October- December 2024 Vol. 12 Issue 4

ISSN 2319-6432 (Print)
ISSN 2349-4433 (Online)

NAAS RATING
4.95
w.e.f.
01.01.2024

JOURNAL OF KRISHI VIGYAN

A Quarterly Publication of Society of Krishi Vigyan

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Subscription fee:
Fee for 1 year-Rs. 1500/- and Life Membership (10 Year) Rs. 7500/-

Edited and published by: Dr. Manoj Sharma on behalf of Society of Krishi Vigyan at M/S Dewa Enterprises, Jabalpur, M P.

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ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 737-742

DOI : 10.5958/2349-4433.2024.00128.X

Agri-entrepreneur's Awareness on Government Schemes

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ABSTRACT

Agriculture plays a significant part in the Indian economy and therefore entrepreneurship in agriculture holds great potential for the development of the country. The study was done in Kottayam district in Kerala state. A purposive sampling technique was used. Entrepreneurs with more than three years' experience were selected. These entrepreneurs were grouped into four sectors, *i.e.,* value addition, fisheries, animal husbandry and other enterprises. For each group 100 respondents were identified. The data were collected through telephonic interview using a pre-structured interview schedule. Data analysis was done by SPSS 20.0. Descriptive statistics were used to describe and summarize the properties of the mass of data. To test the hypothesis that two attributes are associated or not, the Chi-square test for independence was applied. Out of the total 400 agri-entrepreneurs, majority of them (68%) were found to be self-reliant agri-entrepreneurs and the remaining (32%) belonged to government-reliant entrepreneurs. Nearly 94.1% of self-reliant agri-entrepreneurs and 71.9% of government-assisted agri-entrepreneurs were unaware of the schemes of assistance launched by Government of India. Agri-entrepreneurs' awareness about various schemes of assistance launched by the Government of India differs. There exists a difference in the opinion among the agri-entrepreneurs regarding the reasons for not availing the schemes launched by the government.

Key Words: Agri entrepreneurs, Awareness, Government Schemes, Red Tapism,

INTRODUCTION

Agriculture is an important sector in the global economy, generating Rs. 272.3 trillion in 2019 from agriculture, forestry, and fishing, providing employment for 874 million people in 2020 and totaling 27 percent of the global workforce. Entrepreneurship can be considered as the backbone of economic development and the level of economic growth of a region is greatly influenced by the level of entrepreneurial activities in that specific region. Government schemes, policies and laws have a significant influence on entrepreneurs. Peck *et al (*2018) found that regulation influences the behaviour of entrepreneurs. Bosma *et al (*2018) and Chowdhury *et al (*2019) found evidence for a positive association between entrepreneurship and government regulations and promotion programmes. Audretsch *et al (*2022) described the effect of government policies on opportunity entrepreneurs and necessity entrepreneurs. Opportunity entrepreneurs reduce spend and investments when government policy is non-conducive but are likely to invest in a business when government policy is conducive. Necessity entrepreneurs are forced out of the labour force and take up entrepreneurship under adverse economic conditions. However, Ipinnaiye *et al (*2017) noted that the studies were ambiguous on benefits of government support and entrepreneurial growth.

The agri-entrepreneurs of the district were classified into self-reliant agri-entrepreneurs and government-reliant agri-entrepreneurs. Self-reliant agri-entrepreneurs are entrepreneurs whose prime motive is the enterprise. A self-reliant entrepreneur starts and continues enterprise by their own volition. For such agri-entrepreneurs,

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Table 1. Distribution of respondents Self-reliant and Government reliant agri-entrepreneurs.

Type of Agri -entrepreneur	Frequency	Percent
Self-reliant	272	68
Government reliant	128	32
Total	400	100.0

Table 2. Agri-entrepreneurs' awareness about various schemes of assistance launched by the government of India

Parameter	Type of agri -entrepreneur				Total	
	Self-reliant		Government reliant			
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Aware	16	5.9	36	28.1	52	13.0
Unaware	256	94.1	92	71.9	348	87.0
Total	272	100.0	128	100.0	400	100.0

government assistance grants, subsidies and other schemes play a minor role. A self-reliant entrepreneur may accept assistance when and if they are available but such assistance is not significant to their decisions. Government-reliant entrepreneurs on the other hand are those whose prime motives are government subsidies, grants and schemes. For such entrepreneurs, government assistance, grants, subsidies and other schemes play a major role. The availability or the lack of grants, subsidies and schemes play a significant part in their decisions.

Considering these factors, the study was conducted with an objective to assess the agri-entrepreneurs' awareness with regard to various schemes of assistance launched by the Government of India and to analyse the various reasons for such unawareness towards the schemes launched by the Government of India.

MATERIALS AND METHODS

The study was done in Kottayam district in Kerala state as this district had high potential for agri-entrepreneurs. Purposive sampling technique was used and entrepreneurs with more than three years' experience were selected. These entrepreneurs were grouped into four sectors, *i.e.*, value addition, fisheries, animal husbandry and other enterprises including mushroom, floriculture and apiculture. For each group 100 respondents were identified. The study was done in two phases. A survey was conducted in Phase I to collect the data from the selected sample. In Phase II the data was analyzed and interpreted with the help of appropriate procedures and statistical techniques.

The information was collected through telephonic interview using a pre-structured interview schedule. Data analysis was done by SPSS 20.0. Descriptive statistics were used to describe and summarize the properties of the mass of data. To test the hypothesis that two attributes are associated or not, the Chi-square test for independence was applied.

RESULTS AND DISCUSSION

Classification of Agri-entrepreneurs into Self-reliant and Government reliant agri-entrepreneurs

The category-wise distribution of agri-entrepreneurs with regard to Self-reliant and Government reliant agri-entrepreneurs is presented in table 1.

Agri-entrepreneurs' awareness of various schemes of assistance launched by the government of India

The results revealed that 5.9% of self-reliant agri-entrepreneurs and 28.1% of government-assisted agri-entrepreneurs were aware about the various schemes of assistance launched by the Government of India for entrepreneurship development. 94.1per cent of

Table 3. Chi-Square Tests.

	Value	df	p value
Pearson Chi-Square	38.074	1	<0.001
Significant			

Table 4. Reasons for the unawareness of agri-entrepreneurs.

Sr. No	Reason	Type of Agri entrepreneur				Total	
		Self-reliant		Government reliant			
		Count	Percentage	Count	Percentage	Count	Percentage
1	Lack of information	40	15.6	20	21.7	60	17.2
2	Lack of interest	28	10.9	4	4.3	32	9.2
3	Lack of Time	84	32.8	28	30.4	112	32.2
4	Involves cost	12	4.7	4	4.3	16	4.6
5	Red Tapism	68	26.6	36	39.1	104	29.9
6	Non-co-operative officials	24	9.4	0	0.0	24	6.9
7	Total	256	100	92	100	348	100

self-reliant agri-entrepreneurs and 71.9per cent of government-assisted agri-entrepreneurs were unaware of the schemes of assistance launched by Government of India. This indicates that there exists a difference among the agri-entrepreneurs regarding the awareness of the various schemes of assistance launched by the government.

Analysis of the agri-entrepreneurs' awareness

For the analysis of agri-entrepreneurs' awareness about various schemes of assistance launched by the Government of India**,** the following hypotheses were formulated.

H_0: The agri-entrepreneurs' awareness of various schemes of assistance launched by the Government of India is the same.

H_1: The agri-entrepreneurs' awareness of various schemes of assistance launched by the Government of India differs.

To test the above hypothesis, we used the chi-square test of independence and the result is given in Table 3.

The outcome of the test indicated that the result was significant as the p value is less than 0.05. Therefore, H_0 was rejected and H_1 accepted. So, it was concluded that agri-entrepreneurs' awareness about various schemes of assistance launched by the Government of India differed significantly.

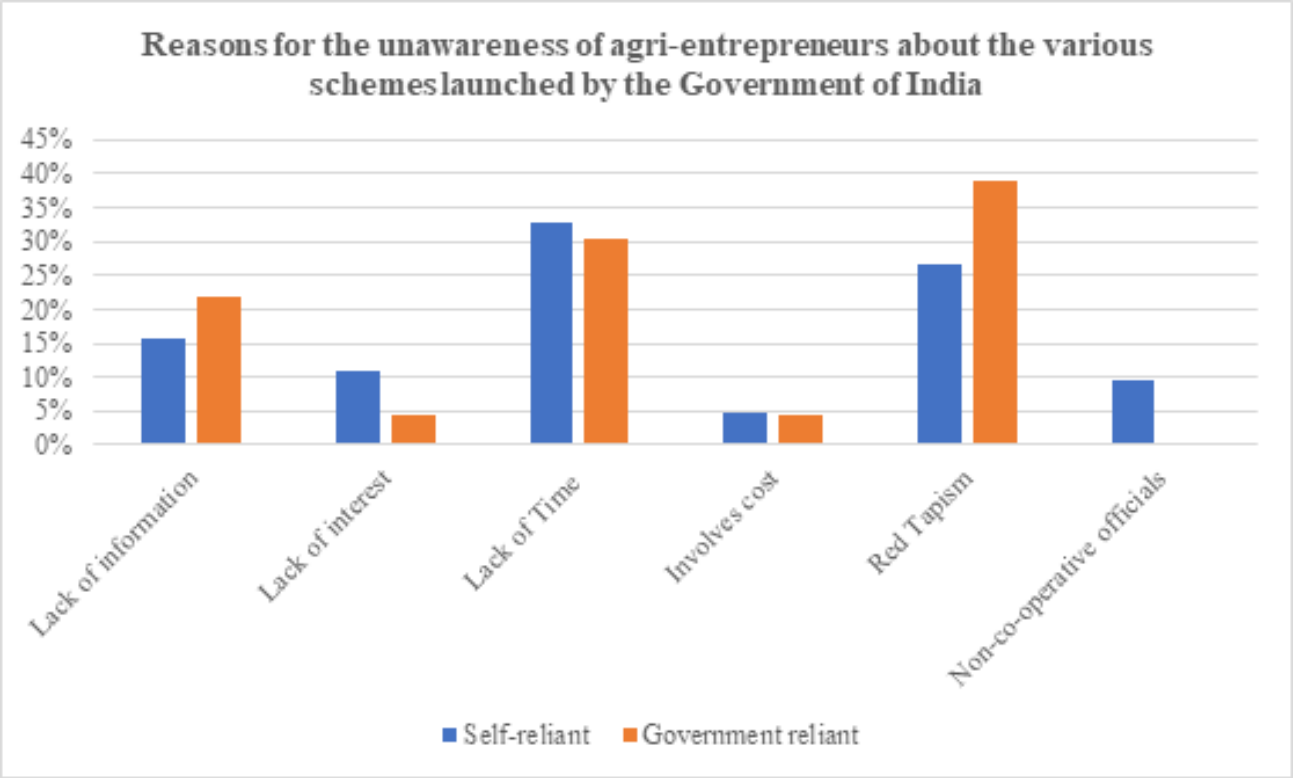

Figure 3. Reasons for the unawareness of agri-entrepreneurs about the various schemes launched by the Government of India

Reasons for the unawareness by agri-entrepreneurs of the various schemes

Intrinsic and extrinsic factors were gathered to discover the reasons for unawareness of the government schemes. The intrinsic factors being lack of information or unawareness, lack of interest and lack of time and the extrinsic factors cost, red tape, and non-cooperative officials (Table 4).

