tomato fruit was derived by averaging the weight of 5 randomly selected fruits from the tagged plants and weighed individually using digital scale and was expressed in grams.

Fruit yield (kg/plant): Fruit yield of five erratically tagged plants was estimated by the summation of weight of each picking per plant and the average yield per plant was calculated and stated in kg per plant.

Fruit yield (kg/plot) : It was computed by multiplying the total yield per plant with the total number of plants per plot and it was expressed in kg per plot.

Fruit yield (t/ha): Total yield from each replication was noted and multiplied on the basis of per ha population of plants and expressed in t ha⁻¹.

Dry matter yield (kg/ha) : Five plants in each net plot were arbitrarily uprooted at the final phase of experiment, washed with tap water and wiped-out extra moisture by sponging with dry cotton wool and immediately their fresh weight. To determine the dry weight of different parts of plant roots, stem, leaves and fruits were separated and they were chopped separately into small pieces to enable drying and were dried at 65-

70 °C until stable mass was obtained and multiplied on the basis of per ha population of plants and expressed in kg ha⁻¹.

Cost of cultivation (Rs. /ha): Cost incurred from land preparation to harvest of crops including cost of all the inputs, cost of all the operations carried out, interest on the working capital, supervision charge and pre-farm to marketing charge.

Gross returns (Rs. /ha): Gross return per ha was calculated by considering the economic yield obtained per ha and price of the product prevailing in the market at the time of harvest.

Net returns (Rs. /ha): Net returns (Rs. /ha) = Gross returns (Rs. / ha) – Cost of cultivation (Rs. / ha)

Benefit: cost ratio : Benefit: Cost ratio for different treatments were worked out based on the expenditure and income to study the economics of tomato production by using different methods of application of *Beauveria bassiana*.

$$\text{B: C ratio} = \frac{\text{Gross returns (Rs. /ha)}}{\text{Cost of cultivation (Rs. /ha)}}$$

RESULTS AND DISCUSSION

Growth parameters

The most coveted observations noticed in the treatment involving seeds soaked for 12 hrs (T₃) yielded the best results across various parameters (Table 3). Specifically, this treatment achieved a 100 per cent germination rate, with the radicle length reaching 3.43 cm and the plumule length extending to 4.43 cm. The overall seedling height was 23.38 cm with 100 per cent seedling survivability. Additionally, the seedlings had a dry weight of 0.37 g.

These outcomes are attributed to the treatment with *Beauveria bassiana*. This fungus helps in breaking the seed dormancy and enhances germination rates. When seeds are soaked, they absorb water, which is crucial for initiating the germination process. The presence of *B. bassiana* further promotes healthier and more vigorous seedlings, leading to better overall growth and development. However, the less than 12 hrs-soaked seeds were failed due to insufficient colonization of *B. bassiana* and more than 12 hrs-soaked seeds were failed due to over succulents of seeds (Akello and Sikora, 2012).

Plant height

The data concerning to plant height at 30, 60, 90 days after transplanting (DAT) and at final harvest

showed significant differences among the treatments owing to different methods of application with *B. bassiana* UHSB - END1. Compared to other treatments the highest plant height was observed in the treatment of T₇- seed treatment + soil drenching + foliar spray (48.92, 57.30, 63.82 and 67.34 cm) at 30, 60, 90 days after transplanting (DAT) and at final harvest, respectively (Table 4). This could be a result of higher seedling vigour and colonization rate showed by *B. bassiana* which significantly boosted the plant height (Dara *et al*, 2017; Afandhi *et al*, 2019).

Leaf area

The data concerning to leaf area at 30, 60, 90 days after transplanting (DAT) and at final harvest revealed notable variations among the treatments, inspired by different methods of application with *B. bassiana* UHSB - END1. Compared to other treatments the maximum leaf area was noticed in the treatment of T₆ - seed treatment + seedling root dip treatment + foliar spray (29.75, 32.87, 35.04 and 35.50 cm²) at 30, 60, 90 days DAT and at final harvest respectively (Table 5). This may be result of combination of different application methods likely facilitates the easy colonization of *B. bassiana* on leaf tissue of plant, shows positive impact on the leaf area. These observations align with the outcomes of various studies (Krell *et al*, 2018; Pal and Ghosh, 2018).

Chlorophyll content

The leaf chlorophyll content at final harvest ranged between 21.11 SPAD to 29.04 SPAD (Table 6). The significantly higher leaf chlorophyll content was recorded in treatment T₇ - seed treatment + soil drenching + foliar spray (29.04 SPAD), followed by T₆ - seed treatment + seedling root dip treatment + foliar spray (27.83 SPAD). The minimal leaf chlorophyll content was recorded in the treatment T₁₀ (21.11 SPAD) of standard check (control) This shows that, bioactive compounds produced by the *B. bassiana* boost the photosynthetic activity which enhances the chlorophyll content in plants (Jaber, 2018 ; Shao-Fang *et al*. 2017).

Total dry matter

The data on total dry matter (kg/ha) of tomato crop after the final harvest showed significant differences among the treatments, persuaded by different methods of application with *B. bassiana* UHSB - END1 (Table 6). Compared to other treatments the maximum total dry matter was obtained in the treatment T₆ - seed treatment + seedling root dip

Influence of Entomopathogenic Fungi on Growth and Yield of Tomato

Table 3. Growth characteristics of tomato seedlings as influenced by duration of soaking seed treatment with *Beauveria bassiana* UHSB - END1 (experiment -1)

Treatment No.	Germination (%)	Radicle length (cm)	Plumule length (cm)	Seedling height (cm)	Seedling survivability (%)	Seedling dry matter (g)
T ₁	92.31	2.23	2.88	15.15	92.31	0.30
T ₂	92.31	2.85	3.60	20.30	92.31	0.31
T ₃	100.00	3.43	4.43	23.38	100.00	0.37
T ₄	84.62	3.00	3.65	20.98	84.62	0.27
T ₅	92.31	2.00	3.98	15.73	92.31	0.16
S. Em ±	1.20	0.33	0.33	0.70	1.31	0.07
C.D. at 1%	5.02	1.37	1.38	2.91	5.46	0.30

Table 4. Plant height (cm) at various growth stages of tomato as influenced by different methods of *Beauveria bassiana* UHSB – END1 application

Treatment No.	Treatment	30 DAT	60 DAT	90 DAT	At final harvest
T ₁	Seed treatment	40.21	46.40	58.91	63.21
T ₂	Seedling root dip treatment	39.33	43.72	55.43	58.83
T ₃	Soil drenching	37.70	40.51	48.92	60.40
T ₄	Foliar Spray	39.91	50.11	57.30	59.94
T ₅	T ₁ +T ₂ +T ₃	40.84	49.32	54.52	64.23
T ₆	T ₁ +T ₂ +T ₄	42.31	53.74	57.41	62.72
T ₇	T ₁ +T ₃ +T ₄	48.92	57.30	63.82	67.34
T ₈	T ₂ +T ₃ +T ₄	43.73	52.23	60.70	64.11
T ₉	T ₁ +T ₂ +T ₃ +T ₄	45.13	55.51	62.10	65.80
T ₁₀	Standard check	35.12	40.23	47.81	52.33
S. Em ±		0.64	0.82	0.63	0.81
C.D. at 5%		1.91	2.45	1.88	2.42

DAT – Days after transplanting

treatment + foliar spray (3878.33 kg/ha). This is because of the faster growth rate and photosynthetic assimilation rate brought by these fungi improved availability and translocation of nutrients, which encouraged greater partitioning of photosynthates for dry matter yield (Jirakkakul *et al* 2015).

Yield attributes and yield

The yield attributes such as fruit volume, fruit diameter and fruit weight found to be the highest in treatment T₆ - seed treatment + seedling root dip treatment + foliar spray (67.34 cm³, 69.17 mm and 70.23 g), respectively (Table 7). The increase in yield attributing characters leads to increase the yield of crop. Thereby, T₆ recorded the highest yield per plant, per plot and per hectare (2.56 kg, 112.64 kg and 56.32 t)

respectively. This can be attributed to the enhanced translocation of photo assimilates to the fruits when various methods of *B. bassiana* were applied combinedly induces the yield (El-Gepaly, 2021; Sánchez-Rodríguez *et al*, 2018).

Economics

The maximum gross return (Rs. 5,63,200/ha), net return (Rs. 3,90,389/ha) with B: C (3.26) ratio was found in the treatment T₆ - seed treatment + seedling root dip treatment + foliar spray compared to other treatments. This might be due to effective utilization of nutrients through different methods of *B. bassiana* application yield attributes were increased. So, economics of tomato in the treatment T₆ was amplified, followed by different studies who have shown that *B.*

Table 5. Leaf area (cm²) at various growth stages of tomato as inspired by different methods of *Beauveria bassiana* UHSB – END 1 application

Treatment No.	Treatment	30 DAT	60 DAT	90 DAT	At final harvest
T ₁	Seed treatment	22.51	29.02	29.99	33.47
T ₂	Seedling root dip treatment	19.77	21.53	25.26	32.78
T ₃	Soil drenching	21.30	27.44	29.13	32.38
T ₄	Foliar Spray	23.55	29.61	29.94	31.47
T ₅	T ₁ +T ₂ +T ₃	19.23	20.66	27.86	28.37
T ₆	T ₁ +T ₂ +T ₄	29.75	32.87	35.04	35.50
T ₇	T ₁ +T ₃ +T ₄	25.63	24.94	28.88	30.96
T ₈	T ₂ +T ₃ +T ₄	20.77	25.62	26.14	28.77
T ₉	T ₁ +T ₂ +T ₃ +T ₄	23.27	24.94	25.51	28.83
T ₁₀	Standard check	17.97	19.79	24.46	25.66
S. Em ±		1.31	2.24	2.60	2.20
C.D. at 5%		3.90	6.66	7.72	6.52

DAT – Days after transplanting

Table 6. Leaf chlorophyll content (SPAD) of tomato at various growth stages and total dry matter at final harvest as inspired by different methods of *Beauveria bassiana* UHSB – END 1 application

Treatment No.	Treatment	30 DAT	60 DAT	90 DAT	At final harvest	TDM at final harvest (kg/ha)
T ₁	Seed treatment	40.41	34.73	34.13	25.42	3580.23
T ₂	Seedling root dip treatment	45.31	42.31	32.20	26.21	3698.01
T ₃	Soil drenching	39.20	38.42	31.32	24.74	3601.22
T ₄	Foliar Spray	49.92	42.23	35.81	26.53	3623.31
T ₅	T ₁ +T ₂ +T ₃	44.30	38.41	31.40	26.94	3811.19
T ₆	T ₁ +T ₂ +T ₄	52.13	42.80	36.93	27.83	3878.33
T ₇	T ₁ +T ₃ +T ₄	52.51	50.52	39.82	29.04	3830.24
T ₈	T ₂ +T ₃ +T ₄	42.52	37.43	31.04	23.52	3729.13
T ₉	T ₁ +T ₂ +T ₃ +T ₄	45.81	42.71	35.43	22.42	3740.07
T ₁₀	Standard check	35.63	32.74	28.12	21.11	3564.11
S. Em ±		0.48	0.61	0.54	0.31	64.12
C.D. at 5%		1.43	1.81	1.61	0.93	190.50

DAT – Days after transplanting

TDM – Total dry matter

Influence of Entomopathogenic Fungi on Growth and Yield of Tomato

Table 7. Yield attributes and yield of tomato as influenced by different methods of *Beauveria bassiana* UHSB – END 1 application

Treatment No.	Treatment	Fruit volume (cm ³)	Fruit diameter (mm)	Fruit weight (g)	Fruit yield (kg/plant)	Fruit yield (kg/plot)	Fruit yield (t/ha)
T ₁	Seed treatment	47.16	51.33	56.39	2.09	91.96	45.98
T ₂	Seedling root dip treatment	52.83	55.16	57.50	2.01	88.44	44.22
T ₃	Soil drenching	51.40	53.03	55.69	1.99	87.56	43.78
T ₄	Foliar Spray	52.06	53.49	55.83	2.16	95.04	47.52
T ₅	T ₁ +T ₂ +T ₃	58.44	60.63	62.19	2.47	108.68	54.34
T ₆	T ₁ +T ₂ +T ₄	67.34	69.17	70.23	2.56	112.64	56.32
T ₇	T ₁ +T ₃ +T ₄	61.69	63.33	66.51	2.51	110.44	55.22
T ₈	T ₂ +T ₃ +T ₄	57.78	59.25	61.89	2.43	106.92	53.46
T ₉	T ₁ +T ₂ +T ₃ +T ₄	53.88	55.81	61.16	2.38	104.72	52.36
T ₁₀	Standard check	44.50	48.56	54.87	1.87	82.28	41.14
S. Em ±		2.58	2.25	2.74	0.03	0.97	0.64
C.D. at 5%		7.67	6.69	8.14	0.10	2.87	1.90

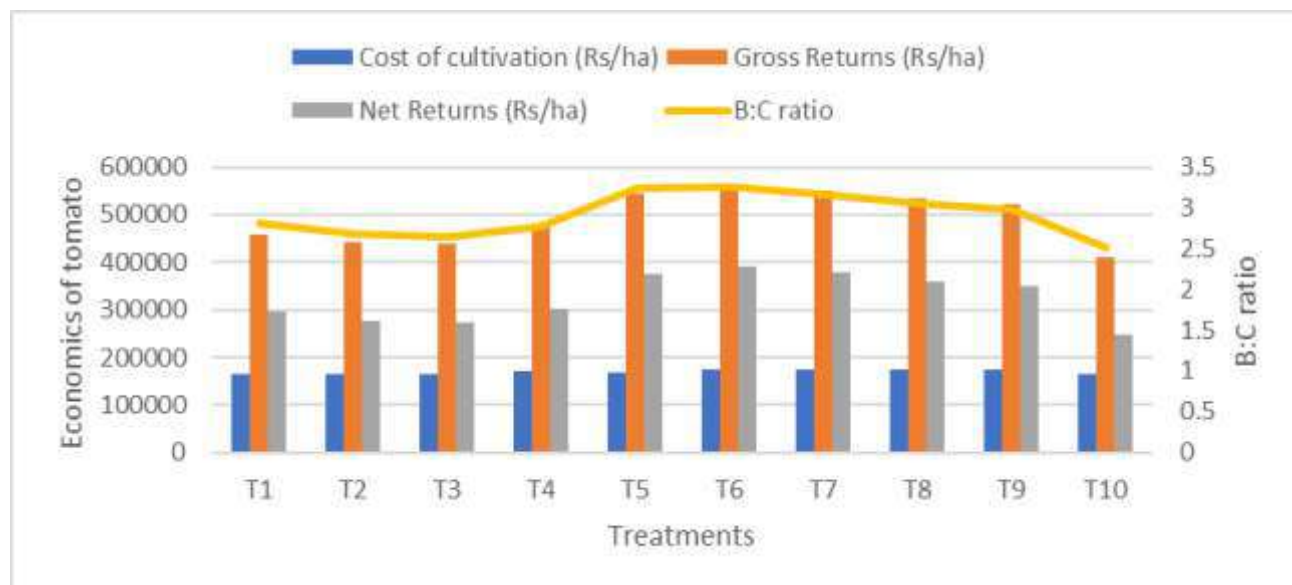


Fig 1. Economics (Rs. / ha) of tomato plants as influenced by different methods of *Beauveria bassiana* UHSB – END1 application

bassiana treated seeds can lead to an increase in plant biomass and fruit production, contributing to a better B:C ratio (Krell *et al*, 2018; Pal and Ghosh, 2018).

CONCLUSION

Based on a comprehensive evaluation of the results, it can be inferred that the application of

treatment T₆ - seed treatment + seedling root dip treatment + foliar spray had a notably positive effect on tomato growth and yield, influenced by the entomopathogenic microbe *Beauveria bassiana* UHSB-END1. Beyond its role as an entomopathogen, *B. bassiana* offers significant advantages, which enhances overall crop growth and development. This

beneficial effect can serve as an indirect supplement to traditional fertilizers, providing a sustainable alternative to commercial fertilization methods.

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Influence of Entomopathogenic Fungi on Growth and Yield of Tomato

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Integrated Management of Stem and Root Rot of Sesame caused by *Macrophomina phaseolina* (Tassi) Goid

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ABSTRACT

Sesame (*Sesamum indicum* L.) is an important oilseed crop known for its high-quality oil (48-55%) and nutritional value, making it a key agricultural commodity globally. However, its production is constrained by various biotic stresses, including fungal, bacterial and phytoplasmal diseases like *Alternaria* leaf spot, stem and root rot, powdery mildew, *Cercospora* leaf spot, bacterial blight and phyllody. Among these stem and root rot caused by *Macrophomina phaseolina* attributes significant yield losses. This soil-borne, saprophytic pathogen affects all parts of the plant and is challenging to manage due to its ability to survive in the soil as sclerotia. Hence, the current investigation examined the effects of using botanicals, bioagents and fungicides to assess their effectiveness in disease management. Field experiments during *Kharif* 2024 demonstrated that soil application of *T.harzianum* enriched with Neem cake and FYM @ 1:20:250 kg/ha + seed treatment with *T. harzianum* @ 10g/kg of seeds followed by spray of (Tebuconazole 50% + Trifloxystrobin 25 %) 75% WG @ 0.5g/l at 45, 60 and 90 DAS resulted in the lowest stem and root rot incidence (14.94 %) and highest yield (8.74q/ha) which was significantly superior to other scheduled combinations. The lowest yield of 3.42 q/ha and maximum stem and root rot incidence of 38.82 per cent was recorded in untreated control. Thus explore the integrated approaches for the management of diseases an experiment was conducted with different treatments against the control of *M. phaseolina* causing stem and root rot in sesame.

Keywords: *Macrophomina*, Oilseed, Sesame, Stem and root rot, *Trichoderma harzianum*

INTRODUCTION

Sesame (*Sesamum indicum* L.) often referred to as the Queen of Oilseeds due to its high content of polyunsaturated fatty acids, which help prevent rancidity. The seeds contain 48-55 per cent oil and 20-28 per cent protein, along with essential amino acids, niacin and various minerals. Additionally, they are rich in sesamin and sesamol, which contribute to the formation of sesamol—an antioxidant that enhances shelf life. This remarkable longevity has also earned sesame the title of seeds of immortality (Bashir, 2017). In Karnataka, sesame is primarily cultivated under rainfed conditions, covering 0.20 lakh ha with an annual production of 0.13 lakh tonnes and an average productivity of 650 kg/ha (Anonymous, 2023).

The decline in sesame cultivation across traditional growing regions is attributed to various yield-limiting factors, particularly biotic and abiotic stresses. Among these, diseases pose a major threat, with sesame being highly susceptible to fungal,

bacterial, and phytoplasmal infections such as *Alternaria* leaf spot, stem and root rot, powdery mildew, *Cercospora* leaf spot, bacterial blight, and phyllody. Among these, stem and root rot, caused by *Macrophomina phaseolina*, is one of the most severe. It begins with black lesions at the plant's base, gradually spreading upward along the stem, while the roots darken and secondary rootlets decline. As the infection worsens, capsules turn brown, dry out and open prematurely, eventually causing the entire plant to blacken, wilt and shed its leaves (Khamari and Patra, 2018).

The pathogen persists in soil and plant debris by producing an asexual structure called microsclerotia, which can remain viable in infected root debris for over 5–12 years. These hard resting structures, including sclerotia and microsclerotia, are dispersed throughout the soil. The drying and decomposition of host tissue further support the pathogen's survival under unfavorable environmental conditions. Additionally, pycnidial growth develops

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Treatment details

T ₁	Soil application of <i>Trichoderma harzianum</i> enriched with Neem cake and FYM @1:20: 250kg/ha + Seed treatment with <i>T.harzianum</i> @10g/kg of seeds followed by spray of <i>T.harzianum</i> @ 10g/l at 45,60 and 90 DAS
T ₂	Seed treatment with Azadirachtin (10000ppm) @2ml/l followed by Spray of Azadirachtin (10000ppm) @2ml/l at 45,60 and 90 DAS
T ₃	ST with Carbendazim 50 WP @2g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25 %) @ 0.5g/l at 45,60 and 90 DAS
T ₄	ST with (Carboxin 37.5% + Thiram 37.7 %) @ 3g/kg of seeds followed by spray of <i>T.harzianum</i> @ 10g/l at 45,60 and 90 DAS
T ₅	ST with (Carbendazim 12%+ Mancozeb 63 %) @ 2g/kg of seeds followed by spray of Azadirachtin (10000 ppm) @2ml/l at 45,60 and 90 DAS
T ₆	Soil application of <i>T.harzianum</i> enriched with Neem cake and FYM @1:20:250kg/ha + ST with <i>T.harzianum</i> @10g/kg of seeds followed by spray of Azadirachtin (10000 ppm) @2ml/l at 45,60 and 90 DAS.
T ₇	Soil application of <i>T.harzianum</i> enriched with Neem cake and FYM @1:20:250kg/ha + ST with <i>T.harzianum</i> @10g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25 %) @ 0.5g/l at 45,60 and 90 DAS
T ₈	Seed treatment with <i>T.harzianum</i> @10g/kg of seed (RC)
T ₉	Seed treatment with Captan 70% WP @3g/kg of seed (RC)
T ₁₀	Untreated control

on plant tissues, eventually rupturing to release aseptate, ellipsoid to ovoid conidia, facilitating successive infections in the field (Marquez *et al*, 2021).

MATERIALS AND METHODS

A field trial was conducted on integrated management of stem and root rot of sesame during *kharif* 2024 at AICRP on sesame and Niger, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad by following Randomized block design . There were 10 treatments with three replications each. The variety of sesame used was DSS 9 which was sown at 30X 10 cm spacing in a plot size of 2.4mX 3 m. The detail of treatments is given as under

The observations like seed germination was done after 15 days of sowing, disease incidence was calculate by the given by Wheeler (1969). The yield of the plot was recorded and converted into per hectare basis. Observations on stem and root rot incidence were recorded at different intervals, beginning 45 days after sowing and continuing until crop maturity.

RESULTS AND DISCUSSION

A field investigation was conducted during *Kharif* 2024 at the Main Agricultural Research Station, UAS, Dharwad, using a randomized block design with three replications and the DSS-9 variety of sesame. The study evaluated the efficacy of the fungicide (Tebuconazole 50% + Trifloxystrobin 25%), which had shown the highest effectiveness in *in vitro* studies, along with the best biocontrol agent, *Trichoderma*

harzianum IOF strain from UAS Dharwad. A total of ten treatment combinations were evaluated against stem and root rot, all of which showed a significant reduction in disease incidence and performed better than the control treatment.

After 15 days of sowing, the percentage of germination was calculated and result indicated that there were no significant differences among the treatments, highest germination percentage of sesame plants of 92.63 per cent was recorded (T₇) and least in treatment T₁₀ (Untreated control), 62.04 per cent respectively.

Among the ten treatments evaluated during *kharif* 2024, results revealed that all the treatments significantly reduced the stem and root rot incidence as compared to the control. The treatment T₇ (Soil application of *T.harzianum* enriched with Neem cake and FYM @1:20:250kg/ha + Seed treatment with *T.harzianum* @10g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25 %) @ 0.5g/l at 45, 60 and 90 DAS) recorded least disease incidence of 14.94 per cent during *kharif* 2024, which was significantly superior to other scheduled combinations. Next best treatment was T₃ (ST with Carbendazim 50 WP @2g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25%) @ 0.5g/l at 45,60 & 90 DAS) which had recorded disease incidence of 18.51 per cent during *kharif* 2024. Untreated control (T₁₀) recorded a maximum stem and root rot incidence of 38.82 per cent and it is significantly highest over all other treatments (Table 1)

Integrated management of stem and root rot of sesame caused

Table 1. Evaluation of different treatment against stem and root rot of sesame (Kharif-2024)

Treatment		Germination (%)	Disease incidence (%)			Yield (q/ha)
			45 DAS	60 DAS	90 DAS	
T1	Soil application of <i>Trichoderma harzianum</i> enriched with Neem cake and FYM @1:20:250kg/ha + Seed treatment with <i>T.harzianum</i> @10g/kg of seeds followed by spray of <i>T.harzianum</i> @ 10g/l at 45,60 and 90 DAS	90.01 (71.87) *	9.6 (14.5) *	13.25 (18.27) *	26.77 (29.78) *	5.33
T2	Seed treatment with Azadirachtin (10000ppm) @2ml/l followed by spray of Azadirachtin (10000ppm) @2ml/l at 45,60 and 90 DAS	74.2 (59.57)	10.76 (15.74)	18.05 (22.67)	33.42 (34.73)	4.18
T3	ST with Carbendazim 50 WP @2g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25%) @ 0.5g/l at 45,60 & 90 DAS	82.1 (65.06)	8.06 (12.74)	10.63 (15.6)	18.51 (23.07)	8.32
T4	ST with (Carboxin 37.5% + Thiram 37.7 %) @ 3g/kg of seeds followed by spray of <i>T.harzianum</i> @ 10g/l at 45,60 and 90 DAS	83.5 (66.03)	8.55 (13.3)	12.16 (17.18)	22.91 (26.75)	5.79
T5	ST with (Carbendazim 12%+ Mancozeb 63 %) @ 2g/kg of seeds followed by spray of Azadirachtin (10000 ppm) @2ml/l at 45,60 and 90 DAS	84.5 (66.86)	8.88 (13.69)	13.61 (18.62)	21.15 (25.32)	4.57
T6	Soil application of <i>T.harzianum</i> enriched with Neem cake & FYM @1:20:250kg/ha + ST with <i>T.harzianum</i> @10g/kg of seeds followed by spray of Azadirachtin (10000 ppm) @2ml/l at 45,60 & 90 DAS.	91.1 (72.7)	9.81 (14.72)	12.02 (17.05)	22.52 (26.45)	6.01
T7	Soil application of <i>T.harzianum</i> enrichedwith Neem cake and FYM @1:20:250kg/ha + ST with <i>T.harzianum</i> @10g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25 %) @ 0.5g/l at 45,60 and 90 DAS	92.63 (74.26)	6.49 (10.83)	10.36 (15.3)	14.94 (19.89)	8.74
T8	Seed treatment with <i>T.harzianum</i> @10g/kg of seed (RC)	87.83 (69.7)	9.64 (14.53)	14.65 (19.6)	28.60 (31.17)	4.85
T9	Seed treatment with Captan 70% WP @3g/kg of seed (RC)	81.8 (64.78)	9.10 (13.93)	13.29 (18.3)	24.79 (28.24)	5.11
T10	Untreated control	62.04 (51.95)	13.98 (18.96)	19.84 (24.22)	38.82 (38.58)	3.42
	S.Em±	1.58	0.80	1.09	1.43	0.35
	CD at 5%	4.69	2.39	3.25	4.26	1.03
	C. V.	4.12	9.76	10.16	8.75	10.75

*Arcsine transformed values ST: Seed treatment DAS: Days after sowing

Highest yield of 8.74 q/ha was obtained in T₇ [Soil application of *T.harzianum* enrichedwith Neem cake and FYM @1:20:250kg/ha + Seed treatment with *T.harzianum* @10g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25 %) @ 0.5g/l at 45,60 and 90 DAS] followed by 8.32 q/ ha in T₃ [ST with Carbendazim 50 WP @2g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25%) @ 0.5g/l at 45,60 & 90 DAS]. However, lowest yield of 3.42 q/ha was noticed in T₁₀ (Untreated control).

Results of the present studywere in line with findings of Prasad *et al* (2022) reported that treatment involving Tebuconazole 50 %+ Trifloxystrobin 25 % @ 0.5 g/l resulted in least mean disease incidence (13.2 %) and highest mean yield (685 kg/ha) compared to (27.5 % and 343.9kg/ha) control against stem and root rot of sesame (*Macrophomina phaseolina*). In

addition, Geat *et al* (2023) found that the seed treatment with *Trichoderma viride* @ 10 g/kg, furrow application of enriched *Trichoderma* (2.5kg *Trichoderma viride* + 100 kg vermicompost) @ 250 kg/ha and spray of combi-product (Tebuconazole 50 % + Trifloxystrobin 25%) @ 0.5 g/l at 30-35 DAS and second spray at 50-60 DAS. This treatment resulted in the lowest disease incidence (13.66 %), with a maximum yield of 405kg/ha, compared to untreated control was 38.99 per cent of disease incidence and yield about 301 kg/ha.

CONCLUSION

Field experiments during *kharif* 2024 demonstrated that Soil application of *T.harzianum* enrichedwith Neem cake and FYM @1:20:250kg/ha + Seed treatment with *T.harzianum* @10g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25 %) @ 0.5g/l at 45,60 and 90 DAS

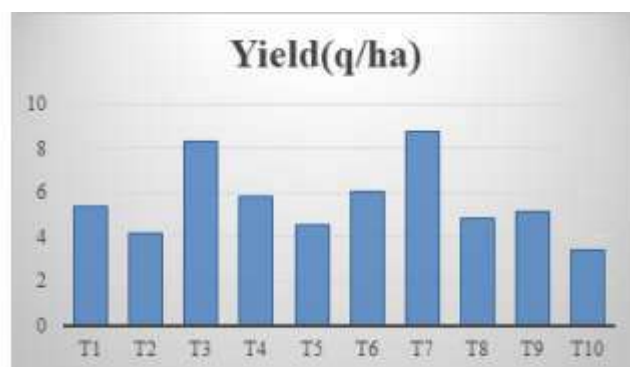
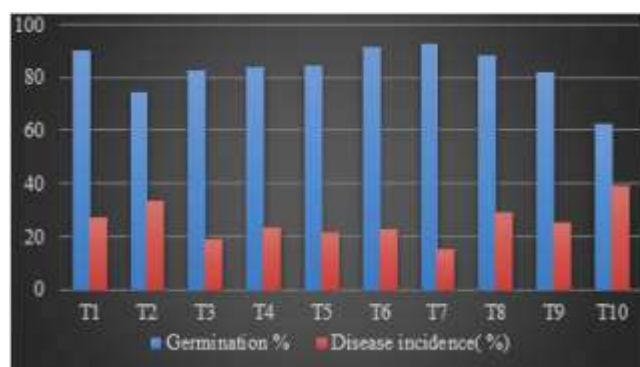


Fig. 1. Effect of different treatments on disease incidence and yield



Fig 1. Performance of crop under T₇ (Soil application of *T.harzianum* enriched with Neem cake and FYM @1:20:250kg/ha + ST with *T.harzianum* @10g/kg of seeds followed by spray of (Tebuconazole 50 % + Trifloxystrobin 25 %) @ 0.5g/l at 45,60 and 90 DAS)



Fig 2. Performance of crop under T₁₀ (Untreated control)

recorded least disease incidence of 14.94 per cent and highest yield of 8.74 q/ha. These studies collectively suggested that an integrated approach, involving the use of (Tebuconazole 50 % + Trifloxystrobin 25%) and *T. harzianum*, supplemented with organic amendments like FYM or vermicompost, offers a highly effective strategy for managing sesame diseases, leading to significant reductions in disease incidence and substantial increases in sesame yield.

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Management of Grape Downy Mildew under Field Conditions Using Fungitoxicants

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ABSTRACT

Downy mildew is destructive and yield limiting disease in grapes incited by a biotrophic fungi *Plasmopara viticola*. Owing to aggressive virulence in pathogen the development of resistance against the fungicides is early. To cater this need, efforts were made to evaluate newer fungicides against grape downy mildew during two seasons (*rabi/ summer* 2021-22 and 2022-23), at college of Horticulture, Bagalkot, Karnataka. Of the different treatments in both seasons the combi fungitoxicant, mandipropamid and zoxamide revealed lowest disease index (DI) of 13.02 per cent and 12.70 per cent with higher grape yield of 18.07 t/ha and 19.05 t/ha, respectively. Thus, this combi fungicide may be included in integrated downy mildew management schedule in grape cultivation.

Keywords: Disease, Fungitoxicants, Grapes, Mandipropamid + Zoxamide, *Plasmopara viticola*,

INTRODUCTION

In India, grape (*Vitis vinifera* L.) is commercially cultivated in Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu (Ramya and Subbarayappa, 2017). Grape production is hindered by numerous biotic stresses of which downy mildew disease is more detrimental and yield limiting. Downy mildew of grapes incited by biotrophic fungi *Plasmopara viticola*, is highly destructive disease under disease conducive environment it infects leaves, tender shoots, young flower buds, and berries leading to crop loss of 50-100 percent (Sawant and Sawant, 2010). Previously attempt was made to combat the disease through genetic resistance as the pathogen was so aggressive that resistance did not last for long time (Gessler *et al*, 2011). The management of grape downy mildew was heavily relied on usage of synthetic fungicides. Of which the copper compounds are indiscriminately used (Caffi *et al*, 2010) which has led to accumulation of heavy metals to the toxic level in the soil and environment. Further, the soil properties and micro-flora also affected which intern has adverse effect on grape production (Martinez *et al*, 2012). Additionally, the fungicides employed to curb the disease in field have narrow mode of action against the oomycetes *P. viticola* which resulted in low efficacy within short time due to resistance deployment in

pathogen (Toffolatti *et al*, 2024) which necessitates the need of alternate chemicals to manage this deadly disease in field. Hence, the present study was conducted to evaluate different fungitoxicants under field conditions for sustainable management of grape downy mildew throughout the grape growing season.