The results revealed that 15.6% of self-reliant agri-entrepreneurs and 21.7% of government assisted agri-entrepreneurs cited a lack of information about the assistance given. Phillips *et al* (2014) and Mahajar and Yunus (2012) found that low levels of awareness regarding government schemes was prevalent not only in developing nations but also in developed countries. Mgbenka *et al* (2016) and Shehrawat *et al* (2020) discussed the low awareness about various schemes by the government of India like Prampragat Krishi Vikas Yojana (PKVY) and Small Farmers Agri-business Consortium (SFAC) and E-NAM. Nguyen *et al* (2021) proposed that uncertainty and unawareness may be beneficial acting as an exogenous shock enabling only the fittest enterprises to survive. From the above results it was noticed that 10.9 % of self-reliant agri-entrepreneurs and 4.3% of government-assisted agri-entrepreneurs did not require any assistance. A lack of interest and lack of time with regard to the policies and schemes introduced by the government was based on various factors like lack of trust, the need for autonomy, the prevalence of the informal or shadow enterprises and the effects of networking.

Trust is a prime requirement for the efficient operation of institutions, schemes and policies (Habibov *et al*, 2017). This trust is known is system trust and it gets diminished due to heavily regulated procedures and rules but policies aimed at fostering entrepreneurship positively increase trust (Welter *et al*, 2012). It was evident that 32.8% of self-reliant agri-entrepreneurs and 30.4% of government assisted agri-entrepreneurs responded that it was time

consuming. It was noticed that 4.7% of self-reliant agri-entrepreneurs and 4.3% of government assisted agri-entrepreneurs responded that availing schemes required much cost. Furyther, 26.6% of self-reliant agri-entrepreneurs and 39.1% of government assisted agri-entrepreneurs were dissuaded due to red-tapism. Nisar (2018) views red tape to be associated with burdensome and time-consuming procedures that obstruct the delivery of services. Keiser and Miller (2020) emphasized that the provision of information and the manner in which the information is provided is important to avoid rules being considered as red tape. Finally, 9.4% of self-reliant agri-entrepreneurs were unwilling to avail assistance due to the uncooperative nature of officials. Distrust was also considered as a major factor for the disruption to the new agricultural policy (Chatterjee, 2021). Such effects were seen with regard to Pradhan Mantri Fasal Beema Yojana (PMFBY) where distrust in the scheme was evident due to a suspicion of corruption, time consuming processes and dissatisfactory service from financial institutions (Shehrawat *et al*, 2020). This indicated that there exists a difference in the opinion among the agri-entrepreneurs regarding the reasons for not availing the schemes launched by the Government.

CONCLUSION

It was concluded that majority of the agri entrepreneurs were unaware of the schemes launched by the Government of India. The various reasons put forth by the agri-entrepreneurs were based on presumptions and experiences of agri-entrepreneurs historically. There are a large number of schemes which are designed for the benefit of these agri-entrepreneurs, they remain ineffectual due to the prevailing mindset of the agri-entrepreneurs. Therefore, it is necessary for the government to concentrate on programmes that are designed to attract agri-entrepreneurs and also on methods that enable the smooth delivery of schemes towards the intended beneficiaries.

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Received on 24/10/2024 Accepted on 20/11/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 743-748

DOI : 10.5958/2349-4433.2024.00129.6

Antagonistic Activities of Various *Trichoderma* spp. against the isolates of *Fusarium oxysporum* f.sp. *ciceri*

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ABSTRACT

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops grown in the Indian subcontinent and known to cope with the protein demand of the major vegetarian population of our country. Besides its significance, the crop faces prodigious ignorance due to a range of biotic and abiotic stresses. However, Fusarium wilt caused by *F. oxysporum* f. sp. c*iceri* is one of the significant catastrophes to chickpea cultivation in every Indian state. The present study explored the potential of some indigenous *Trichoderma* isolates against two isolates of *Fusarium oxysporum* f.sp. *ciceri* viz., *FOC*UP1 (Uttar Pradesh) and *FOC*RJ1 (Rajasthan). Interestingly, all the tested *Trichoderma* isolates significantly inhibited the radial growth of both *Fusarium* isolates. However, more inhibition of indigenous *Fusarium* isolates (*FOC*UP1) (ranged between 71.85 to 80.37%) was recorded against all the tested *Trichoderma* isolates when compared to nonindigenous isolate, i.e., *FOC*RJ1 (ranged between 55.19 to 67.41%). Among all the tested isolates of *Trichoderma* spp., the highest inhibition in *FOC*UP1 was exhibited by *T. viride* (80.00%), followed by *T. hamatum* (77.78 %). However, in the case of *FOC*RJ1, *T. hamatum* (67.41%) was superior to other tested *Trichoderma* isolates, followed by *T. viride* (62.96%). This *in-vitro* study gave a clue to further exploitation of indigenous bioagents to mitigate losses incurred by this pathogen at a large scale.

Key Words: Fusarium wilt, *Trichoderma* spp., *Fusarium oxysporum* f.sp. *ciceri, in-vitro*

INTRODUCTION

Chickpea or Bengal gram is one of the most important annual grain legumes, cultivated mainly for its protein-rich dried grains (Didinger and Thompson, 2021). These grains are comparable cheap protein sources to animal protein sources, predominantly consumed as dal or snacks (Iriti and Varoni, 2017; Venkidasamy *et al,* 2019). However, the green leaves and seeds are also utilised as vegetables or consumed raw (Amulya *et al,* 2020). India is the largest producer of chickpeas around the globe and accounts for nearly 90 per cent of total global production. Not only production but the Indian subcontinent also covers the highest area under cultivation (10.74mha) of this crop *i.e.*, 72.51 per cent of total global coverage (Sharma and Singh, 2024). However, the productivity of this crucial pulse crop is still marginalised *i.e.,* 1261 kg/ha, which is quite lower than Russia, Australia, Myanmar, and Turkey. A range of abiotic and biotic factors has been reported to hamper the stable production of chickpea all around the globe. The losses caused by individual insect pests and diseases in temperate and tropical regions range between 5-10 per cent and 50-100 per cent, respectively (Dubey *et al,* 2006). However, among various biotic stresses affecting global production of chickpea, Fusarium wilt caused by *Fusarium oxysporum* f.sp. *ciceri* (Padwick) Synd. and Hans. (*Foc*) is one of the most important threat (Jimenez-Diaz *et al,* 2015; Bhar *et al,* 2021).

This soil-borne and internally seed-borne (Farhana *et al,* 2022) fungus is well known for its global occurrence (at least 33 countries) and significant loss of up to 10-40 per cent worldwide (Sharma *et al,* 2014), however, in India it is reported to lead an annual loss of 10-15 per cent, which may also result in total crop failure under favourable conditions (Sharma *et al,* 2014). The

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symptoms of this disease may be classified as early wilt and late wilt according to the stage of plant infection. The loss incurred in late wilt is comparatively less than to that of in early wilt *i.e.,* 24-65 per cent and 77-94 per cent, respectively (Jiménez-Díaz *et al,* 2015). The disease may affect any stage of the crop and results in development of characteristic symptoms of yellowing and sudden drooping of leaves and petioles. Although, there is no external rotting symptom on root or stem but internal discolouration of xylem and pith can be clearly seen when the root or stem is split opened.

The cultural management practices fail to manage this notorious pathogen due to its prolonged saprophytic survival ability (up to 7 years, due to chlamydospores), use of host-resistance is quite recommended but fails due to limited availability of resistant cultivars. Ultimately, chemical management is the only left option, but this nether economical, nor environment friendly (causes soil and water pollution). At the same time, the rising global concern against environment and human health also leads to adaptation of some alternatives to chemical pesticides. Hence, the alteration of soil micro-flora is one of the most promising options. *Trichoderma* spp. in recent past attracted the attention of researchers due to its multiprong action against several phytopathogens and growth promoting activities to plants (Thaware *et al,* 2017; Rathore *et al,* 2020).

MATERIALS AND METHODS

Isolation, identification and maintenance of *F. oxysporum* f.sp. *ciceri*

The test pathogen was isolated from infected chickpea plants showing characteristics symptoms, i.e., yellowing, drooping and internal discolouration of xylem. The infected chickpea plants were collected from two locations, i.e., Jhalawar (Rajasthan) and Aligarh (Uttar Pradesh). The pathogen was isolated by chopping the infected materials in small pices of 1cm. these small pieces were surface sterilised in NaOCl for 1 minute, followed by two washing in distilled water, and then blot dried for removal of excess moisture. These pieces were then placed in Petri plates containing solidified PDA and incubated in BOD at 25±2°C. the plates were observed regularly for mycelial growth (if any) and purified by single spore culture technique; however, the culture was maintained on PDA slants at 4°C (Belabid and Fortas, 2002). The pathogen was identified on the basis of cultural and morphological characteristics such as, colony growth, pigmentations, more specifically size and shape of micro and macro conidia, septation observed under compound microscope. The Species of Trichoderma were isolated on Trichoderma selective medium (TSM) from the soil collected from the chickpea rhizosphere (all from Aligarh locality) (Elad *et al,* 1981).

Bio-efficacy of *Trichoderma* spp. on radial growth of *F. oxysporum* f.sp. *ciceri* (*Foc*):

Total five isolates of *Trichoderma*, namely, *T. harzianum (isolate1), T. harzianum isolate2, T. viride, T. longibrachiatum,* and *T. hamatum* were evaluated using Dual culture technique, against two isolates of *Foc*, i.e., *FOC*RJ1 and *FOC*UP2, isolated from, Jhalawar (Rajasthan), and Aligarh (Uttar Pradesh), respectively (Dhingra and Sinclair, 1985). Appropriate controls were maintained for monoculture and inoculated plates were incubated at 25±2°C. Observations on radial growth of interacting test fungi, overgrowth, and zone of inhibition, were recorded and % growth inhibition of test fungi was calculated by the formula suggested by Dubey *et al* (2007).

RESULTS AND DISCUSSION

In-vitro experiment was conducted to ascertain the efficacy of various *Trichoderma* spp. against *Fusarium oxysporum* f.sp. *ciceri.* The observation was recorded in terms of radial growth and its inhibition and are presented in Table 1, Fig. 1 and Plate 1.

Perusal of data (Table 1) revealed that all the species of *Trichoderma* had expressed their potential against the test pathogen and significantly inhibited the radial growth of *Foc,* over control, however, a variation in terms of inhibition was also recorded, with more inhibition in Uttar Pradesh isolate of *Foc* (*FOC*UP1) was recorded in compare to Rajasthan isolate

Table1. Bio-efficacy of various Trichoderma spp. against the isolates of *Fusarium oxysporum* f.sp. *Ciceri.*

Trichoderma strains	Per cent growth inhibition of *Fusarium oxysporum* f.sp. *ciceri* isolates (%)	
	***FOC*RJ1**	***FOC*UP1**
T. harzianum isolate1	55.19	72.96
T. harzianum isolate 2	67.04	77.41
T. longibrachiatum	61.11	71.85
T hamatum	67.41	77.78
T. viride	62.96	80.37
Control	0.00	0.00
LSD (P<0.05)		
Fusarium isolates	0.47	
Trichoderma isolates	0.82	
Fusarium: Trichoderma	1.16	

(*FOC*RJ1). Meanwhile, in case of both isolates of fusarium *i.e., FOC*RJ1, and *FOC*UP1, highest inhibition was reported in case of *T. viride viz.,* 62.96 and 80.37 %, followed by *T. hamatum* (67.41 and 67.04 %) and *T. hamatum* (isolate 2) (77.78 and 77.41 %), which were statistically at par to each other. *T. harzianum* isolate 1 was least effective to inhibit the growth of *Foc* isolate of Rajasthan (*FOC*RJ1), i.e., 55.19 %; meanwhile, in case of *FOC*UP1, *T. longibrachiatum* was least effective with only 71.85 % of growth inhibition.

It was clear from Fig.1 and Plate1, that the all the *Trichoderma* spp. under evaluation have a great inhibitory effect on radial growth of *F. oxysporum* f.sp. *ciceri* causing chickpea wilt. Moreover, there was also a significant variation in response among all these species of *Trichoderma* (isolated from different locations). The *Trichoderma* spp. have more inhibitory effect on the *Foc* isolated from same locations. Moreover, in case of both tested isolates of *Foc, T. viride* was the most effective to inhibit the radial growth, *in-vitro,* followed by *T. harzianum* and *T. hamatum.*

Present study signifies the utilization of various species of *Trichoderma* in inoculum reduction and radial growth inhibition of *F. oxysporum* f.sp. *ciceri,* which were also earlier reported by several other researches (Dubey *et al,* 2007; Kumar *et al,* 2019; Moutassem *et al,* 2020; Younesi *et al,* 2021). Amulya *et al.* (2020) evaluated 24 sympatric isolates of *Trichoderma* from six different chickpea growing mandals of Prakasam district (Andhra Pradesh) and one isolate from Bapatla against their inhibitory potential against Bapatla isolate of *Fusarium oxysporum* f. sp. *ciceri (Foc).* They also recorded a variation among *Trichoderma* isolates tested in terms of their antagonistic potential. Screening of *Trichoderma* isolates was done based on the radial growth of interacting test fungi, overgrowth, zone of inhibition, pigmentation of *Foc* and sporulation of *Trichoderma.* In this experiment they identified, 5 potential isolates of *Trichoderma i.e.,* T 19001, T 19007, T 19012, T 19020, T 19023 which were fast in growth and overgrowing the *Foc*. Whereas, T 19001, T 19007 and T 19012 isolates were found to overgrow and sporulate on *Foc*. Media pigmentation in *Foc* changed from light colour in monocultured *Foc* plates to dark in dual cultured plates in interactions involving T 19020 and T 19023 isolates, however, without sporulation on the test pathogen.

CONCLUSION

Fusarium wilt in chickpea, is a great problem in all the chickpea cultivation areas around the globe. However, managing this disease in farmers filed is still a great challenge. The use of chemical fungicides is neither a permanent solution nor a healthy option for the environment and human health. In this case the soil borne

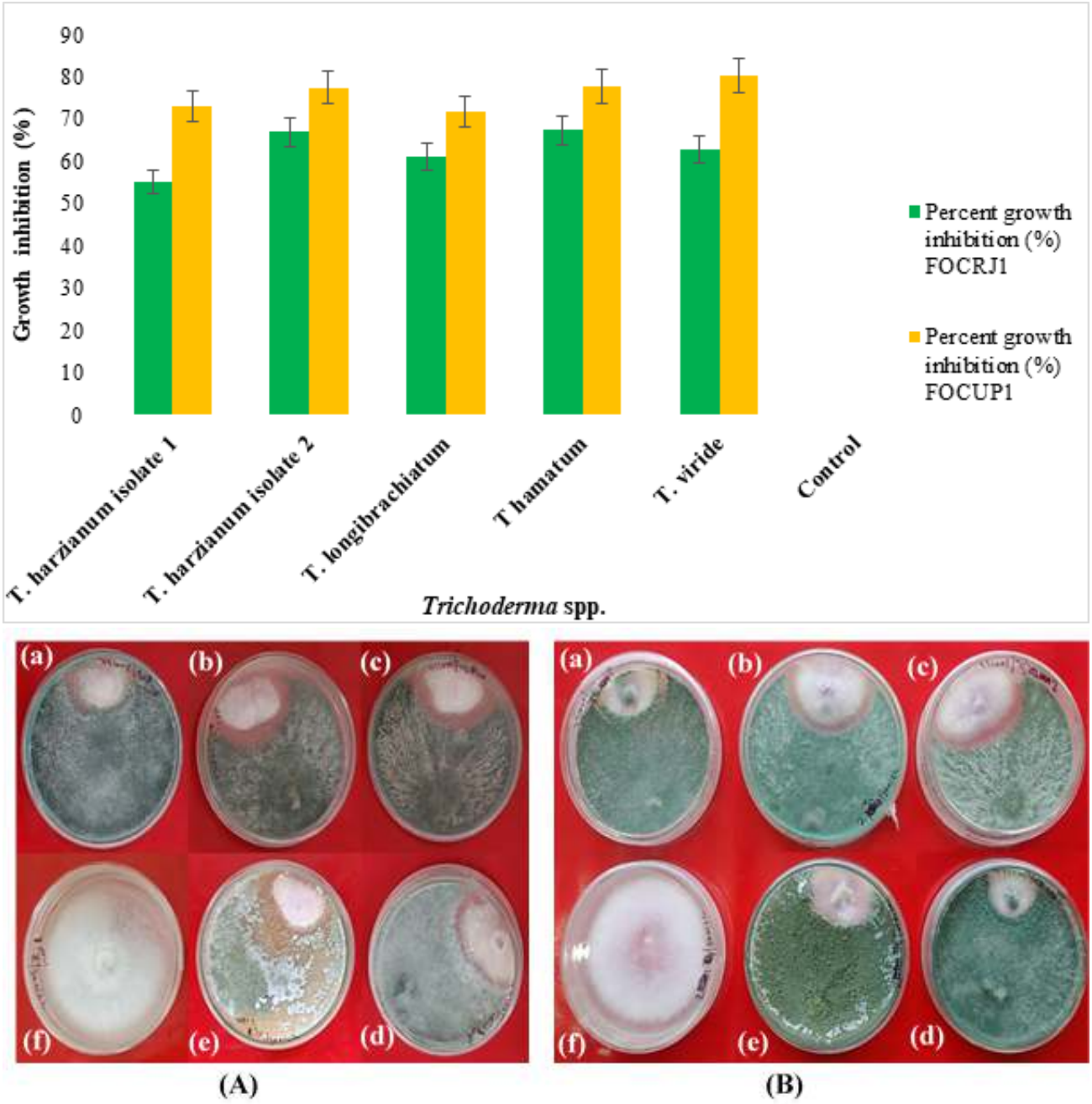

Plate1. Radial growth inhibition of *Foc* isolates; FOCRJ1 (A) and FOCUP1 (B), by various *Trichoderma* spp., i.e., *T. viride* (a), *T. harzianum (isolate1)* (b), *T. harzianum (isolate2)* (c), *T. longibrachiatum* (d), *T. hamatum* (e) and control

antagonistic fungi, *Trichoderma,* which were found to be effective against a range of soil borne phytopathogens provides a great potential to mitigate the losses caused by this pathogen. The present study also signifies the efficacy of the *Trichoderma* spp., against chickpea wilt pathogen, i.e., *F. oxysporum* f.sp. *ciceri.* However, it was also recorded that the isolates of Trichoderma, isolated from the rhizosphere of the same locality, have more inhibitory potential against the *Foc* isolates. Hence care should be taken while selecting the *Trichoderma* isolates.

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Received on 31/8/2024 Accepted on 25/10/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 749-756

DOI : 10.5958/2349-4433.2024.00130.7

Bio Efficacy and Phytotoxicity Evaluation of Premixed Fomesafen plus Quizalofop Ethyl for Weed Control in Soybean

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ABSTRACT

Soybean is the most important oil seeds crop in many states of the country as a rain fed crop in *kharif* season, in terms of total production and international trades. However, losses due to weeds have been one of the major limiting factors in soybean production. So, successful weed control is one of the most important practices for economical soybean production. An experiment was laid out at the instructional farm of Krishi Vigyan Kendra, Ujjain to evaluate the efficacy of premix herbicide which could control both the grassy and broad leaf weeds. Use of fomesafen 12 % + quizalofop 3% w/w SC at different concentrations ranging from 1125 to 3000 ml ha^{-1} as post emergence reduced the weed density, increased weed control efficiency and yield apart from no phototoxic effect on plants and succeeding crop of garden pea.

Key Words: Soybean, Phyto-toxicity, Pre-mix Herbicides, Weed Density, Weed Control Efficiency.

INTRODUCTION

Madhya Pradesh is a leading state in India for cultivation of soybean, where it is grown on 5.51 million hectares with the total production of 5.15 million tons. But the productivity is 934 kg/ha which is far below than its yield potential *i.e.* 2500 kg/ha (SOPA, 2023). Soybean [*Glycine max* (L.) Merrill] is an important grain legume crop, which has ability not only to fix nitrogen for its own use but also leave some residual nitrogen for the succeeding crop. It is grown in *Kharif* season and thus weed management plays an important role for its successful cultivation. Depending upon the nature, density and period of occurrence of weeds, they can cause loss of 35-80% in yield. Wadafale *et al* (2011) and Kamble *et al* (2017) observed that the critical period of crop-weed competition in soybean crop was 30-40 days after sowing (DAS). Keeping the crop weed free through manual weeding and hoeing, though effective, but has several limitations such as timely availability of adequate labour and difficulty in using mechanical weeders during rainy season etc. The only and the best alternative, therefore, seem to be application of herbicides at proper time and optimum dose. The herbicides applied as pre-emergence may fail to provide weed control for the entire growing season due to herbicide dissipation in the dry weather conditions. The stress is mainly due to presence of dominating grassy weeds viz; *Echinochloa crusgalli, Echinochloa colona, Cyperus spp. Cynodon dactylon* and broad leaved weeds viz; *Commelina benghalensis, Commelina communis, Phyllanthus niruri,Euphorbia spp.* and *Corcorus acutangulus* etc. (Sharma and Shrivastava, 2002). If weeds are not controlled during critical period of crop-weed competition during the initial 20-45 days, there is severe reduction in the yield of soybean ranging from 58 to 85 per cent, depending upon the types and intensity of weeds (Kewat *et al.,* 2000). According to Kundu *et al* (2011) the loss in yield of soybean due to weeds was 43% in control which indicates the necessity of controlling weed for exploiting the yield potential of soybean. Therefore, it is necessary to control weeds during this period as they compete for nutrients, moisture, and light so as to obtain maximum fertilizer and water use efficiency.

Competition between crops and weeds generally begin at the early stages after emergence

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Table 1. Physico-chemical properties of soil of the of the experimental field.

Property	Quantity
A) Mechanical composition	
Sand (%)	19.35
Silt (%)	32.42
Clay (%)	48.23
Textural class	Clayey, Vertisol
B) Chemical properties	
pH	7.80
Organic carbon	0.40 (%)
Electrical conductivity	0.33 (d/Sm)
Available Nitrogen	201.72 (kg/ha)
Available Phosphorus	27.80 (kg/ha)
Available Potash	490.5 (kg/ha)

of the crop. If the weeds are checked during this period, the soybean gets an advantage over the weeds and smothers them afterwards. To overcome the deleterious effects of weeds in soybean, it is imperative that weeds population be kept below the economic threshold level. In soybean, weed is generally managed through manual weeding and hoeing but due to intermittent rainfall during rainy season and scanty labour, timely inter culture becomes a very difficult task. Adverse weather conditions also limit the use of tools and implements for clearing weeds in the field. Under such situations, different pre and post-emergence herbicides can control annual grass and broad-leaved weeds effectively in soybean. The present study was carried out to evaluate the efficacy of fomesafen 12 % + quizalofop ethyl 3% w/w SC weed control and effect on growth and yield of soybean.