MATERIALS AND METHODS

Experimental location and growth conditions

The field trials were conducted at College of Horticulture, Bagalkot (Karnataka) for assessing the bio-efficacy of fungitoxicants against of grape downy mildew for two consecutive seasons (*rabi/ summer* 2021-22 and 2022-23). The experimental plot soil was sandy loam and susceptible grape hybrid was raised as per the package of practice of University of Horticultural Sciences, Bagalkot (Karnataka).

Treatment

The experiment was carried out in randomized block design (RBD) which consisted of five treatments and in each treatment, four replications were maintained. In each treatment two foliar sprays of fungitoxicants were imposed at 15 days' gap and the first spray was taken up on-set of disease in grape. The details of treatment were as T₁- foliar application of Mandipropamid 25% w/w + Zoxamide 24% w/w WG

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Table 1: Details of fungitoxicants used.

Common name	Product name	Supplier	Dosage (%)	Mode of action	FRAC code
Mandipropamid 25% w/w + Zoxamide 24% w/w WG	Miravis duo	Syngenta	0.05	Cell wall biosynthesis of fungi and tubulin polymerization or cyto skeleton and motor protein	H5 B3
Mandipropamid 23.4 % w/w(25% w/v) SC	Revus	Syngenta	0.30	Cell wall biosynthesis of fungi	H5
Zoxamide 240 SC	Zoxium®	Avima	0.10	Tubulin polymerization or cyto skeleton and motor protein	B3
Cymoxanil 8% + Mancozeb 64% WP	Curzate	Corteva	0.30	Multi-site contact activity	- -
Fluopicolide 4.44% + Fosetyl Aluminium 66.67%WG	Profiler®	Bayer	0.30	Delocalisation of spectrin -like proteins and host plant defence induction	B 5 P-07

Table 2: Effect of fungitoxicants on grape downy mildew under field conditions.

Treatments	Dosage	Disease Index (%) at 10 days after different sprays		
		Pre spray	I spray	II spray
I season (<i>rabi/ summer</i> 2021-22)				
Mandipropamid + Zoxamide	0.5 ml	1.47 (6.97)	9.96 (18.39)	13.02 (21.16)
Mandipropamid	0.8 ml	1.54 (7.13)	13.19 (21.31)	22.71 (28.47)
Zoxamide	0.6 g	1.74 (7.58)	14.52 (22.41)	24.62 (29.76)
Cymoxanil + Mancozeb	4 g	1.39 (6.77)	15.44 (23.13)	26.69 (31.12)
Fluopicolide + Fosetyl Aluminium	2.5 g	1.74 (7.58)	12.67 (20.86)	22.89 (28.60)
Control	-	1.32 (6.60)	24.12 (29.42)	75.44 (60.32)
S.Em±	-	0.237	0.625	1.208
CD (0.05)	-	NS	1.875	2.288
II season (<i>rabi/ summer</i> 2022-23)				
Mandipropamid + Zoxamide	0.5 ml	1.51 (7.06)	8.62 (17.08)	12.70 (20.89)
Mandipropamid	0.8 ml	1.07 (5.94)	14.24 (22.18)	22.11 (28.06)
Zoxamide	0.6 g	1.61 (7.29)	15.44 (23.15)	24.15 (29.45)
Cymoxanil + Mancozeb	4 g	1.33 (6.63)	16.10 (23.67)	26.05 (30.71)
Fluopicolide + Fosetyl Aluminium	2.5 g	1.47 (6.97)	13.37 (21.46)	22.78 (28.52)
Control	-	1.22 (6.34)	31.91 (34.41)	79.33 (62.99)
S.Em±	-	0.211	0.686	0.605
CD (0.05)	-	NS	2.057	3.085

@ 0.5 ml/l; T₂ - Mandipropamid 23.4 % w/w (25% w/v) SC @ 0.8ml/l; T₃ - Zoxamide 240 SC @ 0.6 g/l; T₄ - Cymoxanil 8% + Mancozeb 64% WP @ 4g/l; T₅ - Fluopicolide 4.44% + Fosetyl Aluminium 66.67%WG @ 2.5g/l; T₆ - Control.

Disease assessment of grape downy mildew

The downy mildew disease severity in each treatment was recorded prior to initiation of experiment

and after ten days of each spray. The disease severity was assessed by using 0-4 severity scale (Horsfall and Barrate, 1986) (0 – no disease; 1 – up to 25 % infected leaf area; 2 – 26 to 50 infected leaf area; 3 - 51 to 75 infected leaf area; 4 - >75 % infected leaf area). The % disease index (PDI) was calculated by using the formula, Disease index (%) = [Sum of all individual ratings/ (number of plants examined x maximum grade in score)] x 100 (Vincent, 1947).

Management of Grape Downy Mildew under Field Conditions Using Fungitoxicants

Table 3: Effect of fungitoxicants on grape berry yield during *rabi/ summer* 2021-22 and 2022-23

Treatments	Dosage	Yield (t/ha)		Increase in yield over control (%)	
		2021-22	2022-23	2021-22	2022-23
Mandipropamid + Zoxamide	0.5 ml	18.07	19.05	82.97	83.99
Mandipropamid	0.8 ml	14.67	15.27	70.29	72.13
Zoxamide	0.6 gm	14.13	15.56	67.79	69.56
Cymoxanil + Mancozeb	4 g	15.21	16.85	65.08	67.16
Fluopicolide + Fosetyl Aluminium	2.5 g	15.47	16.48	70.05	71.28
Control	-	10.84	11.10	-	-
SE.m. $\pm$		0.773	0.714	-	-
CD (0.05)		2.321	2.137	-	-

Table 4: Phytotoxicity assessment of fungitoxicant spray on grape

Treatments	Phytotoxicity observations						
	Leaf injury on tips	Stunting	Necrosis	Chlorosis	Vein clearing	Wilting	Epিনasty/ Hyponasty
I season (<i>rabi/ summer</i> 2021-22)							
Mandipropamid + Zoxamide	-	-	-	-	-	-	-
Mandipropamid	-	-	-	-	-	-	-
Zoxamide	-	-	-	-	-	-	-
Cymoxanil + Mancozeb	-	-	-	-	-	-	-
Fluopicolide + Fosetyl Aluminium	-	-	-	-	-	-	-
II season (<i>rabi/ summer</i> 2022-23)							
Mandipropamid + Zoxamide	-	-	-	-	-	-	-
Mandipropamid	-	-	-	-	-	-	-
Zoxamide	-	-	-	-	-	-	-
Cymoxanil + Mancozeb	-	-	-	-	-	-	-
Fluopicolide + Fosetyl Aluminium	-	-	-	-	-	-	-

- No phytotoxicity

Phytotoxicity assessment of fungitoxicants spray and yield

Observations of phytotoxicity evaluation were recorded by visual observations for phytotoxicity symptoms *viz.*, leaf injury on tips/ surface, necrosis, stunting, chlorosis, vein clearing, wilting, epinasty and hyponasty at 1, 3, 5, 7 and 10 days after each spray following 0-10 scale, where: 0 = no phytotoxicity, 1 = 1-10%, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = 51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100% (Kabade, 2022).Yield of grapes was recorded plot wise at each harvest and pooled data of all pickings have been presented in terms of t/ha.

RESULTS AND DISCUSSION

Grape downy mildew caused by biotrophic fungi *Plasmopara viticola*, is highly destructive and yield limiting disease under conducive environment and capable of inducing 50 to 100 percent crop loss to the growers (Sawant and Sawant, 2010). The genetic resistance in grape cultivars failed to curb the downy mildew menace due to aggressive virulence of the pathogen (Gessler *et al*, 2011) which made the synthetic fungicides the principle means of disease control in filed (Caffi *et al*, 2010). The narrow mode of action of the fungicides employed to curb the disease in field resulted in low efficacy within short time due to

resistance deployment in pathogen (Toffolatti *et al*, 2024) indicating the need of alternate chemicals for sustainable management of this deadly disease in field. Hence, the present study conducted to evaluate different fungitoxicants under field conditions for sustainable management of grape downy mildew throughout the grape growing season.

Mandipropamid + Zoxamide, a combi fungitoxicant resulted lowest disease index (DI) at the end of the experiment in both seasons (*rabi/ summer* 2021-22 and 2022-23) recording 13.02 per cent and 12.70 per cent of DI in first and second season, respectively (Table 2) and resulted higher grape yield of 18.07 t/ha and 19.05 t/ha in first and second season, respectively against control recording 10.84 t/ha and 11.10 t/ha. Consequently, increasing the per cent yield as 82.97 per cent and 83.99 per cent in first and second season, respectively at terminal stage of the field experiment (Table 3). Further, Fluopicolide + Fosetyl Aluminium was the next best with respect to enhanced disease severity and improved yield for two foliar sprays of fungitoxicants imposed at 15 days' gap. Similarly, the individual fungitoxicants (Mandipropamid and zoxamide) were capable to arrest the disease severity in field in both the seasons but, they performed better in combination. None of the fungicides exhibited any visible phytotoxicity symptoms at their recommended dosage in both the seasons (Table 4). The higher efficacy of Mandipropamid + Zoxamide in managing the grape downy mildew was well documented by early researchers (Massi *et al*, 2020; Dolzhenko *et al*, 2021). Similarly, the higher efficacy of Fluopicolide + Fosetyl Aluminium are in line with findings of Mohapatra *et al* (2011) and Kiran *et al* (2022).

The highest bio-efficacy of fungitoxicant, Mandipropamid + Zoxamide in grape downy mildew management is due to its unique mode of action against fungus. Gradual ingress of Mandipropamid (CAA-Carboxylic acid amides group) into plant tissues inhibits phospholipid biosynthesis in pathogen cell wall and protects the lower surface of leaves which provides for anti-sporulation and curative effect. Further, Zoxamide (benzamide group) having protective action which interfere and inhibit β -tubulin protein assembly thereby prevents normal mitotic cell division in plant fungal pathogens (Dolzhenko *et al*, 2021).

CONCLUSION

Based on the research highlights, combi fungitoxicant Mandipropamid and Zoxamide can be

designated as protective fungitoxicants which interferes in fungal respiratory functions and mitigates the financial strains on farmers by minimizing the need for multiple fungitoxicant applications throughout the grape growing season against pathogens of the oomycetes class and peronosporomycetes.

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New Generation Combination Fungicide Famoxadone 16.6 % + Cymoxanil 22.1 % SC for the Management of Tomato Late Blight

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ABSTRACT

The tomato late blight incited by *Phytophthora infestans* is yield limiting disease in tomato which is threatening global food security leading to sudden disease outbreaks and severe crop losses due to distinct evolutionary nature of pathogen. The genetic resistance in host and conventional fungicides resulted in limited management of this disease. Hence, the efforts were made to evaluate newer fungicides against late blight in field conditions for two successive seasons i.e., *kharif* 2019 and *kharif* 2020. Of the various fungicides, the combination fungicide, Famoxadone 16.6 % + Cymoxanil 22.1 % – 38.7 SC @ 1.0 ml/l resulted in least disease severity of 11.06 per cent and 10.68 per cent during first and second season respectively. The Azoxystrobin 8.3 % + Mancozeb 66.7 %, 75 WG @ 3g/l noted with 12.35 per cent and 11.68 per cent of disease severity in first and second season respectively. Consequently, Azoxystrobin 23 % SC @ 1 ml/l exhibited 19.55 per cent and 18.11 per cent of disease severity in first and second season respectively. Hence, the targeted approach ensures that new fungicide molecules with higher efficacy and safer residue levels are effective at managing tomato late blight disease outbreaks, reducing overall fungicides use and costs and improving tomato farming.

Keywords: Disease severity, Fungicides, Late blight, *Phytophthora infestans*, Tomato.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) has 0.81 million hectares area under tomato cultivation with 21.17 million tonnes annual production and productivity of 25.32 Mt (Raiola *et al*, 2014). Tomato late blight incited by *Phytophthora infestans* is a destructive disease of tomato which leads to 78 per cent crop loss in congenial environmental conditions. In field upon occurrence of late blight, the signs and symptoms first appear on leaves leading to necrosis which reduces the chlorophyll content and affect the yield. Eventually symptoms spread to branches, main stem and fruits leading to complete crop loss. The causal organism is primarily air borne and to some extent it acts as soil inhabiting. Further, the disease is prevalent round the year, occurs at all crop stages and characteristically induces severe necrosis of leaf, stem, blossom leading to qualitative and quantitative loss in particular it infects fruits up to 30 per cent. (Panthee *et al*, 2024; Khan *et al*, 2024).

The genetic resistance is vital approach to combat the disease in field but due to the aggressive and diverse virulence nature of *P. infestans* resistance in the varieties is broken within a decade. Further, the fungicides (contact, systemic and translaminar) applied to manage the disease in field resulted in low efficacy due to resistance deployment in pathogen against them. Indicating the necessity of regular evaluation of newer fungicides to curb the disease under field conditions (Lal *et al*, 2018). Hence, the present study was carried out to identify the newer fungicide molecules with higher efficacy and safer residue levels in crop for disease management under field conditions are needed to the utmost level.

MATERIALS AND METHODS

Collection of *Phytophthora infestans* culture

The culture of *Phytophthora infestans*, a pathogen causing late blight of tomato was taken from Plant Pathology department, UHS, Bagalkot for *in-vitro* studies.

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In vitro* evaluation of fungicides against *P. infestans

Four fungicides were obtained from local market and details of them are given in Table 1. The fungicides were evaluated under *in vitro* for their inhibitory potential against pathogen at their recommended dosage through poisoned food technique using PDA medium and the plate without fungicide served as the control. The experiment was carried out in completely randomized design (CRD) with three replications for each fungicide and the whole process was repeated thrice. The mycelia growth inhibition of pathogen was noted as per the formula, $I = C - T / C \times 100$, where, I is inhibition of pathogen mycelial growth (%); C= radial mycelial growth in control; T = radial mycelial growth in treatment (Vincent, 1927).

In vivo* evaluation of fungicides against tomato late blight*Experimental location and growth conditions**

For assessing the bio-efficacy of fungicides against tomato late blight, the field trials were conducted at ICAR – Krishi Vigyan Kendra, Kolar (Karnataka) for two consecutive seasons (*kharif* 2019 and *kharif* 2020). The experimental plot soil was sandy loam and susceptible tomato hybrid was raised as per the package of practice of University of Horticultural Sciences, Bagalkot (Karnataka).

Treatments

The experiment was conducted using randomized block design (RBD) which consisted of five treatments and in each treatment, four replications were maintained. In each treatment two foliar sprays of fungicides were imposed at 15 days' gap and the first spray was taken up on-set of disease in tomato. The details of treatment were as T₁- foliar application of Famoxadone 16.6 % + Cymoxanil 22.1 % – 38.7 SC @ 1.0 ml/l; T₂ - Azoxystrobin 8.3 % + Mancozeb 66.7 % - 75 WG @ 3g/l; T₃- Azoxystrobin 23 % SC @ 1 ml/l; T₄ - Mancozeb 75 WP @ 3g/l; T₅ – Control.

Disease assessment

Twenty-five plants of each replicate were marked for observations. The late blight severity in each treatment was recorded prior to initiation of experiment and after ten days of each spray. The disease severity was assessed by using 0-5 severity scale, where 0 - No symptoms on the leaf; 1 – up to 11 % infected leaf area covered with spot, no spot on petiole and branches; 2 –12 to 38 % infected leaf area

covered with spot, few spots on petiole; 3 –39 to 61 % infected leaf area covered with spot, spots on petiole and branches; 4 –62 to 88 % infected leaf area covered with spot, spots on petiole, branches and stem; 5 – >89 % infected leaf area covered with spot, spots on petiole, branch, stem and fruits (Sandeep *et al*, 2022). The % disease index (PDI) was computed using the formula, Disease index (%) = [Sum of all individual ratings/ (total no. of plants examined x maximum score)] x 100 (Vincent, 1947).

Phytotoxicity assessment of fungicides spray and yield recording

Observations of phytotoxicity evaluation were recorded by visual observations for phytotoxicity symptoms *viz.*, leaf injury on tips/ surface, necrosis, stunting, chlorosis, vein clearing, wilting, epinasty and hyponasty at 1, 3, 5, 7 and 10 days after each spray following 0-10 scale, where: 0 = no phytotoxicity, 1 = 1-10%, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = 51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100%. Yield of tomato fruit was recorded plot wise at each harvest and pooled data of all pickings have been presented in terms of t/ha (Kabade, 2022).

RESULTS AND DISCUSSION

Late blight caused by *Phytophthora infestans*, heterothallic fungi with A1 and A2 mating types able to cause up to 78 per cent yield loss under conducive environment is the devastating in tomato production causing severe necrosis of leaf, stem and fruit tissue under favourable field environmental conditions. The level of genetic resistance in tomato to combat the disease is relatively limited (Panthee *et al*, 2024) and hence conventional fungicides are the major means of management of late blight in the field (Saha *et al*, 2017). Thus, the new fungicide molecules with higher efficacy and safer residue levels in tomato to combat the late blight under field conditions are need of the hour. With this need in the present study newer fungicide molecules are evaluated under *in vitro* and field conations against tomato late blight.