MATERIALS AND METHODS

The present experiment was carried out at the instructional KVK Farm, Krishi Vigyan Kendra, and RVSKVV at Ujjain during *Kharif* season of 2021 to 2023.

Experimental Site, Weather and Soil

Ujjain is situated in the *Malwa* Agro Climatic Zone in west Madhya Pradesh, lies between $25^0264'$ North latitude and $82^0 99.3'$ East longitudes at an elevation of 129.23 m above mean sea level. The soil of experimental field is clayey commonly categorized as Vertisol of good fertility. Soil samples up to 30 cm, depth was collected prior to application of treatments from 20 places and analysis of physico-chemical properties of the soil is presented in Table 1.

A very promising cultivar of Soybean cv. RVS-24" was used for the present study. It takes 92-98 days for maturity. All the plots received uniform cultural operations throughout the experimental period and the whole of the experimental field was kept clean and well maintained. The amount of fertilizers and manures were applied uniformly under all the treatments as per the Recommended Dose of Fertilizers (RDF) 20:60:40:20 NPKS was applied. The details of the nine treatments related to herbicides are listed below applied in randomized block design (RBD). In all three replications were taken with a plot size of 6.6 m ×2.6 m and the crop were sown in rows 45 cm apart. After the harvest of this crop garden pea was sown in these plots to study the residual nature of the herbicides. The herbicide treatments were applied at 3 to 4 compound leaf stage of soybean and / or 2 to 3 leaf stage of weeds under observation. For this the appropriate herbicide solution was prepared and diluted in 400 lt of water and applied with the help of knapsack sprayer having cut throat nozzle.

Table 2. Details of the treatments.

Tr. No.	Treatment	Doses ml/ha	Dilution in water (litre/ha)
T_1	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC	1125	500
T_2	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC	1500	500
T_3	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC	1875	500
T_4	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample)	1500	500
T_5	Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME	2000	500
T_6	Quizalofop Ethyl 10% EC (Market sample)	375	500
T_7	Imazethapyr 10% SL	1000	500
T_8	Weed free check(hand weeding at 20 and 40 days after sowing)	–	500
T_9	Weedy check (Untreated control)	–	500
T_{10}	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC for phytotoxicity & Residue studies only	3000	500

Observations recorded

Per cent weed control efficiency

Based on weed dry weight per cent weed control efficiency over control (weedy check) was also calculated for each weed species using following formula:

$$WCE\ (\%) = \frac{\text{Dry matter of weeds in un-weeded plot} - \text{Dry matter of weeds in treated plot}}{\text{Dry matter of weeds in un-weeded plot}} \times 100$$

Phytotoxicity

Phytotoxicity was recorded visually for leaf injury on tips/surface, wilting, vein clearing, necrosis, epinasty and hyponasty. The observations were recorded at 10, 20, 30, 45 and 60 days after treatment application for all the treatments. The scale 1-10 was followed to record observations for leaf injury on tips/ surface.

Yield and yield traits

The observations were also recorded for treatment No. 1 to 8 on grain yield/plot (kg) at harvest and converted into grain yield (q/ha).

Residual effect on succeeding crop

For analyzing the residual effect of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC applied in soybean crop on the succeeding crop, garden pea was grown in the same plots without disturbing the original layout plan of the experiment. Observation was recorded on crop germination percentage. Observations for phytotoxicity parameters were also recorded periodically.

Phytotoxicity Rating Scale (PRS)

Crop response / crop injury	Rating
0-10%	1
11-20%	2
21-30%	3
31-40%	4
41-50%	5
51-60%	6
61-70%	7
71-80%	8
81-90%	9
91-100%	10

Statistical analysis

The observations recorded during the course of investigation were subjected to statistical analysis by adopting appropriate Model *i.e.*, "Analysis of variance" as per the procedure described by Panse and Sukhatme (1985) after subjecting to requisite transformation. Critical difference (CD) was calculated in order to compare the treatment at 5% level of significance.

RESULTS AND DISCUSSION

The data pertaining to effect of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC on number of weeds at various crop stage viz., 15, 30 and 60 DAS (Days after crop sowing) during 2021-2023 were recorded and pooled using 100 cm x 100 cm quadrat placing at random at four places per plot and aggregate weed density was expressed on per m^2 basis. The data are presented in Table 3 to 5. The major weed species recorded in the experimental plots at different time intervals were *Echinochloa colonum* (Jungle Rice), *Echinochloa crusgalli* (Cockspur), *Digiteri sanguinalis* (Hairy crabgrass), *Dactyloctenium aegyptium* (Crow foot grass) and *Eleucine indica* (*Goose grass*), whereas *Phalaris minor* (Canary grass) was not present in the field during entire period.

After 15 days of crop sowing dominant weeds observed were *Echinochloa colonum* (Jungle Rice), *Echinochloa crusgalli* (Cockspur), *Digiteria sanguinalis* (Hairy crabgrass), *Dactyloctenium eigiptium* (Crow foot grass) and *Eleucine indica* (*Goose grass*). The population of these weeds was significantly low in the treatment of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Best Crop sample) @ 750 ml/ha followed by Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample) @ 750 ml/ha. The weed population in untreated control (weed free) was at par to untreated control (weedy check) as by that time hand weeding was not done. However, at 30 DAS all the treatments were found significantly effective to control these weeds as compared to untreated control (weedy check). Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Best Crop sample) @ 750 ml/ha was most effective after untreated control (weed free check) followed by Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample) @ 750 ml/ha. Fomesafen 12 % + Quizalofop ethyl 3% w/w SC applied @ 1000 ml/ha was also effective when compared to untreated control (weedy check). Similar trend of effectiveness of these treatments was observed at 30 and 60 DAS.

The weeds *Phalaris minor* (Canary grass) was not observed at 15 to 60 DAS in any of experimental plots. The results thus showed that untreated control (weed free) and Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Best Crop sample) @ 750 ml/ha, and Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample) @ 750 ml/ha effectively controlled these weeds. Fomesafen 12 % + Quizalofop ethyl 3% w/w SC applied @ 1000 ml/ha was also effective when compared to untreated control (weedy check). Overall, the herbicide treatments effectively controlled and checked the growth of weeds in soybean crop.

Weed control efficiency (WCE) at various crop stages

The weed control efficiency calculated over control (weedy check) based on weed dry weight recorded at various time intervals are presented in Table 6 and 7. The results showed that all the treatments were quite effective to control the weeds at each time interval of observations. The weed control efficiency in untreated control (weed free) was lower as compared to other treatments. Amongst the other treatments Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Best Crop sample) @ 750 ml/ha and Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample) @ 750 ml/ha effectively controlled the weeds growth. Fomesafen 12 % + Quizalofop ethyl 3% w/w SC applied @ 1000 ml/ha was also effective when compared to untreated control (weedy check).

Yield

The data pertaining to grain yield of soybean are presented in Table 8. The observations recorded for grain yield q/ha was higher in the treatment of untreated control (weed free) and Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Best Crop sample) @ 750 ml/ha. Fomesafen 12 % + Quizalofop ethyl 3% w/w SC

Table 3. Effect of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC on number of weeds at various crop stage of soybean

Treatment		Dose ml/ha	*Echinochlo acolonum* (Jungle Rice)			*Echinochloa crusgalli* (Cockspur)			*Digiteria sanguinalis (Hairy crabgrass)*			*Dactyloctenium eigiptium (Crow foot grass)*		
			15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS
T1	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1125	3.19 (9.33)	3.10 (8.67)	3.10 (7.33)	2.70 (6.30)	2.99 (8.0)	3.45 (11)	2.36 (4.7)	2.94 (7.7)	3.33 (10.3)	1.82 (2.3)	2.48 (5.30)	2.87 (3.3)
T2	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1500	2.93 (7.66)	2.76 (6.67)	2.76 (5.33)	2.57 (5.70)	3.09 (8.67)	2.46 (3.33)	1.82 (2.3)	1.71 (2.0)	2.88 (6.0)	1.71 (2.0)	2.06 (3.30)	2.88 (6.3)
T3	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1875	2.82 (7.0)	3.09 (867)	3.09 (6.0)	2.36 (4.70)	2.36 (4.67)	2.87 (7.33)	1.71 (2.0)	1.68 (2.0)	3.20 (9.3)	2.22 (4.0)	1.93 (3.0)	1.71 (3.0)
T4	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample)	1500	2.91 (7.6)	2.94 (7.67)	2.94 (6.67)	2.49 (5.3)	2.57 (5.67)	2.48 (5.33)	1.71 (2.0)	1.52 (1.3)	2.81 (7.7)	2.15 (3.7)	2.42 (5.0)	2.64 (8.3)
T5	Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME	2000	3.45 (11)	3.45 (11)	3.45 (15.0)	3.09 (8.7)	2.75 (6.67)	2.275 (6.67)	2.06 (3.3)	2.15 (3.7)	2.45 (6.3)	2.33 (4.7)	1.82 (2.3)	2.36 (4.3)
T6	Quizalofop Ethyl 10% EC Market sample)	375	3.9 (14.3)	3.74 (13)	3.74 (13.67)	2.93 (7.7)	2.75 (6.67)	2.27 (4.33)	2.06 (3.3)	1.73 (2.0)	2.35 (3.0)	1.80 (2.3)	1.52 (1.3)	1.38 (3.7)
T7	Imazethapyr 10% SL	1000	4.38 (18.3)	4.16 (16.33)	4.16 (13.0)	3.94 (14.7)	4.23 (17)	5.27 (27.0)	2.81 (7.0)	2.93 (7.7)	2.76 (8.7)	2.49 (5.3.)	2.57 (5.7)	3.04 (7.7)
T8	Weed free check (hand weeding at 20 and 40 days after sowing)		1.97 (3)	2.15 (3.70)	2.15 (3.33)	1.64 (2.0)	1.38 (1.0)	2.42 (5.0)	(1.0)	1.41 (1.0)	3.04 (3.7)	1.13 (0.3)	1.14 (0.3)	1.38 (4.3)
T9	Weedy check (Untreated control)		7.34 (55.3)	8.26 (67.7)	8.26 (215)	6.96 (47.7)	6.51 (41.7)	4.73 (21.67)	4.38 (18.3)	5.76 (32.3)	4.04 (27.0)	3.90 (14.0)	4.81 (22.3)	5.15 (18.0)
T10	Fomesafen 12% + Quizalofop ethyl 3% w/w SC for phytotoxicity & Residue studies only	3000							1.13 (0.3)	1.41 (3.2)	1.13 (0.3)	1.14 (0.3)	1.13 (0.3)	1.14 (0.7)
	CD 5%		1.31	0.507	0.507	0.564	0.320	0.662	0.476	0.430	NA	0.489	0.664	NS
	Result		Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	NS	Sig	Sig	NS
	Figure in parentheses are original values which are subjected to square root transformation √(x+0.5) DAS – days after crop sowing													

(Market sample) @ 750 ml/ha and Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Best Crop sample) @ 1000 ml/ha was also effective as compared to untreated control (weedy check). The highest yield qt per hectare was obtained in T8 (19.73) whereas among the herbicidal treatments the highest yield of 18.2 and 18.1 was recorded in T4 and T2, although they were statistically at par. Among the herbicide treatments T5 (15.53) recorded the lowest yield, probably due to regular use of Imazethapyr over the last 3 decades, thus inducing resistance towards the efficacy on major weeds. Similar results were earlier reported by Kewat *et al* (2000) and Sharma *et al* (2002).

CONCLUSION

The investigations revealed that Fomesafen 12 % + Quizalofop ethyl 3% w/w SC applied @ 750 to 1000 ml/ha was effective to control weeds in soybean crop. No phytotoxicity of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC applied @ 1500, 1000, 750 and 500 ml/ha to soybean crop and no residual effect on germination of succeeding crop was observed. The germination percentage of the succeeding pea crop ranged from 81.6 to 88 per cent which can be attributed to be normal as per the germination standards prescribed in Indian minimum seed certification standards. Based on the study, the use of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC @ 750 ml/ha is suggested for the control of weeds in soybean crop which is at par with Market sample of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC.

Table 4. Effect of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC on number of weeds at various crop stage of soybean

Treatment		Dose ml/ha	*Eleucine indica* (Goose grass)			*Phalaris minor* (Canary grass)			*Echinochloa colonum* (Jungle Rice)			*Echinochloa crusgalli* (Cockspur)		
			15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS
T_1	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1125	1.72 (2.3)	2.15 (3.7)	2.36 (3.0)	NIL NIL	NIL NIL	NIL NIL	2.72 (6.43)	2.89 (7.4)	3.37 (10.39)	2.66 (6.13)	2.36 (4.59)	2.89 (7.40)
T_2	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1500	1.66 (2.0)	1.82 (2.3)	2.15 (3.7)	NIL NIL	NIL NIL	NIL NIL	2.54 (5.47)	2.69 (6.3)	3.13 (8.83)	2.49 (5.21)	2.21 (3.90)	2.69 (6.28)
T_3	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1875	1.48 (1.3)	2.06 (3.3)	2.50 (5.3)	NIL NIL	NIL NIL	NIL NIL	2.76 (6.67)	2.94 (7.7)	3.42 (10.76)	2.70 (6.34)	2.39 (4.75)	2.94 (7.66)
T_4	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample)	1500	1.66 (2.0)	1.95 (3.0)	2.33 (4.7)	NIL NIL	NIL NIL	NIL NIL	2.22 (3.93)	2.35 (4.5)	2.71 (6.35)	2.17 (3.75)	1.95 2.80	2.34 (4.52)
T_5	Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME	2000	1.79 (2.7)	1.91 (2.7)	2.69 (6.3)	NIL NIL	NIL NIL	NIL NIL	1.98 (2.93)	2.09 (3.4)	2.39 (4.74)	1.91 (2.79)	1.75 (2.09)	2.09 (3.37)
T_6	Quizalofop Ethyl 10% EC Market sample)	375	1.48 (1.3)	1.62 (1.7)	1.82 (2.3)	NIL NIL	NIL NIL	NIL NIL	2.06 (3.27)	2.17 (3.8)	2.50 (5.27)	2.02 (3.11)	1.82 (2.33)	2.17 (3.76)
T_7	Imazethapyr 10% SL	1000	2.16 (4.0)	2.42 (5.0)	3.25 (9.7)	NIL NIL	NIL NIL	NIL NIL	2.67 (6.17)	2.84 (7.1)	3.30 (9.96)	2.62 (5.87)	2.32 (4.40)	2.84 (7.09)
T_8	Weed free check(hand weeding at 20 and 40 days after sowing)	-	1.47 (1.3)	1.33 (1.0)	1.82 (2.3)	NIL NIL	NIL NIL	NIL NIL	1.26 (0.6)	1.29 (0.7)	1.39 (0.57)	1.25 (0.57)	1.19 (0.43)	1.29 (0.69)
T_9	Weedy check (Untreated control)	-	3.0 (8.7)	3.70 (13.3)	2.94 (25.0)	NIL	NIL	NIL	3.7 (12.7)	3.94 (14.6)	4.63 (20.56)	3.61 (12.13)	3.17 (9.08)	3.94 (14.64)
T_{10}	Fomesafen 12% + Quizalofop ethyl 3% w/w SC for phytotoxicity & Residue studies only	3000	1.41 (1.3)	1.24 (0.7)	1.24 (2.3)	NIL	NIL	NIL	1.04 (0.6)	1.04 (0.1)	1.06 (0.14)	1.04 (0.08)	1.02 (0.06)	1.04 (0.10)
	CD 5%		0.588	0.643	NA	NIL	NIL	NIL	0.227	0.245	0.298	0.220	0.185	0.245
	Result		Sig	Sig	NS	NIL	NIL	NIL	Sig	Sig	Sig	Sig	Sig	Sig

Table 5: Effect of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC on number of weeds at various crop stage of soybean

Treatment		Dose ml/ha	*Digiteria sanguinalis* (Hairy crabgrass)			*Dactyloctenium eigiptium* (Crow foot grass)			*Eleucine indica* (*Goose grass*)		
			15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS
T_1	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1125	2.43 (4.93)	2.16 (3.70)	2.15 (3.64)	2.53 (5.43)	2.26 (4.11)	2.22 (3.97)	2.42 (4.88)	2.21 (3.91)	2.12 (3.49)
T_2	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1500	2.15 (3.63)	1.86 (2.47)	1.84 (2.41)	2.35 (4.00)	1.93 (2.75)	1.90 (2.62)	2.14 (3.6)	1.90 (2.61)	1.81 (2.31)
T_3	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1875	1.98 (2.93)	1.81 (2.29)	1.78 (2.19)	2.05 (3.23)	1.88 (2.54)	1.83 (2.38)	1.97 (2.90)	1.84 (2.42)	1.76 (2.10)
T_4	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample)	1500	2.10 (3.43)	1.84 2.4	1.82 (2.34)	2.18 (3.78)	1.91 (2.67)	1.88 (2.55)	2.09 (3.40)	1.88 (2.54)	1.80 (2.24)
T_5	Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME	2000	2.34 (4.5)	2.01 (3.06)	2.09 (3.41)	2.43 (4.95)	2.09 (3.40)	2.16 (3.71)	2.33 (4.46)	2.05 (3.23)	2.06 (3.27)
T_6	Quizalofop Ethyl 10% EC Market sample)	375	2.42 (4.88)	2.23 (4.00)	1.93 (2.76)	2.52 (5.36)	2.33 (4.45)	2.00 (3.01)	2.41 (4.83)	2.28 (4.22)	1.90 (2.65)
T_7	Imazethapyr 10% SL	1000	2.71 (6.40)	2.57 (5.63)	2.68 (6.22)	2.83 (7.04)	2.69 (6.26)	2.78 (6.78)	2.70 (6.34)	2.63 (5.95)	2.63 (5.96)
T_8	Weed free check(hand weeding at 20 and 40 days after sowing)		1.29 (0.67)	1.23 (0.53)	1.11 (0.24)	1.31 (0.73)	1.26 (0.59)	1.12 (0.27)	1.28 (0.66)	1.25 (0.56)	1.11 (0.23)
T_9	Weedy check (Untreated control)		3.56 (11.73)	3.97 (14.76)	4.97 (23.76)	3.72 (12.91)	4.17 (16.41)	5.18 (25.9)	3.55 (11.62)	4.07 (15.59)	4.87 (22.79)
T_{10}	Fomesafen 12% + Quizalofop ethyl 3% w/w SC for phytotoxicity & Residue studies only	3000	1.05 (0.11)	1.03 (0.08)	1.02 (0.06)	1.05 (0.12)	1.04 (0.09)	1.03 (0.06)	1.05 (0.11)	1.03 (0.08)	1.02 (0.05)
	CD 5%		0.111	0.097	0.111	0.117	0.104	0.117	0.110	0.100	0.108
	Result		Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	Figure in parentheses are original values which are subjected to square root transformation **(x+0.5) DAS – days after crop sowing**										

Bio Efficacy and Phytotoxicity Evaluation

Table 6: Effect of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC on per cent weed control efficiency (WCE) at various crop stage of soybean.

Treatment		Dose ml/ha	*Echinochloa colonum* (Jungle Rice)			*Echinochloa crusgalli* (Cockspur)			*Digiteriasang uinalis (Hairy crabgrass)*			*Dactyloctenium eigiptium (Crow foot grass)*		
			15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS
1.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1125	49.5	49.5	57.1	49.5	49.5	51.9	58.0	74.9	84.7	58.0	74.9	84.7
2.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1500	57.1	57.1	63.7	57.1	57.1	59.1	69.0	83.3	89.9	69.0	83.3	89.9
3.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1875	47.6	47.6	57.8	47.6	47.6	50.1	75.0	84.5	90.8	75.0	84.5	90.8
4.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample)	1500	69.1	69.1	71.1	69.1	69.1	70.6	70.7	83.7	90.2	70.7	83.7	90.2
5.	Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME	2000	77.0	77.0	79.3	77.0	77.0	78.1	61.6	79.3	94.5	61.6	79.3	85.7
6.	Quizalofop Ethyl 10% EC Market sample)	375	74.3	74.3	71.1	74.3	74.3	75.6	58.4	72.9	88.4	58.4	72.9	88.4
7.	Imazethapyr 10% SL	1000	51.6	51.6	57.8	51.6	51.6	53.9	45.5	61.8	73.8	45.5	61.8	73.8
8.	Weed free check(hand weeding at 20 and 40 days after sowing)	-	95.3	95.3	93.3	95.3	95.3	95.5	94.3	96.4	99.0	94.3	96.4	99.0
9.	Weedy check (Untreated control)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC for phytotoxicity & Residue studies only	3000	99.32	99.3	99.4	99.3	99.3	99.3	99.1	99.5	99.8	99.1	99.5	99.8

Table 7: Effect of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC on per cent weed control efficiency (WCE) at various crop stage of soybean

Treatment		Dose ml/ha	*Eleucine indica* (Goose grass)			*Phalaris minor* (Canary grass)		
			15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS
1.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1125	58.0	84.7	84.7	NA	NA	NA
2.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1500	69.0	89.9	89.9	NA	NA	NA
3.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1875	75.0	90.8	90.8	NA	NA	NA
4.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample)	1500	70.7	90.2	90.2	NA	NA	NA
5.	Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME	2000	61.6	85.7	85.7	NA	NA	NA
6.	Quizalofop Ethyl 10% EC Market sample)	375	58.4	88.4	88.4	NA	NA	NA
7.	Imazethapyr 10% SL	1000	45.5	73.8	73.8	NA	NA	NA
8.	Weed free check(hand weeding at 20 and 40 days after sowing)	-	94.3	99.0	99.0	NA	NA	NA
9.	Weedy check (Untreated control)	-	0.0	0.0	0.0	NA	NA	NA
10.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC for phytotoxicity & Residue studies only	3000	99.1	99.8	99.8	NA	NA	NA

Table 8: Effect of Fomesafen 12 % + Quizalofop ethyl 3% w/w SC on grain yield of soybean

	Treatment	Dose ml/ha	Grain yield (q/ha)
1.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1125	16.733
2.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1500	18.100
3.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (BCSLLP sample)	1875	16.500
4.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC (Market sample)	1500	18.200
5.	Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME	2000	15.533
6.	Quizalofop Ethyl 10% EC Market sample)	375	14.633
7.	Imazethapyr 10% SL	1000	15.733
8.	Weed free check(hand weeding at 20 and 40 days after sowing)	–	19.733
9.	Weedy check (Untreated control)	–	11.367
10.	Fomesafen 12 % + Quizalofop ethyl 3% w/w SC for phytotoxicity & Residue studies only	3000	
	CD 5%		1.104
	Result		Sig

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Received on 28/9/2024 Accepted on 30/10/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 757-762

DOI : 10.5958/2349-4433.2024.00131.3

Classification of Tubewell Water for Sustainable Soil Health and Crop Growth

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ABSTRACT

The study was conducted at Krishi Vigyan Kendra, to evaluate the groundwater quality in Nathusari Chopta block, Sirsa district, Haryana, during the year 2019 to 2021. Due to an average rainfall of only 300 mm, farmers in the region heavily rely on canal and tubewell water for irrigation. A total of 150 water samples were analyzed for parameters such as pH, electrical conductivity (EC), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), and residual sodium carbonate (RSC). The results indicated that 38% of the samples were suitable for all crops, with EC levels between 0-2 dS/m. However, 35% of samples exhibited medium to high salinity (4-8 dS/m), and 11% showed very high salinity (>12 dS/m), which limits crop choices and requires careful management. The study highlighted the importance of regular groundwater quality monitoring and management for sustaining soil health and crop production. Recommendations included blending saline groundwater with canal water, periodic water quality testing, and adjusting crop choices based on water quality to mitigate adverse effects, especially in areas with high salinity and low rainfall.