Effect of fungicides on growth of *P. infestans* under *in vitro*

The glance of literature indicated usage of different fungicides for the management of tomato late blight. With these information different fungicides (contact, systemic and combi) were tested against *P. infestans* under *in vitro*. The complete arrest of mycelial growth was seen in combi fungicide, Famoxadone + Cymoxanil and next best was

New Generation Combination Fungicide Famoxadone 16.6 % + Cymoxanil 22.1 % SC

Table 1: Details of fungicides used.

Common name	Product name	Supplier	Dosage (%)	Mode of action	FRAC code
Famoxadone 16.6 % + Cymoxanil 22.1 % SC	Equation pro 38.7 SC	Corteva	0.10	QoI and Multi -site contact activity	11 27
Azoxystrobin 8.3 %+ Mancozeb 66.7 % WG	Avancer Glow 75 WG	UPL	0.30	QoI inhibition and Multi-site contact activity	11 M 03
Azoxystrobin 23% SC	Amistar 23 SC	Syngenta	0.10	QoI inhibition	11
Mancozeb 75 WP	M-45 75 WP	Indofil	0.30	Multi-site contact activity	M 03

Table 2: Evaluation of fungicides against *Phytophthora infestans* under *in vitro*.

Fungicide	Concentration (%)	Mycelial growth (cm)	Mycelial growth inhibition (%)
Famoxadone + Cymoxanil	0.05	0.00	*100.00 (90.00)
Azoxystrobin + Mancozeb	0.30	0.35	96.11 (78.63)
Azoxystrobin 23% SC	0.10	1.67	81.44 (64.48)
Mancozeb 75 WP	0.30	4.45	50.56 (45.32)
Control	-	9.00	0.00 (0.00)
S.Em±	-	0.07	0.81
CD (0.05)	-	0.21	2.44

*Mean of three replications, and figures in the parenthesis are arcsine transformed values

Table 3: Bio-efficacy of fungicide spray on severity of late blight disease of tomato under field conditions.

Treatment	Dosage	Disease Index (%) at 10 days after different sprays		
		Pre - spray	I spray	II spray
I season (<i>Kharif</i> 2019)				
Famaxadone + Cymoxanil	1.0 ml	7.00 (15.34)*	9.88 (18.32)	11.06 (19.42)
Azoxystrobin+Mancozeb	3.0 gm	6.38 (14.63)	9.26 (17.72)	12.35 (20.57)
Azoxystrobin	1.0 ml	7.00 (15.34)	15.64 (23.30)	19.55 (26.25)
Mancozeb	3.0 gm	6.38 (14.63)	23.25 (28.84)	33.13 (35.16)
Control	-	7.00 (15.34)	37.16 (37.56)	58.84 (47.78)
S.em±	-	0.73	0.49	0.36
Cd (0.05)	-	Ns	1.51	1.08
II season (<i>Kharif</i> 2020)				
Famaxadone + Cymoxanil	1.0 ml	6.58 (14.87)	7.87 (16.30)	10.85 (19.24)
Azoxystrobin+Mancozeb	3.0 gm	5.97 (14.14)	8.49 (16.94)	11.68 (19.99)
Azoxystrobin	1.0 ml	6.69 (14.99)	14.09 (22.05)	18.11 (25.19)
Mancozeb	3.0 gm	5.97 (14.14)	21.40 (27.56)	30.97 (33.83)
Control	-	6.58 (14.87)	34.79 (36.14)	69.91 (56.73)
S.Em±	-	0.48	0.32	0.37
CD (0.05)	-	NS	0.82	0.94

*Figures in the parenthesis are arcsine transformed values NS – Non significant

Table 4: Effect of fungicide spray on yield of tomato.

Treatment	Yield (t/ha)		Cost: Benefit Ratio (Rs.)	
	<i>Kharif 2019</i>	<i>Kharif 2020</i>	<i>Kharif 2019</i>	<i>Kharif 2020</i>
Famaxadone + Cymoxanil	51.25	45.83	1:2.72	1:2.43
Azoxystrobin + Mancozeb	64.79	59.58	1:3.42	1:3.14
Azoxystrobin	64.17	59.17	1:3.36	1:3.10
Mancozeb	43.33	37.08	1:2.28	1:1.95
Control	18.54	14.38	1:1.01	1:0.78
S.Em ±	0.958	0.376	-	-
CD (0.05)	2.39	0.94	-	-

Table 5: Phytotoxicity assessment of fungicide spray on tomato.

Treatment	Phytotoxicity observations						
	Leaf injury on tips	Stunting	Necrosis	Chlorosis	Vein clearing	Wilting	Epinasty/Hyponasty
I season (<i>Kharif 2019</i>)							
Famaxadone + Cymoxanil	-	-	-	-	-	-	-
Azoxystrobin + Mancozeb	-	-	-	-	-	-	-
Azoxystrobin	-	-	-	-	-	-	-
Mancozeb	-	-	-	-	-	-	-
Control	-	-	-	-	-	-	-
II season (<i>Kharif 2020</i>)							
Famaxadone + Cymoxanil	-	-	-	-	-	-	-
Azoxystrobin+Mancozeb	-	-	-	-	-	-	-
Azoxystrobin	-	-	-	-	-	-	-
Mancozeb	-	-	-	-	-	-	-
Control	-	-	-	-	-	-	-

- No phytotoxicity

Azoxystrobin + Mancozeb with 96.11 per cent mycelial inhibition (Table 2). Further, Azoxystrobin exhibited 81.44 per cent mycelial inhibition and least effect was seen with Mancozeb 75 WP @ 3g/l. The complete cessation of mycelial growth of *P. infestans* by Famoxadone + Cymoxanil (oxazolidinedione + cyanoacteamide-oxime group of fungicide) was evidenced by early workers under *in vitro* (Saha *et al*, 2017; Lal *et al*, 2018). Mere on *in vitro* studies the efficacy cannot be confirmed, as the evaluation is done under controlled environment wherein the only pathogen directly interacts with the test fungicide. Further, the test fungicide is not exposed to numerous field factor like variations in temperature, relative humidity and dilution factors (rain and irrigation) *etc.* Thus, to validate the efficacy, the fungicides were further evaluated under field conditions.

Field screening of fungicides against tomato late blight

In the field condition the combi fungicide, Famoxadone + Cymoxanil resulted in lowest disease index (DI) at the end of the experiment in both the seasons (*kharif 2019* and *kharif 2020*) documenting 9.88 per cent and 11.06 per cent of DI in first and second season, respectively (Table 3). It was also noticed the least increase in severity of disease from beginning till end of the experiment evidencing higher effect of fungicide on pathogen. The same fungicide was noted with higher tomato yield of 51.25 t/ha and 45.83 t/ha in first and second season, respectively as against control recording 18.54 t/ha and 14.38 t/ha. Consequently, higher the cost-benefit ratio was also recorded in the same fungicide (Table 4). Further, combi fungicide Azoxystrobin + Mancozeb was noted

New Generation Combination Fungicide Famoxadone 16.6 % + Cymoxanil 22.1 % SC

to be next best with respect to enhanced disease control and improved yield which can be employed in management of disease if more than two sprays needed. Interestingly, the individual component fungicides (Azoxystrobin and Mancozeb) were capable to arrest the disease menace in field in both the seasons but, they performed better in combination. None of the fungicides exhibited any visible phytotoxicity symptoms at their recommended dosage in both the seasons (Table 5). The higher efficacy of famoxadone + cymoxanil in managing the late blight of tomato was well documented by early researchers (Saha *et al*, 2017; Lal *et al*, 2018, Supriya *et al*, 2020; Hegde, 2022). Similarly, the higher efficacy of Azoxystrobin in managing the late blight of tomato are in line with findings of Amin *et al* (2013) and Supriya *et al* (2020).

The possible mechanism for higher efficacy Famoxadone against the pathogen is due to its oxazolidinedione group of fungicide belonging to the quinol inhibitor family-QoI (quinol oxidation site of Complex III), which inhibits the mitochondrial respiration of fungi by decreased production of ATP in pathogen there by suppressing the growth and multiplication of the fungi. Similarly, the Cymoxanil is absorbed by the whole plant due to its degrading compound, cyanoacteamide-oxime to glycine within 16-44 h, disrupting the metabolic processes of fungal pathogens, effectively halting their growth and development Comparing to the individual fungicides, the combination proved more effective and reason would be synergetic effect of both oxazolidinedione + cyanoacteamide-oxime groups (NCBI, 2025).

CONCLUSION

The present study highlights the higher bio efficacy of Famoxadone + Cymoxanil, due to its broad-spectrum management adhering to best practices and safety guidelines, while promoting sustainable and environmentally responsible agricultural practices in the pursuit of higher yields and healthier harvests against tomato late blight and hence it may be employed in management of the same under field condition and optimizing resource utilization and mitigating the financial strains on farmers by minimizing the need for multiple fungicide applications throughout the growing season.

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Optimized Approach for Managing Post-Parturient Uterine Prolapse in Non-descript Goats

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ABSTRACT

This paper presents two post-partum total uterine prolapse in 3 and 4 years old pluriparous non-descript goats and its successful management. On gross examination, the uterine mass was found to be hyperemic, swollen, and soiled with intact fetal membranes in Patient 1 and without fetal membranes in Patient 2. Both cases were presented within 8 hours after parturition. Administered epidural anaesthesia using 2% lignocaine, the prolapsed uterine mass was washed with potassium permanganate solution, hypertonic salt solution (to reduce the edema) and the prolapsed uterus was repositioned back into the pelvic cavity. The vulval retention sutures were placed to avoid reoccurrence. Broad spectrum antibiotics (Amoxycillin-cloxacillin), anti-inflammatory, antihistamines, calcium borogluconate, supplements and supportive fluid therapy were administered for five days. The vulval sutures were removed after 7 days and the patients recovered uneventfully.

Keywords: Goat, Non-descript, Post-partum, Repositioning, Suture, Uterine Prolapse.

INTRODUCTION

Prolapse of uterus, otherwise called as casting of wethers or casting of the calf bed is a usual complicity of the third stage of parturition in animals and it needs immediate attention (Noakes *et al*, 2001). Casting of wethers is the eversion of the post parturient gravid horn in which the uterus turns inside out as it passes through the vagina and hangs below or up to the level of hock. This condition is common in cow and ewe than doe, sow, mare, queen and bitch (Oh and Shin, 2017). The etiology of the uterine prolapse in small ruminants is obscure but various factors contribute to the occurrence of this condition. They are hypocalcemia, excessive traction to relieve dystocia or retained fetal membranes, absence of uterine tone, extreme relaxation of the pelvic and perineal regions, intense straining caused by pain after parturition, increased intra-abdominal pressure due to bloat, lack of exercise and exorbitant estrogen levels in feed/fodder (Senthilkumar, 2014; Oh and Shin, 2017). However, prepartum vaginal prolapse is not a predisposing factor for the postpartum uterine prolapsed (Youngquist and Threlfall, 2007).

Casting of the calf bed usually occurs immediately after parturition or few hours after

parturition when cervix is dilated with absence of uterine tone (Robking, 2012). Prolapse of uterus after 24 hrs is extremely rare and even if it occurs, it is difficult to replace / sometimes unfeasible because of the partially closed cervix (Fubini and Ducharme, 2006). If the prolapse occurs immediately after the parturition, uterus will be warm to touch and looks normal. With the passage of time, uterus becomes cold, edematous, congested and after several hours uterus may become ischemic and necrotic. In some cases, animal may progress into the state of hypovolemic shock due to internal blood loss or tears/lacerations in the prolapsed uterus (Senthilkumar, 2014). The prognosis depends upon duration of the condition and degree of damage in the prolapsed uterus. The prognosis is good if the condition is treated within one or two hours of occurrence.

The small ruminants affected by the prolapse of uterus usually conceive again and the reoccurrence of this condition in subsequent parturition is exception rather than the rule. In very delayed cases, when the degree of damage/ contamination is excessive, prognosis is poor; in such cases amputation of the uterus is an option (Noakes *et al*, 2001). The present paper reports two cases of post partum uterine prolapse in Non-descript goats and its successful management.

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Table 1: History and Vital Parameters of the Patients.

Patient	Weight	Age	Parity	Body Temperature	Pulse	Respiratory rate	Time of presentation
Patient 1	22 Kg	4 years	3	102.7 °F	82/ minute	20/ minute	4 hours
Patient 2	25 Kg	3 years	2	102.4 °F	85/ minute	19/ minute	7 hours

CASE HISTORY AND CLINICAL EXAMINATION

A total of two cases of post-partum uterine prolapse in pluriparous does were presented to Veterinary Dispensary, Mukkudal, Tirunelveli, Tamil Nadu. Both the does were thoroughly examined and all vital parameters were found to be normal (Table 1). On further examination, the uterine mass was found to be hyperemic, swollen, soiled, with intact fetal membranes in Patient 1 and without fetal membranes in Patient 2. But both the whole uterus was fresh without any wounds or damages. The uterine masses were hanging up to the level of hock joint.

TREATMENT

Two ml of 2% lignocaine was administered epidurally to both the goats to reduce the straining. The prolapsed uterus was washed with washed with 1:1000 potassium permanganate solutions gently to remove all the debris, faeces and then the intact fetal membranes were removed manually from the caruncles in Patient 1. Then the uterine masses were washed with hypertonic salt solution to reduce the edema and again washed with 1:1000 potassium permanganate solutions. The uteruses were lubricated liberally with cetrimide cream and with the help of another assistant the uteruses were elevated up to the level of the vulva and held high. The hind quarter of the does were also raised. By everting the vulval lips, the uterine masses were replaced by manual pushing with gentle manipulations to avoid uterine tear or haemorrhages. Proper replacement of the uterine mass was ascertained by introducing hand into the uterus and vulval retention sutures were applied to prevent reoccurrence.

Each doe was treated with 100 ml of 5 per cent Dextrose injection and 100 ml Ringer's lactate intravenously, Inj. Amoxicillin Cloxacillin @ 20mg/Kg (I/V), Inj. Oxytocin - 10 IU (I/V), Inj. Calcium borogluconate - 75 ml (slow I/V), Inj. Tetanus toxoid 0.5ml (I/M), Inj. Chlorpheniramine maleate @ 0.5mg/Kg (I/M), Inj. Meloxicam @ 0.5mg/Kg (I/M) and 2 ml B complex (I/M). The treatment with antibiotic, antihistamine and analgesic was continued

for five days, the vulval retention suture was removed after seven days and the animals recovered uneventfully.

RESULTS AND DISCUSSION

The uterine prolapse usually occurs during the third stage of labor when the fetus was expelled and fetal membranes get separated from maternal caruncles. In small ruminants, prolapse of both the post gravid uterine horns are possible (Jackson, 1995). Sometimes the intestines or bladder may get strangulated inside the everted uterus, in such cases careful replacement should be carried out. But in the present two cases, only prolapse of the uterus was observed. One of the most important complications observed in uterine prolapsed cases was toxemia, which was due to the soiled uterus. Hence, proper gentle cleaning of the prolapsed mass with antiseptic solution is mandatory to avoid such complications. But aggressive cleaning procedures to remove dirt/contaminants adhering to the endometrium may facilitate the systemic absorption of toxic contaminants (Scott and Gessert, 1998).

The duration, degree of damage and contamination are the crucial components associated with the prognosis of the animal. In the present two cases, mild uterine damages and contamination of the uterus was observed as the owner covered the prolapsed mass with clean cloth which aided in decreased occurrence of complications. In addition, both the does were presented within 8 hours which resulted in easy management of the condition. Unattended uterine prolapse cases for a longer time may hinder the blood supply to the uterus resulting in congestion, edema, necrosis and gangrene, thus resulting in poor prognosis (Kapadiya *et al*, 2015). Similar cases of uterine prolapse in goats were reported by many authors (Selvaraju *et al*, 2010, Manokaran *et al*, 2011, Senthilkumar, 2014, Oh and Shin, 2017, Nair *et al*, 2019, Bharti and Singh, 2020 and Krishnaveni and Kumar, 2024). In case of milder uterine damages, the future fertility of the goats will not be affected as in this case report.