Key Words: Electrical conductivity, Salinity, Cation, Anions, Soil health, Water quality.

INTRODUCTION

Water is one of the most important resources needed for sustainable crop production. All living organisms on the earth need water for their survival and growth (Jain *et al,* 2007). The water qualities largely affect soil fertility and crop production, therefore, critical evaluation of subsurface water quality is necessary to figure out the important properties of ground water (Kaif *et al,* 2021).To increase production with limited water resources, sustainable management and judicious use of water are the only options available(Kumar *et al,* 2023).In canal command areas during lean period when there is less canal water supply at the tail end of canal, ground water is used by the farmers to supplement irrigation in different crops without considering its impact on soil physico-chemical properties as well as on crop production. The periodic monitoring of ground water becomes a need to minimize the risk of deteriorations soil health and its effects on crop production. Rainfall is also an important factor which plays a key role in changing the water quality of underground aquifers (Kaushik *et al,* 2002). As the average rainfall of Sirsa district is low (300 mm), yet the district, tubewells are the key source of irrigation. The irrigation sources in Nathusari Chopta block largely depend on canal water as well as underground water. In the areas where canal water is not sufficient to meet irrigation requirement, the underground water is used to fulfil the water needs of various crops grown in the district. Therefore, it becomes necessary to have an overall idea of ground water quality to sustain soil health and in turn the crop production in the district. Thus, the present investigation was carried out to assess the quality parameters of underground water being used for irrigation in the district Sirsa of Haryana.

MATERIALS AND METHODS

Sirsa is located in western parts of Haryana touching the boundaries of Rajasthan and Punjab.

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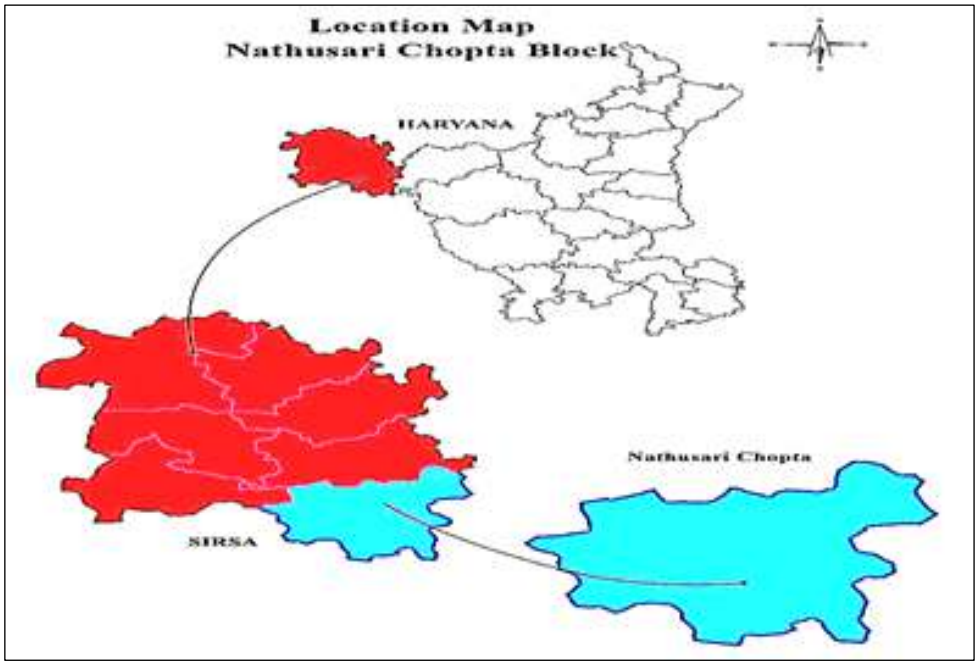

Figure: 1. Location map of study area

The soil of the district varies from sandy loam to loam with very low water holding capacity. Cotton-wheat and rice-wheat are the dominant cropping patterns prevalent in the district but the soil and climate are suitable for growing all the crops. It is the quality of water available which decides cropping pattern. Although canal water is available for irrigation yet the farmers have to rely upon alternate sources of irrigation primarily on ground water depending on the water needs of the crops. As the ground water quality of the wholedistrict is not good at all locations and the farmers are advised to get their tube-well water tested at regular intervals for safe use in agriculture. For getting their water samples tested, a large number of farmers visit KrishiVigyan Kendra, Sirsa so that crops may be grown according to the quality of water available with them. In the present study, water samples received from the villages of blockNathusariChopta during the years 2019, 2020 and 2021 in the soil testing laboratory of KrishiVigyan Kendra Sirsa were analysed for studying the suitable of tubewell water in the block for growing different crops. A total of 150 water samples were tested.

The chemical analysis of samples was done using standard procedures for electrical conductivity (EC), carbonate (CO_3^-), bicarbonate (HCO_3^-), calcium and magnesium (Ca^{2+}+Mg^{2+}), and residual sodium carbonate (RSC) by the procedure developed by Richards (1954). For the ease of understanding, the values of all the parameters have been expressed in per cent of total samples and average per cent of samples.

RESULTS AND DISCUSSION

pH level

The pH levels were divided into three categories: less than 6.5, between 6.5 and 7.5, and between 7.5 and 8.5 (Table 1). In pH range 6.5-**7.5**the number of samples in this slightly acidic to neutral range varied over the years, with 4 samples in 2019, 6 in 2020, and 3 in 2021. The percentage of total samples for each year in this category was 5.8% on average, with individual yearly percentages being 13% in 2019, 8.3% in 2020, and 9.03% in 2021. In 2019, 64 samples fell within this range, followed by 40 in 2020, and 33 in 2021. The average percentage of samples in this category over the three years is 94.2%, with yearly percentages of 87% in 2019, 81.7% in 2020, and 87.6% in 2021. The results suggested that the water quality in terms of pH has remained fairly consistent over the years, with most samples being good for crop growth and soil health. Similar

Table 1. Variation of pH and EC of water samples during the year 2019 to 2021.

Parameter	No of water samples			Average
pH	**2019**	**2020**	**2021**	
<6.5	0 (0)	0 (0)	0 (0)	0
6.5-7.5	4 (5.8)	6 (13)	3 (8.3)	9.03
7.5-8.5	64 (94.2)	40 (87)	33 (81.7)	87.6
EC (dSm $^{-1}$)				
0.2-2	17 (25)	5 (10.8)	8 (22.2)	19.33
2-4	11 (16.2)	4 (8.6)	4 (11.1)	11.96
4-8	26 (38.2)	13 (28.2)	14 (38.8)	35.06
8-12	12 (17.6)	10 (21.7)	9 (25)	21.43
>12	2 (2.9)	14 (30.4)	1 (2.7)	12.0

Table 2.Variation of Carbonate and Bi-Carbonate of water samples during the year 2019 to 2021

CO_3^- concentration meL $^{-1}$	No of samples			Average
	2019	**2020**	**2021**	**Percentage**
0 to 0.2	36 (52.9)	27 (58.6)	16(44.4)	51.96
0.21 to 0.30	24 (35.2)	12(26.0)	13 (36.1)	32.46
0.31 to 0.40	5 (7.35)	5 (10.8)	4 (11.1)	9.75
>0.40	3 (4.4)	2 (4.3)	3 (8.3)	5.66
HCO_3^- concentration meL $^{-1}$				
<2	6 (8.8)	2 (4.3)	1 (2.8)	5.3
2to4	28 (41.1)	16(34.7)	12 (33.3)	36.36
6 to 8	6 (8.8)	0 (0)	3 (8.33)	5.71
>8	2 (2.9)	0 (0)	1(2.8)	1.9

results have also been obtained by Girdhar and yadav (1982).

Electrical conductivity (EC)

EC Range 0.2-2 dSm^{-1} represents low salinity water, which is generally considered safe for most agricultural purposes. The number of samples in this category decreased significantly from 17 in 2019 to 5 in 2020, with a slight increase to 8 in 2021. The percentage of total samples in this range was 25% in 2019, dropping to 10.8% in 2020, and increasing to 22.2% in 2021. The average percentage over the three years was 19.33%.The**EC Range of 2-4** dSm^{-1}**,** there were 11 samples in 2019, with a decrease to 4 samples in both 2020 and 2021. The percentage of total samples in this range was 16.2% in 2019, dropping to 8.6% in 2020 and slightly increasing to 11.1% in 2021. The three-year average percentage was 11.96%. This is a category where choice of crops is restricted to semi tolerant crops in the sandy to sandy loam soils and irrigation should be applied by mixing in canal water or in cyclic moded with canal water. A large area of soils in the block NathusariChopta came under the soil type sandy to sandy loam so this quality of water may be signified as medium level from quality perspective hence all the crops in the *Rabi* season and semi tolerant crops in the *kharif* season can be successfully grown. EC range **4-8** dSm^{-1} indicates moderately high salinity, which can pose risks for both drinking and irrigation. The number of samples in this category was 26 in 2019, decreasing to 13 in 2020 and 14 in 2021. The percentage of total samples in this range was 38.2% in 2019, 28.2% in 2020, and 38.8% in 2021, with an average of 35.06% over the three years. Across the years, particularly in the extreme values (>12 dSm^{-1}),

Table 3.Variation in $Ca^{++}+Mg^{++}$ and RSC Concentration of water samples.

Parameter	No of samples			Average
$Ca^{++}+Mg^{++}$	2019	2020	2021	
0 to 8	20 (29.4)	4 (8.6)	6 (16.6)	18.2
8 to 16	16 (23.5)	9 (19.5)	4 (11.1)	29.03
16 to 24	8 (11.7)	11 (23.9)	7 (19.4)	18.33
24 to 28	6 (8.8)	1 (2.2)	9 (25)	12
>28	18 (26.2)	21 (45.6)	10 (27.7)	33.16
RSC (meL^{-1})				
1.5 to 3.5	11 (91.6)	0 (0)	0 (0)	30.5
3.6 to 4.5	1 (83.3)	1 (100)	1 (100)	94.3

indicating potential anomalies or shifts in water quality conditions. In assessing the water quality, EC is considered as good criterion (Singh *et al* 2014) and level of salinity is marked accordingly.

Carbonate Concentration :

In 2019, 36 samples fell within range 0-0.2 meL^{-1}, the respective number was 27 in 2020 and 16 in 2021. The percentage of total samples in this category was 52.9%, 58.6% and 44.4% in the year 2019, 2020 and 2021respectively; three-year average of samples in therange 0-0.2 meL^{-1} was 51.96%. CO_3^{2-}concentration 0.21 to 0.3 meL^{-1} indicates a moderate level of carbonate concentration.

There were 24 samples in this category in 2019, which decreased to 12 in 2020 and slightly increased to 13 in 2021. The percentage of total samples was 35.2% in 2019, 35.2%, 26.08% and 36.1% in the year 2019,2020 and 2021 respectively with an average of 32.46%. This suggested some variability in the carbonate concentration, but overall, a substantial number of water sources had moderate carbonate levels.CO_3^{2-} levelsranging between 0.31 to 0.4 meL^{-1}may be considered as highercarbonates levels, which can be problematic for water use, particularly in agriculture. The number of samples in this category remained stable with 5 samples in both 2019 and 2020, and a slight decrease to 4 samples in 2021. The percentage of total samples in this range increased from 7.35% in 2019 to 10.8% in 2020 and 11.1% in 2021, averaging 9.75% over the three years. This trend indicated a minor but consistent presence of higher carbonate levels in the water. The percentage of total samples in the category **>0.4** $meL^{-1}$was 4.4% in 2019, 4.3% in 2020, and 8.3% in 2021, with an average of 5.66%. The reason for carbonate(CO_3^-) and bicarbonate (HCO_3^-) concentrationsin groundwater can be ascribed to carbonateweathering as well as from the dissolution ofcarbonic acid in the aquifers. (Serawat*et al,* 2022). These results were in line with Singh *et al* (2006) and Kumar *et al* (2017).

Biocarbonate concentration (HCO_3^-)

Bicarbonate is a crucial component in determining the alkalinity of water, influencing its suitability for irrigation. HCO_3^- Concentration under <2 meq/L typically indicating lower alkalinity in water. The percentage of total samples in this category was 8.8% in 2019, 4.3% in 2020, and 2.8% in 2021, The average percentage of 5.3% over the three years. The decreasing trend suggests that fewer water sources had low bicarbonate levels over time.In the range 2 to 4 meq/L the number of sampleswere highest in 2019 with 28 samples, decreasing to 16 samples in 2020 and 12 samples in 2021. The percentage of total samples in this range was 41.1% in 2019, 34.7% in 2020, and 33.3% in 2021, with an average of 36.36% across the three years. The number of samples in the range 4 to 6 increased from 26 in 2019 to 28 in 2020, before decreasing to 19 in 2021. The percentage of total samples in this range was 38.2% in 2019, rising significantly to 60.8% in 2020, and slightly decreasing to 52.7% in 2021. HCO_3^- concentration 6 to 8 meL^{-1} and

higher this range reflects very high bicarbonate concentration. There were 6 samples in this range in 2019, none in 2020, and 3 in 2021. The percentage of total samples was 8.8% in 2019, 0% in 2020, and 8.33% in 2021, with an average of 5.71%. The absence of samples in this range in 2020 suggests a temporary reduction in very high bicarbonate concentrations, though this increased again in 2021. The results obtained were in line with those from Kumar *et al* (2017).

$Ca^{2+}+Mg^{2+}$ concentrations in water samples are important indicators of water hardness, which affects water quality and usability for agriculture. In the range 0 to 8 meL^{-1} in 2019, 20 samples where as 4 samples in 2020 and 6 samples in 2021. The percentage of total samples in this range was 29.4% in 2019, dropping significantly to 8.6% in 2020, and rising to 16.6% in 2021. The three-year average percentage is 18.2%. The number of samples in the range 8 to 16 meL^{-1} was 16 in 2019, 9 in 2020, and decreased further to 4 in 2021. The percentage of these samples in this category was 23.5% in 2019, 19.5% in 2020, and 11.1% in 2021, with an average of 29.03%. In the range 16-24 meL^{-1} the number of samples were 8, 11 and 7 in the years 2019, 2020 and 2021. The percentage of 11.7%, 23.9% and 19.4% in 2019, 2020 and 2021 respectively with an average percentage over the three years was recorded 18.33%. like wise the number of samples in 24 to 28 and more than 28 was 34, 47 and 50 percent during the respective years with combined average percentage 45 per cent. The presence of Ca^{++} in ground water might be attributed to calcium-rich minerals suchas amphiboles, pyroxenes and feldspars and the Mg^{++} in groundwater might be due to olivine mineral and the ion exchange is with the ions in minerals (Serawat *et al* 2022).

Residual sodium carbonate (RSC)

Residual sodium carbonate of water is very good indicator for its use in crop cultivation. In the block Nathusari Chopta, majority of water samples received did not show considerable values of RSC which can be of concern to the crop and soil health. Only during the year 2019 some samples recorded RSC values ranging from 2.5 to 3.5 meL^{-1}. The soils of block Nathusari Chopta range from sandy to sandy loam hence the RSC values between 2.5 to 3.5 hardly affect soil sustainable health and choice of crops. Exceptionally during the same year some of water samples recorded higher values to the tune of 3-4meL^{-1}. It is suggested that soils irrigated with such waters should be tested and if any adverse effect of high RSC is noticed on the soil then proper management practices should be followed. It is advised that wasters of such tubewells should be checked after every cropping season to reach up to a clearcut conclusion and proper solution. Most of the samples RSC values were in the safe range. Similar results have been obtained by Singh *et al*(2006) and Kumar *et al* (2017).

CONCLUSION

In Nathusari Chopta block, only 38% of water samples were of good quality for irrigation. Medium saline water (12.6% samples) can be used in conjunction with canal water. High salinity water (20.6%) poses challenges for crop selection and requires careful management. Regular monitoring and appropriate management practices are essential to sustain soil health and crop productivity.

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Received on 25/10/2024 Accepted on 23/11/2024

J Krishi Vigyan 2024, 12(4) : 763-770
DOI : 10.5958/2349-4433.2024.00132.X
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Compatibility of *Trichoderma asperellum* with Some Selected Fungicides and Insecticides

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ABSTRACT

An investigation was conducted to assess the compatibility of widely utilized fungicides and insecticides, applied at recommended dosages, with *Trichoderma asperellum* under in vitro conditions. A total of ten fungicides and nine insecticides were individually evaluated for their compatibility.. *Trichoderma asperellum* was compatible with fungicides sulphur and copper oxychloride, where the percentage inhibition was 18.55 and 31.55, respectively. The biocontrol agent showed moderate compatibility with fungicides, potassium phosphonate, mancozeb and propineb. All the systemic fungicides tested were highly incompatible with *Trichoderma asperellum* and exhibited cent percent inhibition. As compared to fungicides, insecticides were relatively more compatible with *Trichoderma asperellum*. Insecticides acephate, flubendiamide, thiamethoxam and spiromesifen did not suppress the *in vitro* growth of *Trichoderma*. Imidacloprid and cartap hydrochloride inhibited the growth of *Trichoderma* partially and expressed moderate compatibility. High level of incompatibility of *Trichoderma* was observed with insecticides quinalphos and dimethoate. The *in vitro* study indicated the possibility of using these compatible chemicals in integrated pest management along with the biocontrol agent, *Trichoderma asperellum*.; further field level investigations are needed for further confirmation.
Key Words: Compatibility, Fungicides, Insecticides, *Trichoderma*, biocontrol agent.

INTRODUCTION

Plant diseases are said to be an important factor in reducing food production. Plant diseases are estimated to cause losses ranging from 10% to 40% (Tyskiewicz *et al*, 2022). Though chemical pesticides are the most commonly adopted method for disease control, it poses various threats to environment (Ghorbanpour *et al*, 2018). The non judicious use of pesticides will also lead to resistance development in pathogens (Bora *et al* 2024). Integrated Disease Management (IDM) strategy is the most sustainable and reliable approach for plant disease management. IDM is the integration of various disease management practices such as chemical management, cultural management, biological management etc. for the management of diseases. Biological control agents (BCAs) form an integral part of IDM. *Trichoderma* species are widely utilized as fungal biocontrol agents against plant pathogens. Various *Trichoderma* species exhibit antagonistic properties toward phytopathogenic fungi and nematodes, primarily through the production of enzymes and antibiotics. Apart from its effect as a biocontrol agent, it also acts as a biostimulant (Lopez-Bucio *et al*, 2022)

The integration of biological antagonists with synthetic chemical treatments can mitigate the risk of resistance development while lowering the required application of chemical pesticides (Ons *et al*, 2020). Evaluating the compatibility of prospective biocontrol agents with fungicides, insecticides, and fertilizers is essential for developing a sustainable and environmentally friendly disease management strategy. Understanding how fungicides and insecticides affect both the pathogens and the antagonists can help the selection of appropriate fungicides and resistant antagonists through in vitro compatibility studies. Additionally, findings of certain

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Table 1. Compatibility of *Trichoderma asperellum* with different fungicides.

Sr. No.	Treatment	Dose of chemical	Radial growth of fungus(cm)*	Inhibition (%)
T1	Mancozeb 75WP	0.30%	3.82^{f}	57.55^{b}
T2	Mancozeb 75WP	0.40%	3.48^{f}	61.33^{b}
T3	Propineb 50WP	0.25%	4.45^{e}	50.55^{c}
T4	Tebuconazole 250EC	0.15%	0.00^{g}	100.00^{a}
T5	Propiconazole 25EC	0.10%	0.00^{g}	100.00^{a}
T6	Sulphur 80WP	0.20%	7.33^{b}	18.55^{f}
T7	Copper Oxychloride 50WP	0.30%	6.16^{c}	31.55^{e}
T8	Hexaconazole 5EC	0.20%	0.00^{g}	100.00^{a}
T9	Trifloxystrobin 25%+Tebuconazole 50% (75 WG)	0.05%	0.00^{g}	100.00^{a}
T10	Potassium Phosphonate 40%	0.30%	4.88^{d}	45.77^{d}
T11	Carbendazim 50WP	0.10%	0.00^{g}	100.00^{a}
T12	Carbendazim 50WP	0.20%	0.00^{g}	100.00^{a}
T13	Control	-	9.00^{a}	0.00^{g}
	CD(0.05)		0.345	3.835

**Mean of 5 replications*

researchers indicate a synergistic effect of *Trichoderma* with fungicides when applied in combination for the management of soil-borne diseases (Wojtkowiak-Gebarowska and Pietr, 2006).

In this context, the study sought to investigate the potential of combining *Trichoderma asperellum* with fungicides and insecticides under in vitro conditions.

MATERIALS AND METHODS

The experiment was conducted during 2019-2020 at the laboratory of Krishi Vigyan Kendra, Pattambi, Kerala. Pure culture of antagonistic microorganism *Trichoderma asperellum* maintained at KVK Pattambi was used for the study. The efficacy of the isolate against major plant pathogens is already proven. The *Trichoderma asperellum* culture was subcultured and maintained on Potato Dextrose Agar (PDA) plates for further studies. (Potato 250g, Dextrose 20g, Agar 20g, Water 1 l).

An *in vitro* study was conducted to assess the compatibility of ten fungicides and nine insecticides with the biocontrol agent, *Trichoderma asperellum* employing the poisoned food technique. The recommended concentrations of each chemical, as detailed in Tables 1 and 2, were incorporated into molten sterile potato dextrose agar (PDA) before being poured into separate sterile petri dishes. Control plates were prepared using PDA without any added chemicals. For each treatment, five plates were maintained. Mycelial discs, 0.5 cm in diameter, were aseptically obtained from a seven-day-old actively growing fungal culture using a sterile cork borer and positioned at the center of the treated PDA plates. The inoculated dishes were incubated at room temperature (28 ± 2°C), and measurements of radial colony growth (in cm) were taken after five days, at which point the control plate recorded full growth of *Trichoderma asperellum*.