Optimized Approach for Managing Post-Parturient Uterine Prolapse

Patient 1:



Patient 2:



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Physiological Characteristics of *Colletotrichum gloeosporioides*: The Causal Agent of Arecanut Leaf Spot

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ABSTRACT

The experiment aimed to study the physiological characteristics of the *Colletotrichum gloeosporioides* at College of Horticulture Bagalkot, Karnataka, India. During 2024, the pathogen was cultured in 40 ml of potato dextrose broth and its dry mycelial growth was recorded over 20 days at two-day intervals. The highest mycelial growth was recorded on the 12th day after incubation (DAI) with a dry weight of 284.7 mg, followed by the 10th day with 246.3 mg. The study also examined the pH effect on mycelial growth. The pathogen exhibited the highest dry mycelial growth at pH 6, with a weight of 362.3 mg, followed by pH 7, which showed a mycelial weight of 314.7 mg. The least mycelial growth was recorded at pH 10, with a weight of 176 mg. Temperature also played a crucial role in the growth of *C. gloeosporioides*. The optimal temperature for the growth of *C. gloeosporioides* exhibited the highest mycelial growth at 25°C, reaching 290.5 mg. The next most favourable temperature was 30°C, where the growth measured 214.3 mg. There was no growth observed at 40°C and 45°C. Therefore, the temperature range of 25 to 30°C was considered optimal for the growth of pathogen. The maximum growth (88.3 mm) under alternate cycles of 12 hours of darkness and 12 hours of light, with excellent sporulation. It can be concluded that *Colletotrichum gloeosporioides* exhibits its highest growth potential at pH 6, 25°C and under alternate cycles of 12 hours of darkness and 12 hours of light.

Keywords: Growth, Light, pH, Physiology, Temperature

INTRODUCTION

Arecanut (*Areca catechu* L.) is a monocotyledonous palm belonging to the family Arecaceae with a chromosome number of 2n=32. It is widely grown in subtropical and tropical regions of Asia and East Africa. Arecanut is vulnerable due to recent outbreak of arecanut leaf spot which affect the production and productivity. The leaf spot disease was caused by *Colletotrichum gloeosporioides*. Fungal growth is significantly influenced by factors such as light, substrate pH and temperature. These environmental conditions play a crucial role in regulating fungal growth, sporulation and various other biological activities. The production of spores, which is vital for fungal dissemination and subsequent infection, is also strongly affected by environmental factors. These conditions determine whether a species will sporulate and at what rate it will multiply (Eicher and Ludwig, 2002). Understanding the physiological

requirements of plant pathogens is essential for developing effective control strategies (Jaruhar and Prasad, 2011). In this context, the present study focuses on examining the effects of physiological factors on the vegetative growth and sporulation of *Colletotrichum gloeosporioides*.

MATERIALS AND METHODS

Studies on the growth phase of pathogen

The 40 ml of potato dextrose broth (PDB) was prepared in 100 ml conical flasks and autoclaved. A 5 mm mycelial bit from a pure 12 day old culture was inoculated into each flask after cooling. The flasks were then incubated at 27±1°C. Starting from the day of inoculation, three flasks were harvested every two days until the 20th day. The mycelial mat was collected by filtering through filter paper (Whatman no.1). which, along with the mycelium, was dried at 60 °C and then weighed.

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Table 1. Growth phase of isolated pathogens on potato dextrose broth *Colletotrichum gloeosporioides*

Sr. No.	Days after incubation	Mycelial dry weight in mg (Mean)
1	02	89.3
2	04	137.9
3	06	206.5
4	08	213.7
5	10	246.3
6	12	284.7
7	14	263.7
8	16	254.1
9	18	238.9
10	20	229.1
	S. Em $\pm$	2.60
	CD (P=0.01)	10.48

Effect of different temperatures on the growth of pathogen

To investigate effect of different level of temperatures on pathogen growth, six different temperatures 15 °C, 20 °C, 25 °C, 30 °C, 35 °C, 40 °C and 45 °C were used. A total of 40 ml of PDB was prepared in 100 ml flasks, sterilized by autoclaving and inoculated with a 5 mm disc of fungus from a 12-day-old culture. The inoculated conical flasks were incubated at the selected temperatures, with the replicates (3) for each condition. After 12 days of incubation, the dried mycelium weight was measured, and the data were analysed statistically.

Effect of hydrogen ion concentration (pH) on the growth of pathogen

To study the pH effect on the growth of pathogen, seven different pH levels were selected: 4, 5, 6, 7, 8, 9 and 10. The pH of the PDB was adjusted using 0.1N NaOH or 0.1N HCl. Potato dextrose broth served as the basal medium and autoclaved. A 5 mm culture bit of the pathogen was inoculated into 40 ml of PDB, which had been autoclaved. Three replicates were maintained for each pH level. The dry mycelial weight of the pathogen was measured, and the data were analyzed statistically.

Effect of light on the growth and sporulation of pathogen

The effect of light and darkness on growth of the pathogen and sporulation were studied on PDA media by exposing the pure culture to continuous dark, continuous light and alternating with 12 hours of light and 12 hours of darkness. The inoculation of culture to PDA containing Petri dishes were done with seven replications per treatment. The plates were incubated at

27 $\pm$ 1 °C. Observation on mycelium diameter and sporulation were recorded.

RESULTS AND DISCUSSION**Studies on the growth phase of pathogen**

The growth of *Colletotrichum gloeosporioides* varied significantly depending on the day of mycelial harvest (Table 1). The highest dry mycelial growth was recorded on the 12th day after incubation with a dry weight of 284.7 mg, followed by the 10th day with 246.3 mg. In contrast, the lowest dry mycelial weight of 89.3 mg was observed after just two days of incubation. Afterwards, the growth of mycelium decreased with an increased number of days. Similarly, Tejashwini (2023) got a higher dry mycelial weight of pathogen (337.2 mg) on the 12th day of inoculation on PDB.

Effect of different temperatures on the growth of pathogen

Th data (Table 2) regarding the effect of temperature on growth of pathogens. *Colletotrichum gloeosporioides* exhibited the highest mycelial growth at 25°C, reaching 290.5 mg. The next most favourable temperature was 30°C, where the growth measured 214.3 mg followed by 173.7 mg at 35°C and 169.1 mg at 20°C. There was no growth observed at 40°C and 45°C. Therefore, the temperature range of 25 to 30°C is considered optimal for the growth of *C. gloeosporioides*. These findings are similar with Kommula *et al* (2017), who obtained the maximum mycelial growth of *Colletotrichum capsici* (72.4 mm) at 25°C. On the other hand, Dev and Somasekhara (2018) reported higher mycelial weight of *C. gloeosporioides* at 30°C, followed by 25°C.

Physiological Characteristics of *Colletotrichum gloeosporioides*: The Causal Agent

Table 2. Effect of temperature on growth of pathogen *Colletotrichum gloeosporioides*

Sr. No.	Temperature(°C)	Mean mycelial dry weight (mg)
1	15	99.0
2	20	169.1
3	25	290.5
4	30	214.3
5	35	173.7
6	40	0.00
7	45	0.00
	S. Em ±	2.93
	CD (P=0.01)	8.88

Effect of hydrogen ion concentration (pH) on the growth of pathogen

Colletotrichum gloeosporioides exhibited the highest dry mycelial growth at pH 6, with a weight of 362.33 mg, followed by pH 7, which showed a mycelial weight of 314.7 mg (Table 3). The least mycelial growth was recorded at pH 10, with a weight of 176 mg and pH 8 at 250.7 mg. It indicated that acidic media is preferred by the fungus for its growth. Sharma and Kulshreshta (2015), Chaudhari *et al* (2017) and Dev and Somasekhara (2018) also reported the maximum growth of *C. gloeosporioides* at pH 6.0. However, Kumara and Rawal (2008) obtained the maximum weight at pH 5.

Effect of light on the growth and sporulation of pathogen

The effect of light and darkness on the growth of *C. gloeosporioides* was examined. After 10 days of incubation, *C. gloeosporioides* exhibited the maximum growth (88.29 mm) under alternating cycles of 12 hours of light and 12 hours of darkness, with excellent (++++) sporulation. This was followed by growth under continuous light (77.29 mm) and continuous darkness (64.57 mm), which showed moderate (++) and good (+++) sporulation, respectively. This agrees with the findings of Dev and Somasekhara (2018) recorded the maximum radial growth of *C. gloeosporioides* (85.60 mm) for 12 hrs light and 12 hrs dark compared to the continuous light (61.3 mm) and continuous dark (54.3 mm) exposure. Similar findings were also recorded by Kamanna (1996), Alexander *et al* (2004) and Tejaswini (2023) on *C. gloeosporioides*. (Table 4)

CONCLUSION

The study concluded that pH, temperature and light conditions significantly influence the mycelial

Table 3. Effect of pH on growth of pathogen *Colletotrichum gloeosporioides*

Sr. No.	pH	Mean mycelial dry weight (mg)
1	04	196.1
2	05	210.3
3	06	362.3
4	07	314.7
5	08	250.7
6	09	212.7
7	10	176.0
	S. Em ±	5.50
	CD (P=0.01)	16.66

growth of *Colletotrichum gloeosporioides*. The pathogen exhibited the maximum dry mycelial growth at pH 6 followed by pH 7. Temperature played a crucial role, with optimal growth observed at 25°C, followed by 30°C. No growth was observed at 40°C and 45°C, indicating that the ideal temperature range for the pathogen is between 25°C and 30°C. Light conditions also influenced growth, with the highest mycelial growth and excellent sporulation occurring under alternating 12-hour light and dark cycles. This was followed by continuous light and continuous darkness which exhibited moderate to good sporulation. These findings highlight the optimal environmental factors that regulate the growth and development of *C. gloeosporioides* under *in vitro* condition.

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Table 4. Effect of light on the growth and sporulation of pathogen *Colletotrichum gloeosporioides*

Treatment	Mean diameter(mm)	Sporulation
Continuous light	77.29	+++
Continuous dark	64.57	++
12 hours light and 12 hours dark	88.29	++++
S. Em±	0.09	-
CD (P=0.01)	0.37	-

- No sporulation; + Poor (1-25 spores/microscopic field 400 X); ++ Moderate (25-50); +++ Good (50-75);
++++ Excellent (>75)

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Screening of Bitter Gourd (*Momordica charantia* L.) Germplasm against Downy Mildew under Field Conditions

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ABSTRACT

The present study was undertaken to screen various bitter gourd genotypes for resistance against downy mildew caused by *Pseudoperonospora cubensis* under natural field screening conditions. The experiment was laid out in a RCBD with two replications during the 2022–23 season evaluating 75 genetically diverse bitter gourd genotypes including commercial varieties and improved lines. None of the genotypes showed complete resistance to the pathogen. The percentage disease index (PDI) observed under natural conditions ranged between 23.98 to 86.77 per cent. The results indicated that the minimum percent disease index (PDI) of 23.98 per cent was recorded in genotype Green Long followed by 29.46 (IC470565), 34.22 (IC68335), 36.09 (PVIG-2) and 37.33 (IC467681) suggesting moderately resistant to downy mildew. The maximum PDI was recorded in the genotype Kashi Mayuri with 86.77 per cent followed by 86.14 (MC-3), 86.10 (Hirkani), 82.33 (UHSB-025) and 82.28 (IC113875) genotypes were found to be susceptible to downy mildew under field conditions. Thus, the identified bitter gourd genotypes can be used for further breeding programme for the development of new bitter gourd hybrids (or) varieties with downy mildew resistance.

Keywords: Bitter gourd, Downy mildew, PDI, *Pseudoperonospora cubensis*, Resistance

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is a tropical and subtropical vegetable crop belonging to the subfamily *Cucurbitoidae* of the family *Cucurbitaceae*, which comprises 125 genera and approximately 960 species. It is a monoecious and highly cross-pollinated crop, exhibiting a high degree of heterozygosity. Globally, the members of the *Cucurbitaceae* family are widely valued as food crops consumed either raw or cooked. The fruit is an excellent source of essential nutrients, including beta-carotene, vitamin C, folic acid, magnesium, phosphorus and potassium. Additionally, bioactive compounds extracted from bitter gourd seeds have been shown to inhibit the proliferation of human liver cancer cells and breast cancer cells (Adil *et al*, 2024).

Bitter gourd is vulnerable to several fungal diseases including powdery mildew, downy mildew, anthracnose, leaf spot, wilt and charcoal rot. Among these, downy mildew stands out as one of the most

serious foliar diseases. The disease is common in warm temperate and tropical climates and causes significant damage in regions such as North America, Europe and Asia. In India, downy mildew is widespread except in the high-altitude temperate zones of the Himalayas, with higher incidence observed in the northern parts of the country. The disease leads to considerable losses in several cucurbit crops including bitter gourd, sponge gourd, watermelon, cucumber, ridge gourd and muskmelon. It is also destructive particularly in bottle gourd, pumpkin and vegetable marrow. Downy mildew is most prevalent during the rainy season, flourishing in high humidity and moderately cool to warm temperatures ranging from 12°C to 27°C (Manjusha *et al*, 2017). Although it can survive during hot days, extended periods of hot and dry weather can significantly reduce its spread. Initial symptoms appear as pale green spots on the leaves, which gradually turn yellow. These lesions are typically angular to irregular in shape and are restricted by the leaf veins.

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Table 1. Disease scoring for downy mildew under natural conditions in bitter gourd.

Score	Symptoms
0	Leaf area without infection
1	1 % leaf area infected
2	10 % leaf area infected
3	25 % leaf area infected
4	50 % leaf area infected
5	More than 50 % leaf area infected

Yellow spots on the upper surfaces of leaves initially resemble an indefinite mosaic-like pattern. As these spots expand, the affected leaves begin to yellow uniformly, eventually leading to tissue death. The leaves then wither and die. During periods of high moisture, the lower surface of the infected leaves develops a downy mildew, varying in color from pale gray to purple and, in some cases, white to nearly black (Bommesh *et al*, 2018). Infected leaves generally wither and die but often remain upright, with their margins curling inward. The disease usually initiates in the leaves near the center of a plant hill or row and progressively spreads outward. This leads to defoliation, impaired fruit development and a significant reduction in yield. Under conditions of high humidity and frequent rainfall, the infection can become severe enough to destroy entire leaf veins, exacerbating the damage. Early onset of downy mildew can result in crop yield losses of up to 60% whereas late infections are comparatively less harmful (Prashanth *et al*, 2019). Given the significant impact of this disease, the role of the pathogen in disease development was a key focus of the present study.

MATERIALS AND METHODS

The screening of bitter gourd genotypes under natural field conditions was undertaken during the *Kharif* season of 2023 at the Vegetable Block, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India. A total of 75 genetically diverse genotypes were evaluated, sourced from the National Bureau of Plant Genetic Resources (NBPGR), New Delhi; Kerala Agricultural University (KAU), Thrissur; local collections; the Indian Institute of Vegetable Research (IIVR); along with several improved varieties. Assessment for resistance to downy mildew began one month after transplanting, with disease scoring conducted weekly over a period of seven weeks, continuing until the completion of the crop's growth cycle. The experiment was conducted in a RCBD with two replications for each genotype. The incidence of downy mildew was measured under natural condition with the help of the scoring system (Mayee and Datar, 1986) as per Table 1.

Disease incidence in the field was assessed by evaluating the severity of symptoms on five leaves each from the top, middle and basal portions of the plant, by using a 0–5 rating scale (Table 1). Based on the observed symptomatic leaf area, the Percent Disease Index (PDI) was calculated using the standard formula. Genotypes were classified into four categories according to their PDI values: resistant (0-20 %), moderately resistant (21-40 %), susceptible (41-60 %) and highly susceptible (>60 %). The percent diseases index (PDI) using the formula (Wheeler, 1969) was computed

RESULTS AND DISCUSSION

All seventy five bitter gourd genotypes were evaluated for resistance to downy mildew under natural field conditions during *Kharif* 2023. None of the genotypes exhibited complete resistance, indicating the considerable impact of downy mildew across the tested cultivars. However, the genotypes Green Long and IC-470565 demonstrated moderate resistance, with average PDI values of 23.98 and 29.46, respectively. A total of 34 genotypes were classified as susceptible, exhibiting PDI values between 41 and 60. The remaining genotypes, with PDI values exceeding 60, were categorized as highly susceptible to downy mildew (Table 2). Among them, some of the improved genotypes like Preethi, Kashi Pratishta and PVIG-2 were identified as susceptible, with a PDI values of 57.64, 47.95 and 42.50 respectively. The genotypes like Phule Green Gold, Kashi Mayuri, Pant Karela-1, Pant Karela-2, Hirkani and Katali Vaibhav resulted in highly susceptible to downy mildew with PDI values of 69.87, 86.77, 64.81, 71.78, 86.10 and 66.96, respectively.

The results indicated that among seventy five genotypes, only six genotypes categorized under moderately resistant (MR) cultivars against downy mildew. The minimum percent disease index (PDI) of 23.98 percent was recorded in genotype Green Long followed by 29.46 (IC470565), 34.22 (IC68335), 36.09 (PVIG-2), 37.33 (IC467681) and 39.66

Screening of Bitter Gourd (*Momordica charantia* L.) Germplasm against Downy Mildew

Table 2. Reaction of different bitter gourd genotypes for downy mildew under natural conditions.

Sr. No.	Genotype	Scoring	PDI
1.	IC-505630	1.20	23.98
2.	IC-418486	1.47	29.46
3.	IC68335	1.71	34.22
4.	IC505632	1.80	36.09
5.	IC-264770	1.87	37.33
6.	IC-68275	1.91	38.30
7.	IC541218	1.98	39.66
8.	IC505629	2.08	41.53
9.	IC-541218	2.09	41.85
10.	UHSBP-215	2.10	42.02
11.	IC-44413	2.11	42.17
12.	IC-505637	2.11	42.25
13.	IC-66023	2.18	43.69
14.	IC68232	2.19	43.85
15.	IC-470943	2.27	45.31
16.	IC-50524A	2.29	45.72
17.	IC-427694	2.29	45.83
18.	IC-44418	2.29	45.74
19.	IC-450520	2.31	46.21
20.	IC-505632	2.34	46.71
21.	IC-45351	2.36	47.23
22.	Kashi Pratishta	2.40	47.95
23.	IC-85603A	2.48	49.68
24.	IC427694	2.48	49.65
25.	IC264699 - 2	2.48	49.51
26.	TCR-332 IC 505639	2.51	50.13
27.	IC-68309	2.53	50.55
28.	TCR-75 IC50527	2.53	50.51
29.	IC-50527	2.54	50.73
30.	IC470550	2.69	53.76
31.	IC-505621	2.71	54.25
32.	Mrutyeeenjaya Green	2.71	54.22
33.	IC-398610	2.74	54.75
34.	IC-505639	2.80	56.08
35.	PVIG-2	2.83	56.67
36.	IC-85649	2.84	56.75
37.	Preethi	2.88	57.64
38.	IC68294	2.90	58.03
39.	IC68295	2.91	58.15

Sr. No.	Genotype	Scoring	PDI
40	IC-505623	2.93	58.50
41	IC-541429	2.95	58.96
42	IC-45350	3.05	60.93
43	IC505623	3.07	61.33
44	IC-622910	3.08	61.68
45	IC467681	3.08	61.68
46	IC-541435	3.14	62.71
47	IC-85634	3.17	63.30
48	IC-620908	3.23	64.55
49	IC-470556	3.24	64.84
50	Pant Karela 1	3.24	64.81
51	Ranebennur Local 2	3.25	65.01
52	IC-213307	3.26	65.26
53	TCR-505 IC622910	3.26	65.23
54	IC470943	3.28	65.51
55	IC-505629	3.30	66.00
56	IC-469512	3.32	66.45
57	Katali Vaibhav	3.35	66.96
58	Davanagere Local	3.42	68.36
59	Phule Green Gold	3.49	69.87
60	IC-470550	3.51	70.11
61	IC68294	3.51	70.19
62	Pant karela 2	3.59	71.78
63	MC-11	3.68	73.59
64	IC-599429	3.76	75.11
65	MC-10	3.76	75.22
66	IC450520	3.88	77.65
67	IC-622911	3.90	77.96
68	IC-470553	3.91	78.23
69	IC-505640	3.92	78.44
70	IC264699-3	4.00	80.07
71	IC-33275	4.11	82.28
72	UHSB-025	4.12	82.33
73	Hirkani	4.30	86.10
74	IC-44426	4.31	86.14
75	Kashi Mayuri	4.34	86.77

Screening of Bitter Gourd (*Momordica charantia* L.) Germplasm against Downy Mildew

(IC541218) were moderately resistant to downy mildew. The highest average PDI was observed in genotype Kashi Mayuri (86.77) followed by 86.14 (MC-3), 86.10 (Hirkani), 82.33 (UHSB-025) and 82.28 (IC113875) genotypes and were found to be susceptible to downy mildew under field conditions.

The findings were in agreement with those reported by Wairs *et al* (2014) who screened nineteen bitter gourd varieties for resistance to downy mildew. Among these, two varieties were classified as highly resistant, three as moderately resistant, thirteen as moderately susceptible and one variety (VNR-22) was identified as susceptible. Similarly, Pandey *et al* (2005) evaluated 148 bitter gourd germplasm lines for resistance against *Pseudoperonospora cubensis*. Of these, two lines exhibited moderate resistance and a high degree of tolerance, while seven cultivars were found to be moderately susceptible. The remaining lines were categorized as either susceptible or highly susceptible to the disease.

Thampi *et al* (2024) conducted a study on 22 genotypes of *Momordica charantia* and *Momordica charantia* var. *muricata*, screening them under natural field conditions for resistance to downy mildew caused by *Pseudoperonospora cubensis*. Six genotypes (three most resistant and three highly susceptible), including Priya, Preethi, Priyanka, MC-48, MC-49 and MC-50 were further evaluated during the monsoon season. None of the genotypes exhibited complete resistance to the pathogen. Genotypes MC-50 and MC-48 recorded the lowest PDI values of 11.04 % and 11.98 %, respectively and were classified as moderately resistant. On the other hand, Priyanka with a PDI of 85.22 % was categorized as susceptible. In a similar study, Bhutia *et al* (2005) screened 114 cucumber genotypes and found that ten were resistant, 18 moderately resistant, 37 moderately susceptible and 49 susceptible. Furthermore, studies by Criswell *et al* (2008) and Wan *et al* (2010) also identified resistant sources for downy mildew in cucumber.

CONCLUSION

Among the tested bitter gourd varieties, the genotypes Green Long, IC470565, IC68335, PVIG-2, IC467681 and IC541218 genotypes were moderately resistant to downy mildew under natural field conditions. The identified bitter gourd genotypes can be used for further breeding programme for the development of new bitter gourd hybrids (or) varieties with downy mildew resistance. However, further research is necessary to validate these findings with

artificial screening methods under different changing environmental conditions.

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Studies on Comparative Biology of Fruit Fly *Bactrocera caryeae* (Kapoor) in *Garcinia* spp.

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ABSTRACT

Kokum is an important underutilized crop native of the Western Ghats in India which is greatly affected by fruit flies which can cause significant damage to kokum fruits, impacting production and potentially affecting the livelihoods of farmers who rely on this crop. Hence, investigations were undertaken at the Department of Entomology, College of Horticulture, Sirsi, Uttara Kannada (Karnataka) during 2021 and 2022 to comprehend the biology of *Bactrocera caryeae* (Kapoor) on *Garcinia indica* and *Garcinia morella* under laboratory condition. The facts on comparative biology of *B. caryeae* on *G. indica* revealed the average egg period (1.57 and 1.65 d), larval period (11.15 and 11.47 d), pupal period (12.90 and 12.60 d), male longevity (19.90 and 18.85 d), female longevity (23.10 and 23.05 d), fecundity (183.50 and 182.3 eggs) and total life cycle (25.62 and 25.72 d) during 2021 and 2022. Similarly, in *G. morella* the average egg period (3.05 and 2.87 d), larval period (12.82 and 12.62 d), pupal period (11.85 and 11.85 d), male longevity (18.85 and 18.90 d), female longevity (21.65 and 21.25 d), fecundity (133.7 and 130.80 eggs) and total life cycle (27.72 and 27.35 d) during 2021 and 2022. The present study provided valuable insights into the comparative biology of *Bactrocera caryeae* on *Garcinia indica* and *Garcinia morella*, highlighting significant variations in developmental parameters and reproductive potential. These findings can aid in devising targeted management strategies to mitigate fruit fly infestation in kokum cultivation.

Keywords: *Bactrocera caryeae*, Comparative Biology, *Garcinia indica*, *Garcinia morella*.

INTRODUCTION

Garcinia indica Choisy, generally known as Kokum is an underappreciated crop that grows in the tropical evergreen rain forests of India's Western Ghats. It is also known as wild mangosteen, Goa butter tree, Brand, Anslil, Amsol (Konkani and Marathi), Murugalu (Kannada), and Punarpuli (Malayalam), is the most lucrative of the species known to exist in India (Nayak *et al.*, 2010). *G. indica* is incredibly popular as a spicy and medicinally valuable colorant. Roadsides, backyard wastelands, valleys, streams, and riverbanks are all home to kokum trees. (Karnik and Raorane, 2001). This crop is considered an underutilized and neglected crop but crucial to the means of support of millions of poor farmers across the globe. The total area in Karnataka is about 1200 ha with a yield of 8000 to 10000 t of dried rind per year (Ramachandran, 2014

and Laxminarayan, 2019). *Garcinia* spp. is rarely attacked by insect pests that seriously harm them. Among these, the Konkan region of Maharashtra was discovered to be infested by fruit fly *B. dorsalis*.

Tephritid fruit flies are major key pests in the world with the larval stages feeding on an array of fruits and vegetables. The fruit fly *B. dorsalis* (Hendel), first reported in Taiwan, is one of the most destructive pests of vegetable and fruits across globe, causing vast monetary losses (Wei *et al.*, 2017) and is a serious pest on a wide range of crops in the Indian subcontinent. It is endemic to Southeast Asia, also been introduced to numerous regions of the world and became threats to the wide range of cultivated and wild fruits (Drew and Raghu, 2002). *B. dorsalis* is reported to cause 100.0, 87.0, 78.0 and 61.0% fruit damage in rainy season on guava, mango, peach and pear respectively (Sharma *et*

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al, 2011). Numerous species complexes are existing in this family Tephritidae of which fruit fly, *Bactrocera dorsalis* (Hendel) species complex is of boundless importance. *Bactrocera caryeae* (Kapoor) is a member of this complex. Seven species of the complex are considered to be of economic importance with a wide host range and *B. caryeae* is one of them (Clarke *et al*, 2005). Therefore, the current investigation was carried out to study the comparative biology of *B. caryeae* (Kappor) on *G. indica* and *G. morella* under laboratory condition.

MATERIALS AND METHODS

Maintenance of culture of *Bactrocera caryeae* (Kapoor)

The initial culture of *B. caryeae* was raised by collecting infested fruits of Kokum from the orchards of various places in and around Sirsi, Uttara Kannada, during peak fruiting season in 2021 and 2022. The infested fruits were kept in a rearing cage on a thick layer of sieved moist sand (5 cm) to obtain the pupae. When full-grown maggots entered the sand for pupation, decayed fruits removed from the cages. Sand in the cages sieved after every 4-5 d to collect the pupae. Thereafter pupae were transferred in a clean plastic bottle individually. The bottles were covered with lids to prevent the escape of flies. Later banana fruits were used for maintaining the cultures of fruit flies, because of the *Garcinia* fruits are seasonal and its unavailability around the year. Hence it was used to maintain the fruit fly population. Adults were fed on mixture of milk powder, yeast and honey solution, later these flies were maintained up to 3-4 generations in the laboratory. The flies that emerged were utilized for further studies on life history (Jayanthi and Verghese, 2002).

Experimental details

Investigation was undertaken in the Department of Entomology, College of Horticulture, Sirsi, Uttara Kannada (Karnataka) during fruiting season 2021 and 2022 in the laboratory condition with three replications to comprehend the biology of *Bactrocera caryeae* (Kapoor) on *Garcinia indica* and *Garcinia morella*. A pair of male and female were obtained from parental pure culture, and fully ripened healthy fruits of *Garcinia indica* and *Garcinia Morella* fruits were provided individually for oviposition in the rearing cages. The *Garcinia* fruits were replaced after observing the oviposition puncture. The fruits punctured due to egg laying were cut open with a fine razor blade and eggs laid if any were confirmed using a

magnifying lens. The fruits having eggs were smoothly transferred in a separate petri dish and observed twice a day for their hatching. When eggs hatched out, the neonate maggots were gently transferred on a fresh fruit slice of *G. indica* and *G. morella* fruits, they were kept in a petri dish for further rearing. The food (fruit slices) as well as petri dishes were reformed every day to avoid microbial development on fruit slices. The maggots were reared following this methodology until they were fully grown and transferred along with a petri dish in a cage filled with a layer of 5 cm moist sand. Each petri dish was inspected and recorded the fecundity, incubation period, maggot period, pupal period, adult longevity, and total developmental period.

RESULTS AND DISCUSSION

Incubation period

The mean incubation period of 1.61 and 2.96 d was recorded in *G. indica* and *G. morella* respectively. The result indicated that the lower incubation period of *B. caryeae* was recorded in *G. indica* fruits followed by *G. morella*. Kalia (1992) reported impact of host varieties on egg period was 3.25, 3.00, 2.25 and 2.00 d, respectively on Dashehari, Amrapali, Mallika and Bangalora. Ashoka and Javaregowda (2019) reported that mean incubation period was significantly lowest on Alphonso (1.5 d) followed by Benishan fruits (1.6 d) than all other mango genotypes.

Larval (maggot) period

The data indicated that, the average larval period of 11.31 and 12.73 was recorded in *G. indica* and *G. morella* respectively. Thus, the study indicated that larva could complete its larval period earlier when fed on *G. indica* compared to *G. morella*. Kalia (1992) reported that studies on varietal differences revealed that the maggot period of *B. dorsalis* was 6.50, 6.00, 6.00 and 7.75 d, respectively on variety Dashehari, Amrapali, Mallika and Bangalora. Kalia and Srivastava (1992) also reported that the maggot period was 9.25, 9.00, 8.50 and 6.0 d on fruits of four, three, two and one week before maturity of Amrapali variety. However, it was 9.50, 9.0, 8.25 and 6.0 d on variety Mallika. Ashoka and Javaregowda (2019) reported the mean maggot period were significantly lowest on Benishan fruits (7.8 d) than all other mango genotypes

Pupal period

The mean pupal period 11.85 and 12.75 d was recorded in *G. indica* and *G. morella* respectively. The present study can be comparable with the result of

Table 1: Comparative biology of *B. caryeae* in *G. indica* and *G. morella*.

Stage	<i>G. indica</i>		Pooled mean	<i>G. morella</i>		Pooled mean
	2021	2022		2021	2022	
	Mean $\pm$ SE (Days)	Mean $\pm$ SE (Days)		Mean $\pm$ SE (Days)	Mean $\pm$ SE (Days)	
Incubation period	1.57 $\pm$ 0.11	1.65 $\pm$ 0.16	1.61 $\pm$ 0.12	3.05 $\pm$ 0.16	2.87 $\pm$ 0.17	2.96 $\pm$ 0.16
Maggot period	11.15 $\pm$ 0.27	11.47 $\pm$ 0.15	11.31 $\pm$ 0.18	12.82 $\pm$ 0.29	12.62 $\pm$ 0.27	12.73 $\pm$ 0.26
Pupal period	12.90 $\pm$ 0.23	12.60 $\pm$ 0.24	12.75 $\pm$ 0.20	11.85 $\pm$ 0.33	11.85 $\pm$ 0.24	11.85 $\pm$ 0.26
Male longevity	19.90 $\pm$ 0.38	18.85 $\pm$ 0.21	19.38 $\pm$ 0.21	18.85 $\pm$ 0.20	18.90 $\pm$ 0.19	18.88 $\pm$ 0.16
Female longevity	23.10 $\pm$ 0.53	23.05 $\pm$ 0.24	23.08 $\pm$ 0.30	21.65 $\pm$ 0.39	21.25 $\pm$ 0.40	21.45 $\pm$ 0.38
Total developmental period	25.62 $\pm$ 0.25	25.72 $\pm$ 0.34	25.68 $\pm$ 0.22	27.72 $\pm$ 0.58	27.35 $\pm$ 0.53	27.54 $\pm$ 0.52
Fecundity (No.)	183.50 $\pm$ 1.64	182.3 $\pm$ 1.22	182.90 $\pm$ 1.29	133.7 $\pm$ 0.97	130.8 $\pm$ 0.92	132.25 $\pm$ 0.90

Kalia (1992) when *B. dorsalis* was reared on different varieties of mango, the shortest period was noted on Mallika (7.5 d) followed by Amrapali (8.0 d), Bangalora (8.75 d) and Dashehari (9.0 d). Kalia and Srivastava (1992) reported the pupal period as 8 to 10.50 d on Amrapali and 7.50 to 10.75 d on Malika. Jiji *et al* (2006) also reported that pupal period of *B. dorsalis* was 10.50 and 12.75 d on variety Neelum and Bangalora respectively. Ashoka and Javaregowda (2019) also reported that the mean pupal period of *B. dorsalis* was maximum on Dasher (12.6 d) followed by Neelum (12.3 d) which was at par with each other

Fecundity

The egg laying capacity of gravid female with pooled mean of 182.90 and 132.25 eggs/female was recorded in *G. indica* and *G. morella* respectively. It is clear from the studies that the greater number of eggs were laid in *G. indica* fruit compared to the *G. morella* fruits. Thus, the higher fecundity in *G. indica* fruit indicated the preference of particular fruits. The total sugars were considered to be an essential component in insect nutrition and play a vital role in host selection by phytophagous insects. The *G. indica* fruits has low rind thickness and high T.S.S. compare to *G. morella*. Narayanan and Batra (1960) recorded on an average 50 eggs of *D. dorsalis*, but under favorable conditions they observed 150-200 eggs per female in a period of one month. Ashoka and Javaregowda (2019) reported highest fecundity were recorded on Benishan and Alphonso with 189.5 eggs and 187.4 eggs which were significantly more than other genotypes.