Table 2. Compatibility of *Trichoderma asperellum* with different insecticides.

Sr. No.	Treatment	Dose of chemical	Radial growth of fungus(cm)	Inhibition (%)
T1	Quinalphos 25%EC	0.20%	2.28[e]	74.66[a]
T2	Dimethoate 30%EC	0.20%	3.84[d]	57.33[b]
T3	Acephate 75%SP	0.16%	9.00[a]	0.00[e]
T4	Imidacloprid 200SL	0.03%	6.92[b]	23.11[d]
T5	Thiamethoxam 25% WG	0.02%	9.00[a]	0.00[e]
T6	Cartap Hydrochloride 50 SP	0.20%	6.12[c]	32.00[c]
T7	Flubendiamide 20%WDG	0.025%	9.00[a]	0.00[e]
T8	Flubendiamide 480SC	0.01%	9.00[a]	0.00[e]
T9	Spiromesifen 240SC	0.07%	8.66[a]	3.77[e]
T10	Control	-	9.00[a]	0.00[e]
	CD(0.05)		**0.641**	**7.125**

**Mean of 5 replications*

The radial mycelial growth was evaluated by measuring its diameter. Colony growth on control plates, which were not treated with any chemicals, was compared to the growth on plates treated with different concentrations of the test substances, and the differences were quantified as percent inhibition. The percent inhibition of *Trichoderma* was determined based on the colony's growth diameter using the following formula:

$$I=([C-T]/C)\times 100$$

where I represents percent inhibition, C is the radial growth of *Trichoderma asperellum* in the control plates, and T is the radial growth of *Trichoderma asperellum* in the treated plates. The data were statistically analyzed using analysis of variance for a Completely Randomized Design (CRD), employing the statistical software 'WASP 2.0' for the *in vitro* study results.

RESULTS AND DISCUSSION

Inhibition on mycelial growth of *Trichoderma asperellum* by fungicides

The radial growth of the fungus on PDA media as well as the percentage inhibition compared to untreated control are given in Table 1 and Plate 1.

All the fungicides exhibited some degree of inhibition on the growth of *Trichoderma asperellum*. Contact fungicides exhibited only partial inhibition against *Trichoderma asperellum*. Lowest inhibition was noticed in sulphur 80WP (18.55%). Copper oxy chloride exhibited 31.55 % inhibition at 0.3%. Potassium phosphonate (0.3%) exhibited 45.77 % inhibition whereas highest inhibition among contact fungicides were observed in mancozeb 75 WP. The moderate compatibility of copper oxy chloride and potassium phosphonate has a great practical significance as these fungicides are recommended for the management of quick wilt in black pepper and *Trichoderma* spp. are widely used as a prophylactic measure to combat the disease and is highly efficient for its management. The present results indicated the possibility of integration of both these components for sustainable disease management. The work conducted by Susheela and Thomas (2010) confirms the result as they observed zero percent inhibition of copper oxychloride (0.25%) against *Trichoderma harzianum* in *in vitro* studies. Their field trials also proved compatibility of copper oxychloride against *Trichoderma harzianum.* However, Shahida *et al* (2010) reported 67% inhibition by copper oxychloride on *Trichoderma*

viride and had studied the effect of potassium phosphonate on the growth of *Trichoderma viride* and reported complete compatibility. But in our study 45% inhibition was noticed. Theertha *et al* (2017) reported an inhibition of 52.7% by mancozeb 75 WP on the mycelia growth of *Trichoderma asperellum* even at a lower concentration of 800ppm.

The systemic fungicides fully inhibited the in vitro growth of *Trichoderma asperellum*. Cent percent inhibition was recorded in Tebuconazole (0.15%), Propiconazole (0.1%), Hexaconazole (0.2%), Trifloxystrobin+Tebuconazole (0.05%) and Carbendazim (0.1% and 0.2%). This result suggested that the biocontrol agent *Trichoderma* is incompatible with these fungicides. Similar *in vitro* incompatibility results with *Trichoderma* spp. were reported by several other workers. Shashikumar *et al* (2019) reported 94% inhibition on the *in vitro* growth of *Trichoderma viride* with carbendazim at 0.1%. Research conducted by Arunasri *et al* (2011) and Madhavi *et al* (2011) on the compatibility of *Trichoderma* species with propiconazole revealed that the biocontrol agent was incompatible with the fungicide, as it resulted in 100% inhibition of mycelial growth at the tested concentration. The inhibition of mycelia growth of *Trichoderma* by various insecticides, fungicides and fertilizers used in cardamom was studied by Dhanya *et al* (2017) and observed 90% inhibition by hexaconazole. The incompatibility of hexaconazole with *Trichoderma* was also reported by Soumik *et al* (2010).

The difference in inhibition levels reported by various workers may be due to the difference in strains used. Some strains of *Trichoderma* exhibit better compatibility with fungicides and can be incorporated in IDM strategies (Dutta and Chatterjee, 2004). Yang *et al*. (2005) reported that *Trichoderma* can degrade xenobiotic compounds and persist in environments with fungicide residues. This ability may be helping them to overcome the toxicity of even broad-spectrum fungicides like copper oxy chloride and limit the inhibition to 31%. Further field level investigations are needed to study the possibility of incorporating *Trichoderma* sp. in IDM strategies along with fungicides like sulphur and copper oxychloride which shows moderate compatibility.

Inhibition on mycelial growth of *Trichoderma* by insecticides

Insecticides exhibited lower toxicity to *Trichoderma asperellum* when compared to fungicides (Table 2, Plate 2).

The results revealed that five insecticides out of nine were completely compatible to the growth of *Trichoderma asperellum* at the recommended dosages under *in-vitro* condition. The percent inhibition of Spiromesifen was statistically at par with that of Flubendiamide, Thiamethoxam and Acephate indicating the high compatibility of these insecticides with *Trichoderma asperellum*. Imidacloprid and cartap hydrochloride are moderately compatible with *Trichoderma asperellum*.

Quinalphos 25% EC exhibited highest level of toxicity to *Trichoderma asperellum* followed by Dimethoate. These results were consistent with the findings of Soumik *et al* (2010), which showed that the insecticide quinalphos exhibited toxicity at a low concentration of 10 ppm, indicating substantial incompatibility with *Trichoderma harzianum*. In contrast, research conducted by Madhavi *et al* (2008) reported that *T. harzianum* and *T. viride* demonstrated high compatibility with imidacloprid. Dhanya *et al* (*2017*) studied the *in vitro* inhibition of insecticides against *Trichoderma viride* and reported the compatible nature of imidacloprid 17.8 SL and Flubendiamide 39.35 SC with *T. viride*. Their study also revealed the incompatibility of quinalphos with *T. viride*. Rangathswamy *et al* (2011) found that Thiamethoxam demonstrated strong compatibility with *Trichoderma* sp. In a separate study, Bheemaraya *et al* (2012) noted that imidacloprid and dimethoate were compatible with T. harzianum, while quinalphos exhibited incompatibility. The study by Theertha *et al* (2017) also reveals the incompatibility of quinalphos and dimethoate with *T. asperellum*. The present study also supports these findings.

The study revealed the levels compatibility of various fungicides and

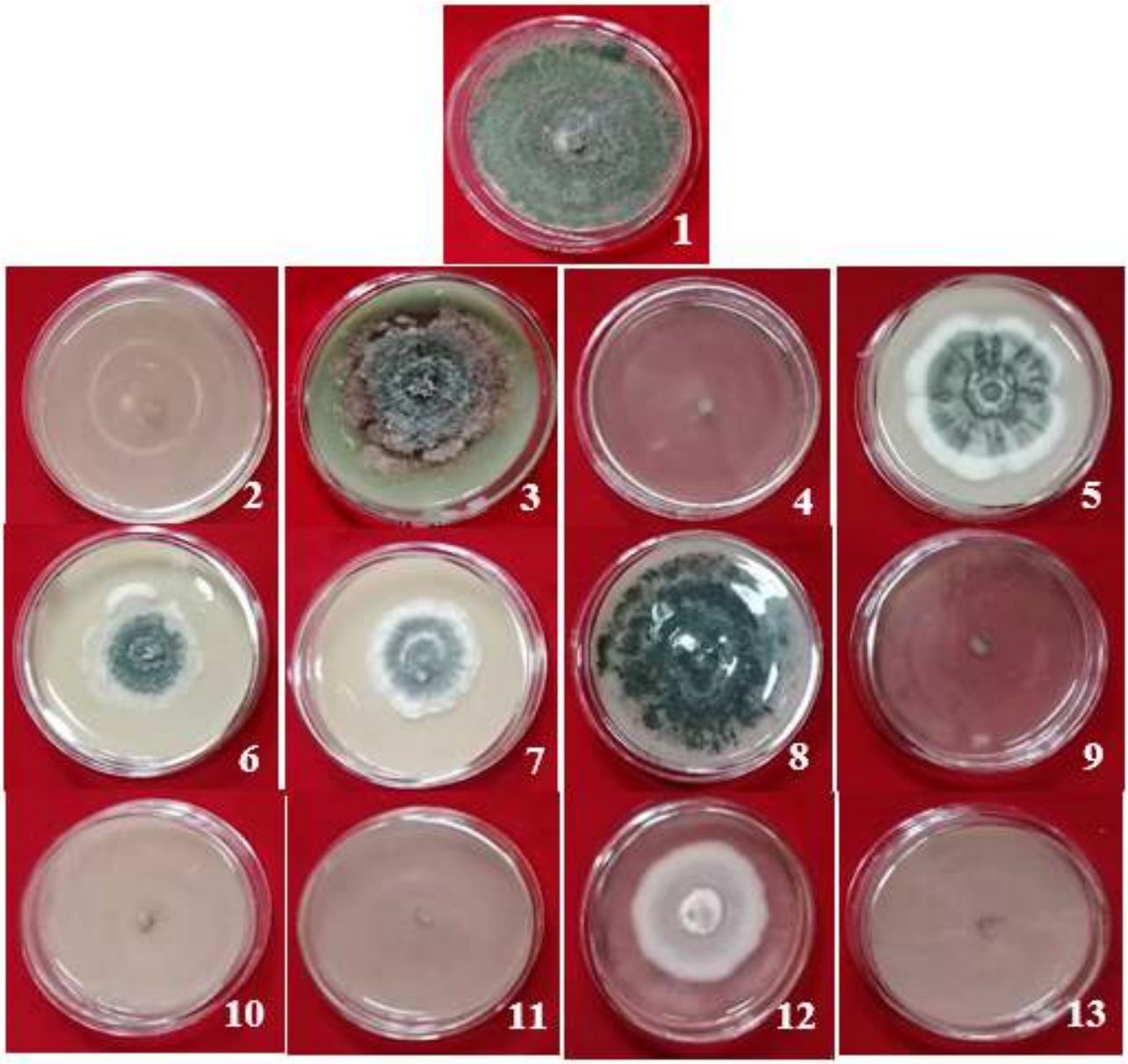

Plate 1 (1-13) *In vitro* effect of fungicides on growth and sporulation of *Trichoderma* 1-Control.2-Propiconazole 25EC (0.10%). 3-Copper Oxychloride 50WP (0.30%). 4-