Adult longevity

The mean male longevity of 18.85 and 18.88 d was recorded in *G. indica* and *G. Morella* respectively. The mean female longevity of 23.10 and 21.45 d was recorded in *G. indica* and *G. morella* respectively. Thus, the study indicated that the *B. caryeae* females lived longer than male. The male and female could live longer when reared on *G. indica* compared to *G. morella*. The variations in adult longevity might be due to differences in nutritional ingredients present in the food. Jiji *et al* (2006) reported adult longevity of *B. dorsalis* in the variety Neelum and Bangalora was 16.50 and 20.30 d respectively. Ashoka and Javaregowda (2019) reported the maximum male adult longevity (20.6 d) was observed on Benishan tailed by the Alphonso (20.1 d).

Total developmental period

It is evident from the data, the average life cycle of 25.68 and 27.54 d was documented in *G. indica* and *G. morella* respectively. It is clear from the studies that, the shorter period taken to complete the whole life cycle of *B. caryeae* on *G. indica* revealed the preference by the pest. The present studies were confined with the life cycle of *B. dorsalis* took lesser duration on mango variety Mallika (15.75 d) followed by Amrapali (17.00 d), Bangalora (18.50 d) and Dashehari (18.75 d) (Kalia, 1992). Ashoka and Javaregowda (2019) reported the total progressive period from hatching of maggot to emergence of adults from pupa was significantly longer on Dasher (27.5 d) followed by Neelum (26.0 d).

CONCLUSION

In conclusion, biology of *B. caryae* (Kapoor) is important to know the feeding preference of *Garcinia* spp. based on the rate of fecundity on different *Garcinia* spp. that support to make efficient strategies to control this economic pest. Based on the resistant/susceptible category of *Garcinia* spp. can be used in the breeding programme which helps to propagate *Garcinia* spp. in the field.

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Surveillance for South American Tomato Leaf Miner *Tuta absoluta* Meyrick in Kolar and Chikkaballapur Districts of Karnataka

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ABSTRACT

Tuta absoluta Meyrick, commonly known as the South American tomato leaf miner (SATLM), has emerged as a highly destructive insect pest of potato (*Solanum tuberosum* L.) across the globe, including in India. Field studies were conducted against SATLM in two districts of Karnataka during Rabi 2019-20 to understand the extent of damage potato foliage. Mean percent infestation of SATLM and number of mined leaves per plant (4.47% and 8.31) in Kolar district and 2.51 percent with 2.95 mined leaves per plant was observed in Chikkaballapur district. Number of mines per plant was observed lowest (5.09) in Kolar and highest of 5.24 mines per plant was witnessed in Chikkaballapur district. The observed damage parameters showed no significant variation across the surveyed villages and taluks of the Kolar district whereas; it was significantly differed in percent SATLM incidence and all the damage parameters in Chikkaballapur district. In recent years, rising temperatures caused by climate change have led to an increase in the occurrence of SATLM, a trend expected to continue. As a result, developing control technologies and strengthening intensive monitoring will be essential to ensure stable potato production and maintain quality after harvest.

Keywords: Potato, South American tomato leaf miner, temperature, *Tuta absoluta*, Survey, Surveillance,

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a starchy tuberous crop native to the South Americas and a perennial member of the Solanaceae family. Ranked among the top four crops globally, it serves as a vital food source in developing countries, following rice, wheat, and maize (Douches *et al*, 2004). Potatoes are naturally fat-free and rich in proteins, vitamins, and minerals. However, significant post-harvest losses often occur during storage, particularly in developing regions where low-income farmers lack access to cold storage facilities. One of the major challenges farmers face today is the global spread of pests, especially as they intensify production to meet the rising demands of international markets. Among these pests, the South American tomato leaf miner (SATLM), *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae), stands out as a serious threat to potato crops worldwide. This oligophagous insect primarily feeds on solanaceous plants, including tomato, brinjal (eggplant), potato, and various related weeds.

The South American tomato leaf miner (SATLM) is considered the most economically damaging potato pest across Europe, Africa, western Asia, and South and Central America, capable of causing up to 100% yield losses if not properly managed. Even when infestations are less severe, they still lead to additional costs for postharvest inspections and financial losses due to unmarketable produce (Biondi *et al*, 2018). SATLM is also known by several other names, including South American tomato pinworm, tomato leaf miner, tomato pinworm, and South American tomato moth. To mitigate storage losses caused by this pest, farmers often rely heavily on broad-spectrum pesticide applications. However, there is growing concern about reducing pesticide dependency and the need to develop and integrate alternative pest management strategies. Temperature plays a crucial role in the survival and development of SATLM, which is why it predominantly inhabits warmer regions, thriving in subtropical and tropical climates. Hence, the present research was conducted with the objective to assess the extent of infestation and

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damage caused by *Tuta absoluta* on potato foliage in different regions of Karnataka to support effective monitoring and management strategies.

MATERIALS AND METHODS

The taluks chosen for the survey were selected based on their significance in potato cultivation. A total of 16 potato fields were surveyed across two taluks each in the Kolar and Chikkaballapur districts of Karnataka during 2019–20. The level of damage caused by SATLM was assessed by recording the percentage incidence. In each taluk, two villages were randomly selected, and within each village, two plots were randomly chosen. From each plot, 10 plants were randomly observed to assess pest infestation. Damage caused by SATLM was measured by recording the number of mined leaves, bored shoots, and damaged tubers.

Percent incidence was calculated by using the formula:

$$\text{Percent incidence} = \frac{\text{Number of plants infested}}{\text{Total number of plants observed}} \times 100$$

For observations on tuber moth at each location, one meter row was randomly selected at three different sites in the field and observed for number of shoots showing mining symptoms and later calculated the percent incidence.

Statistical analysis

All collected data were compiled and subjected to analysis of variance (ANOVA) following a Completely Randomized Block Design (CRBD) using OPSTAT software, with a 5% level of significance, applying necessary data transformations where required.

RESULTS AND DISCUSSION

SATLM infestation in Kolar district during *Rabi* 2019-20

The findings of the survey revealed that the percent mean foliage infestation by *Tuta absoluta* in Kolar district during *Rabi* 2019-20 differed significantly among villages (Table 1). It was lowest in Ekambahalli village (2.50%) with 2.67 mined leaves and 7.50 mines per plant. Infestation and number of mined leaves per plant was highest in Tamaka village (15.00% and 6.50 per plant) (both in Kolar taluk). Highest number of mines per plant (14.00) was recorded in Marakalaghatta village of Mulbagal taluk. But there was no statistical difference among the two taluks (Kolar, 7.97% and Mulbagal, 8.87%).

SATLM infestation in Chikkaballapur district during *Rabi* 2019-20

During *Rabi* 2019-20 in Chikkaballapur district, percent infestation, number of mined leaves per plant and number of mines per plant by *T. absoluta* was recorded lowest in Ullodu village of Gudibande taluk with no visible damage symptoms and the same was recorded highest highest in Gyadarahalli village of Gudibande taluk (16.66%, 12.50 and 16.00, respectively) (Table 2). Among the two taluks, potato foliage infestation by SATLM was least in Gudibande taluk (7.60%) and was highest in Chikkaballapur taluk (9.17%) which were significantly different from each other. At the same time, the number of mined leaves per plant was recorded lowest in Chikkaballapur taluk (5.67) and was significantly different from that in Gudibande taluk (6.37) (Table 2). Number of mines per plant was numerically more in Gudibande taluk (9.31) compared to Chikkaballapur taluk which did not differ statistically from each other. The present damage by SATLM to potato is supported by the findings of Kalleshwaraswamy *et al* (2015) who have reported 3.3 and 5.1 percent potato plants registered damage in Chikkamagaluru district during January and February months of 2015. The present incidence levels of SATLM on potato in Kolar and Chikkaballapur districts are relatively higher compared to earlier levels recorded in Chikkamagaluru district. Whereas cent percent potato plants were infested by SAPLM (South American potato leaf miner) with 30 percent mined and fed leaves at Huocheng, China (Zhang *et al*, 2020). Potato suffered economic loss in the absence of tomato in Turkey and has been recorded as a new host (Unlu, 2012). There are quite good number of laboratory studies indicating potato as a next best host to *T. absoluta* after tomato, followed by eggplant (Medigo *et al*, 2013; Vanitha, 2017; Satishchandra *et al*, 2019).

CONCLUSION

This was a clear indication that, in near future, the South American tomato leaf miner (SATLM), *Tuta absoluta* Meyrick may become a major pest of potato as a foliage feeder. Hence, warranting suitable mitigating measures on a sustainable and eco-friendly manner. The observed infestation levels in both Kolar and Chikkaballapur districts highlight its expanding geographic spread and potential to cause serious yield losses. With climate change contributing to increased pest occurrences, there is an urgent need to develop region-specific monitoring protocols and integrated pest management strategies. Proactive interventions will be crucial to safeguard potato cultivation and maintain post-harvest quality.

Surveillance for South American Tomato Leaf Miner *Tuta absoluta* Meyrick

Table 1: Extent of damage by South American tomato leaf miner, *T. absoluta* on potato leaves in Kolar district.

Taluka	Village	Percent infestation by leaf miner*		No. of mined leaves/plant**		No. of mines/plant**	
		Per village	Per taluk	Per village	Per taluk	Per village	Per taluk
Kolar	Gaddekannur	9.38 (17.83)	7.97 (16.39)	5.50 (2.60)	4.79 (2.44)	9.42 (3.12)	10.21 (3.45)
	Tamaka	15.00 (22.78)		6.50 (2.80)		11.20 (3.60)	
	Ekambahalli	2.50 (9.09)		2.67 (1.88)		7.50 (3.00)	
	Kumbarahalli	5.00 (12.92)		4.50 (2.37)		12.70 (3.81)	
Mulbagilu	Avani	7.90 (16.32)	8.87 (17.32)	6.00 (2.70)	4.31 (2.33)	13.45 (3.92)	12.18 (3.74)
	Marakalaghatta	12.42 (20.63)		4.00 (2.25)		14.00 (3.99)	
	Badamakanahalli	7.50 (15.89)		3.50 (2.12)		10.50 (3.49)	
	Mittahalli	7.64 (16.04)		3.75 (2.19)		10.75 (3.53)	
Mean		8.42		4.55		11.20	
S.Em(±)		0.47		0.37		0.37	
CD		1.37		NS		NS	

* Figures in parentheses are arcsine transformed data** Figures in parentheses are $\sqrt{x} \pm 0.25$ NS: Not significant

Table 2: Extent of damage by South American tomato leaf miner, *T. absoluta* on potato leaves in Chikkaballapur district.

Taluka	Village	Percent infestation by leaf miner*		No. of mined leaves/plant**		No. of mines/plant**	
		Per village	Per taluk	Per village	Per taluk	Per village	Per taluk
Chikkaballapur	Gowdanahalli	12.50 (20.70)	9.17 (17.62)	9.33 (3.30)	5.67 (2.63)	10.67 (3.52)	6.00 (2.70)
	Doddapyalagurki	13.33 (21.41)		11.33 (3.62)		11.00 (3.57)	
	Perasandra	5.83 (13.97)		1.00 (1.25)		1.33 (1.40)	
	Haristhala	5.00 (12.92)		1.00 (1.25)		1.00 (1.25)	
Gudibande	Someshwara	10.00 (18.43)	7.60 (16.00)	10.50 (3.49)	6.38 (2.78)	15.00 (4.12)	9.31 (3.30)
	Gyadarahalli	16.66 (24.08)		12.50 (3.79)		16.00 (4.25)	
	Channenehalli	3.75 (11.16)		2.50 (1.83)		6.25 (2.75)	
	Ullodu	0.00 (0.05)		0.00 (0.05)		0.00 (0.05)	
Mean		8.38		6.02		7.66	
S.Em(±)		0.27		0.25		0.38	
CD		0.79		0.74		1.11	

* Figures in parentheses are arcsine transformed data** Figures in parentheses are $\sqrt{x} \pm 0.25$ NS: Not significant

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Synergistic Effects of Gibberellic Acid and Brassinosteroids on Fruit Development, Yield and Quality in Kokum (*Garcinia indica*)

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ABSTRACT

Kokum (*Garcinia indica*) is an under utilized fruit crop native to the Sahyadri mountain range valued for its health benefits and applications in various industries. Despite its potential, Kokum cultivation faces challenges such as low yield and sub-optimal fruit quality. This investigation undertaken at Sahaja Farms, Kokada in the Uttara Kannada district during the 2022–2023 cultivation cycle explored the modulatory effects of gibberellic acid (GA₃) and brassinosteroids (BRs) on the qualitative and quantitative parameters of Kokum fruit. Employing a Randomized Block Design encompassing nine different treatments with triplicate replications, the study discerned that foliar administration of BR at 1 ppm synergized with GA₃ at 100 ppm (T₈) elicited remarkable augmentation in fruit biometrics in achieving a mass of 35.37 g, a length of 4.23 cm, a circumference of 12.60 cm, and an elevated productivity yield (42.60 kg/tree). Additionally, T₈ (BR @ 1 ppm + GA₃ @ 100 ppm) enhanced total soluble solids (15.65 °brix), titratable acidity (4.25 %), ascorbic acid content (9.96 mg/100 g), reducing sugar, non-reducing sugar and total sugar (5.98, 5.29 and 11.17 %) and anthocyanin content (2.37 g/100 g). The synergistic effects of BRs and GA₃ promoted cellular activities and biochemical efficiency, contributing to improved crop performance which highlighted the efficacy of BRs and GA₃ in enhancing Kokum cultivation outcomes.

Keywords: Kokum, Brassinosteroids, Gibberellic Acid, Yield, Quality.

INTRODUCTION

Kokum [*Garcinia indica* (Dupetit-Thouars) Choisy], a botanically intriguing yet under exploited fruit species, has recently garnered heightened scholarly and industrial interest owing to its myriad therapeutic virtues and multifaceted utility across gastronomic, pharmaceutical, and cosmetological domains. Taxonomically classified within the family Clusiaceae under the order Malpighiales, Kokum is indigenous to the biodiverse Sahyadri hill tracts of peninsular Western India (Mayura *et al*, 2014). Its natural provenance extends across the humid littoral and montane belts of southwestern India, including ecologically rich zones such as Wayanad in Kerala, Uttara Kannada, Udupi, and Dakshina Kannada in Karnataka, the basal terrains of the Nilgiris, as well as the Konkan seaboard of Maharashtra and Goa. Sporadic populations have also been documented in the sylvan landscapes of Assam, West Bengal, and the northeastern uplands (Chate *et al*, 2019).

Cytological investigations have revealed discrepancies in its somatic chromosome complement, with counts reported as either 2n = 54 (Krishnaswamy

and Raman, 1949) or 2n = 48 (Thombre, 1964). Morphologically, Kokum manifests as a lofty, evergreen, and long-lived arboreal species characterized by a monopodial axis of growth. Kokum is a languidly maturing arboreal species, distinguished by its elegant, svelte architecture, typically attaining a stature of up to 10 m, though certain mature individuals may ascend to an imposing 15 m. The tree exudes a yellowish, resinous sap. Following a juvenile latency of 7 to 8 years, Kokum enters its reproductive phase, typically flowering between November and February. Fruit maturation culminates from April to May (Parle and Dhamija, 2013). The drupe consists of three anatomical segments: the outer rind (pericarp), the fleshy mesocarp (pulp), and the enclosed seed. The pericarp is imbued with anthocyanin pigments having principally cyanidin-3-glucoside and cyanidin-3-sambubioside, which bestow the fruit's characteristic crimson hue. The anthocyanin concentration within the rind is estimated at approximately 2.4% (Nayak *et al*, 2010).

Kokum is predominantly localized within the Uttara Kannada district of Karnataka, comprising approximately 10–12% of the overall Kokum

population (Kureel *et al*, 2009). Trees bearing this yellow-fruited morphotype typically exhibit a more diminutive growth habit compared to their red-fruited counterparts. Kokum cultivation is beset with a multitude of constraints that adversely affect both yield and fruit quality. Prominent limitations include diminutive fruit dimensions, reduced mass, shortened length, diminished girth, suboptimal yield, and inferior biochemical characteristics namely, decreased total soluble solids (TSS), titratable acidity, sugar concentration, and ascorbic acid content. These physiological deficiencies are frequently attributed to endogenous hormonal imbalances, restricted mitotic activity, and insufficient cellular elongation. In this context, the synergistic foliar application of Gibberellic Acid (GA₃) and brassinosteroids has emerged as a promising agronomic intervention to ameliorate these impediments.

MATERIALS AND METHODS

Research studies were carried out on the Kokum crop (local cultivar) at Sahaja Farms, Kokada, Uttara Kannada district, during 2022–2023. The experiment employed a Randomized Block Design (RBD) to assess the influence of diverse foliar spray regimens, administered during the post-anthesis phase, on fruit morphometrics and quality attributes. The RBD included nine treatments, each replicated three times. Data analysis followed the methodology proposed by Panse and Sukhatme (1978), with a critical difference calculated at a 5% significance level. Statistical computations were performed using the IRRISTAT software package.

RESULTS AND DISCUSSION

The data (Table 1) illustrated the significant effects of foliar spray treatments on the fruit weight (g), fruit length (cm) and circumference (cm) and yield (kg/tree). The current study demonstrated that spraying BRs and GA₃ significantly enhanced the fruit weight of Kokum, with the T₈ treatment (BR @ 1 ppm + GA₃ @ 100 ppm) yielding the highest fruit weight of 35.37 g. Conversely, the lowest fruit weight of 23.59 g was observed in the T₀ treatment (control). The augmentation in fruit mass is plausibly ascribed to enhanced cellular elongation and the efficient translocation of assimilates toward the developing fruits, facilitated by the synergistic interplay between BRs and GA₃, as reported by Fujioka (1997). These findings align with previous studies by Engin *et al* (2016) on sweet cherries and Rajan *et al* (2017) on banana cv. Grand Naine.

The study revealed that spraying BRs and GA₃ significantly improved fruit length and circumference in Kokum, with T₈ treatment (BR @ 1 ppm + GA₃ @ 100 ppm) producing the highest values of 4.23 cm and 12.60 cm, respectively. In contrast, the lowest fruit length and circumference (2.75 cm and 10.71 cm) were recorded in the T₀ treatment (control). This improvement can be attributed to the synergistic effect of BRs and GA₃, promoting growth through enhanced RNA and DNA content and increased protein synthesis. These outcomes resonate with the empirical observations of Thorat *et al* (2018) in custard apple, Mostafa and Koth (2018) in sugar apple, IŞÇI (2019) in grapes and Khatoon *et al* (2021) in strawberries.

Similarly, the study observed a significant increase in fruit yield in Kokum under the T₈ treatment (BR @ 1 ppm + GA₃ @ 100 ppm), which recorded a maximum yield of 42.60 kg/tree. The T₀ treatment (control) showed the lowest yield at 31.82 kg/tree. This enhancement in yield can be linked to the beneficial effects of BRs and GA₃, which boost carboxylation efficiency, protein synthesis and the coordination of key biochemical and physiological processes in the Kokum plant. The present findings were in concordance with the observations documented by Pujari *et al* (2021) in custard apple and Rajan *et al* (2017) in banana cv. Grand Naine.

The data (Table 2) illustrated the significant effects of foliar spray treatments on the TSS (°Brix), titratable acidity (%), ascorbic acid content (mg/100 g), reducing sugars (%), non-reducing sugars (%), total sugars (%) and anthocyanin content. The study revealed that spraying BRs and GA₃ significantly improved the total soluble solids (TSS) in Kokum, with the highest TSS (15.65 °Brix) recorded in the T₈ treatment (BR @ 1 ppm + GA₃ @ 100 ppm). In contrast, the T₀ treatment (control) showed the lowest TSS (13.67 °Brix). This enhancement may be ascribed to the accelerated biochemical transformation of organic substrates such as starch and pectin into soluble solutes and simple sugars via enzymatic hydrolysis. These inferences were consonant with the empirical findings of Ghorbani *et al* (2017) in Thompson Seedless grapes, Mahorkar *et al* (2020) in custard apple and Sen *et al* (2023) in mango cv. Amrapali. Analogously, a marked diminution in titratable acidity was observed in Kokum fruits subjected to BR and GA₃.

Table 1: Influence of Brassinosteroids and GA₃ on fruit Development and yield parameters of Kokum.

Treatment	Fruit weight (g)	Fruit length (cm)	Fruit circumference (cm)	Yield (kg/tree)
T ₁ - BR @ 0.5 ppm	25.71	2.93	10.95	33.15
T ₂ - BR @ 1 ppm	27.09	3.12	11.18	34.48
T ₃ - GA ₃ @ 50 ppm	28.47	3.30	11.40	35.81
T ₄ - GA ₃ @ 100 ppm	29.85	3.49	11.64	37.14
T ₅ - BR @ 0.5 ppm + GA ₃ @ 50 ppm	33.99	4.04	12.20	38.47
T ₆ - BR @ 0.5 ppm + GA ₃ @ 100 ppm	31.23	3.67	11.87	39.93
T ₇ - BR @ 1 ppm + GA ₃ @ 50 ppm	32.61	3.86	12.14	40.72
T ₈ - BR @ 1 ppm + GA ₃ @ 100 ppm	35.37	4.23	12.60	42.60
T ₉ – Control	23.59	2.75	10.71	31.82
S. Ed	0.58	0.06	0.12	0.39
C.D (p=0.05)	1.17	0.13	0.25	0.80

Table 2: Influence of Brassinosteroids and GA₃ on fruit quality parameters of Kokum

Treatment	TSS (°B)	Titratable Acidity (%)	Ascorbic acid (mg/100g)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)	Anthocyanin content (g/100 g)
T ₁ - BR @ 0.5 ppm	13.92	3.89	8.60	4.70	3.87	8.98	1.95
T ₂ - BR @ 1 ppm	14.16	3.82	8.79	4.88	4.07	9.76	2.07
T ₃ - GA ₃ @ 50 ppm	14.39	3.75	8.98	5.06	4.26	9.24	2.01
T ₄ - GA ₃ @ 100 ppm	14.64	3.96	9.16	5.23	4.67	9.50	2.13
T ₅ - BR @ 0.5 ppm + GA ₃ @ 50 ppm	15.20	4.03	9.64	5.71	4.47	9.87	2.19
T ₆ - BR @ 0.5 ppm + GA ₃ @ 100 ppm	14.88	4.11	9.36	5.42	5.02	10.29	2.25
T ₇ - BR @ 1 ppm + GA ₃ @ 50 ppm	15.17	4.13	9.58	5.63	4.88	10.51	2.31
T ₈ - BR @ 1 ppm + GA ₃ @ 100 ppm	15.65	4.25	9.96	5.98	5.29	11.17	2.37
T ₉ – Control	13.67	3.67	8.41	4.52	3.66	8.19	1.89
S. Ed.	0.15	0.03	0.09	0.05	0.04	0.10	0.02
C.D (p=0.05)	0.32	0.08	0.20	0.11	0.09	0.21	0.05

applications. The titratable acidity (4.92) was recorded under the T₈ treatment, whereas the minimum acidity (3.67) emerged in the untreated control (T₉). This decline may plausibly be attributed to metabolic reconfigurations wherein organic acids are enzymatically converted into sugars and allied metabolites. These observations were in harmonious alignment with the findings reported by Thakur *et al* (2015) and Paikra *et al* (2018) in *Fragaria × ananassa*.

Moreover, the highest ascorbic acid content (9.96 mg/100 g) was discerned in the T₈ treatment, whereas the minimal level (8.41 mg/100 g) was observed in the control (T₉). This enhancement in

ascorbic acid content may be ascribed to sustained glucose biosynthesis during the fruit maturation phase, catalyzed by the physiological action of brassinosteroids and gibberellic acid. Comparable trends have been documented by Rajan *et al* (2017) in banana, Ali *et al* (2022) in strawberry, and Siddiqui *et al* (2018) in tomato. Furthermore, the highest ascorbic acid content (9.96 mg/100 g) was recorded in the T₈ treatment, while the lowest content (8.41 mg/100 g) was noted in the T₉ treatment. The improvement in ascorbic acid levels may be due to the continuous glucose synthesis during fruit development induced by BRs and GA₃. Similar observations were reported by

Rajan *et al* (2017) in banana, Ali *et al* (2022) in strawberry and Siddiqui *et al* (2018) in tomato.

The T₈ treatment also resulted in the highest levels of reducing sugars (5.98%), non-reducing sugars (5.29%) and total sugars (11.17%) in Kokum, compared to the control (T₀), which had reducing sugars at 4.52%, non-reducing sugars at 3.66% and total sugars at 8.19%. This enhancement can be attributed to the synergistic effect of BRs and GA₃, which promote efficient mobilization of photosynthates from source to sink. These results align with Mostafa and Koth (2018) in sugar apple and Zhang *et al* (2022) in *Musa acuminata* cv. Huangdi. T₈ treatment also resulted in the anthocyanin content (2.37 g/100 g), while the lowest content (1.89 g/100 g) was noted in the T₀ treatment. Exogenous application of gibberellic acid (GA₃) and brassinosteroids has been shown to augment anthocyanin accumulation in Kokum by upregulating pivotal enzymatic activities within the phenylpropanoid biosynthetic cascade most notably phenylalanine ammonia-lyase (PAL) and chalcone synthase (CHS). While GA₃ facilitates fruit morphogenesis and cellular expansion, brassinosteroids fortify stress resilience and amplify metabolic throughput, thereby synergistically enhancing anthocyanin biosynthesis and intensifying fruit chromaticity.

CONCLUSION

This study demonstrated the significant potential of gibberellic acid (GA₃) and brassinosteroids (BRs) in enhancing the growth, yield and quality of Kokum. The application of BR @ 1 ppm + GA₃ @ 100 ppm (T₈) proved to be highly effective, resulting in improved fruit weight, size, yield and overall fruit quality, including higher total soluble solids, titratable acidity, ascorbic acid content, sugar levels and anthocyanin content. These findings underscored the synergistic effects of BRs and GA₃, which promote cellular growth and biochemical efficiency in Kokum plants. The results offered valuable insights for improving Kokum cultivation, addressing challenges related to yield and fruit quality and enhancing its commercial and nutritional potential.

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Synergistic Effects of Gibberellic Acid and Brassinosteroids on Fruit Development, Yield and Quality

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TABLE OF CONTENTS

S.No.	Title	Page No.
1.	Analysis on Genotypic and Phenotypic Path Coefficients for Major Traits in Okra Germplasm. Udit Joshi, D K Rana, Yogesh Kumar, Arun Prakash and Kamlesh Kumar Yadav	1-9
2.	Awareness of Meat Safety and Quality among Red Meat Consumers in Kerala. Chethan G N and Senthilkumar R	10-16
3.	Bio-efficacy of Botanicals and Newer Insecticide Molecules against Red spider mite, <i>Tetranychus urticae</i> Koch (Tetranychidae: Acarina) in Jasmine, <i>Jasminum sambac</i> L. K Elanchezhyan, N Rajinimala, D Lenin Raja and K Harini	17-21
4.	Bio-efficacy of Cyantraniliprole against Fruit Borer (<i>Deudorix isocrates</i> Fab.) infesting Pomegranate. Suresh Kumar Jat, Lekha and Mahendra Choudhary	22-25
5.	Causes of Child Labour in Rural Punjab. Baljeet kaur, Shalini Sharma and Gaganpreet Kaur	26-31
6.	Chemical Weed Management in Blackgram for Enhancing Productivity. S Sreenivasulu, V Divya and T Ramu Kumar	32-34
7.	Classification of Tubewell Waters of Block Ellenabad of Sirsa District for Irrigation. D S Jakhar, Renu Devi, Ketan, Vinod Kumar and Satbir Singh	35-40
8.	Comparative Analysis of Junk Food Consumption Patterns among Adolescent Students in Assam. Mridusmita Borthakur and Sanjoy Borthakur	41-46
9.	Comparative Performance of Aseel, Kadaknath and Local Breed of poultry in Mayurbhanj district of Odisha Jhunilata Bhuyan	47-50
10.	Comparative Study of Antimicrobial Activities of <i>Ocimum</i> Sps. Against Pathogenic Microorganism Uma Sharma	51-56
11.	Comparison Between Vegetatively Propagated and Seedling Plants in African Marigold (<i>Tagetes erecta</i>) Hybrid. S. Amruta and M M Meera Manjusha	57-62
12.	Constraints Faced by Vegetable Growers in Chandel District Manipur. Hb Lungni Anal and Kangjam Sonamani Singh	63-67

S.No.	Title	Page No.
13.	Eco-Friendly Management of Sheath Blight Disease in Barnyard Millet (<i>Echinochloa crusgalli</i>) incited by <i>Rhizoctonia solani</i> Kuhn. Akanshu, Laxmi Rawat, Vivek Chauhan and Vijay Kumar	68-75
14.	Efficacy of Fungicides for Management of Sheath Blight (<i>Rhizoctonia solani</i>) of paddy. Ram Prakash Sharma and Neha kumari	76-79
15.	Enhancing Sex Ratio, Yield and its Attributing Traits with Exogenous Application of Phytohormones in Bottle Gourd (<i>Lagenaria siceraria</i> L.). Kamalpreet Singh, Navjot Singh Brar, Nirmal Singh, Manpreet Singh and Deepak Arora	80-87
16.	Evaluating Tendu (<i>Diospyros melanoxylon</i>) Leaves Production for Sustainable Livelihood of Tribal Communities in Jharkhand. Robin Kumar Ram, Firoz Ahmad, Sailesh Chattopadhyay, Jyotish Kumar Kerketta, Kushmita Dhan and Abhishek Kumar	88-92
17.	Factor Analysis of Consumer Preferences Towards Online Food Delivery Services. P Deepthi, K S Purnima, K Uma devi and A Manoj	93-98
18.	Growth Performance of Amur Carp 🐟 in Inland Water Resources of Kerala. Vikas P A and Shinoj Subramannian	99-102
19.	Impact of Weather Parameters on Thrips (<i>Scirtothrips dorsalis</i> Hood) in Pomegranate. P C Yadav, M L Tatarwal, Rohit Sarvate and Ashok Singh	103-107
20.	Investigating Bioactive Compounds from Medicinal Plants for Targeting Nonstructural Proteins of the Chikungunya Virus. Taruna and Anju Ahlawat	108-112
21.	In-vitro Analysis of Inhibitory Potential of Fungicides and Biocontrol Agents against Vascular Wilt Pathogen, <i>Fusarium oxysporum</i> f. sp. vasinfectum infecting Cotton in Western U.P. Rahul Kumar Sharma and Mujeebur Rahman Khan	113-118
22.	Low Cost Feed Formulation for Semi-Intensive Poultry Farming During Brooding Period. Monalisa Behera, Debasis Mishra and Sidhartha Sankar Behera	119-123
23.	Onion Variety Bhima Super Enhances Profitability of Onion (<i>Allium cepa</i>) Growers. Airadevi P Angadi, Sudha S and Archana B	124-129

S.No.	Title	Page No.
24.	Performance of Stionic Combination on Vegetative Growth and Flowering of Exotic Mandarin Germplasm Under Sub-Tropical Plains of Punjab Sukhdip Singh, J S Bal and Jatinder Singh	130-137
25.	Physico-chemical Analytic Comparison between Normal Compost, Swift Compost and PSN Compost at Lawngtlai district, Mizoram. Vanlalmalsawmi Sailo, C Lalfakawma and C Rualthankhuma	138-143
26.	Preferential Analysis on Occupation of the Tribals in Mayurbhanj District of Odisha. Jagannath Patra	144-149
27.	Purpose and Motive of Farmers Visiting Krishi Vigyan Kendra . G Sowjanya Roy, Balusu Gopichand , K Bhagyalakshmi, K Atchuta Raju D Chinnam Naidu, N Rajkumar and S Neelaveni.	150-153
28.	Resource Utilization and Economic Analysis of Cotton Farming in Northern India. Avaldeep Singh and Raj Kumar	154-162
29.	Socio-Economic Dynamics of Left-Behind Wives of Farmers Who Committed Suicide in Punjab. Priyanka Arora, Shalini Sharma and Gaganpreet Kaur	163-170
30.	Status and Screening of Brown Leaf Spot of Rice in Districts of Madhya Pradesh Mohit, Pramod Kumar Gupta ,A K Singh and Yogita Gharde	171-179
31.	Studies on Biology of Mulberry Silkworm (<i>Bombyx Mori</i> L.) Feeding on Mulberry. Khushwinder Singh, Baljinder Singh and Komaljot Kaur	180-184
32.	Transforming Okra (<i>Abelmoschus esculentus</i> L.) Waste in to Wealth: Empowering Farmers Through Sustainable Handicrafts. Kiran Pant and A K Sharma	185-191
<i>Short communication</i>		
33.	Management of Sheath Blight of Rice Using Microbial Formulations under in vivo Condition. Revendra Kushwaha, Pramod Kumar Gupta and Yogita Gharde	192-196

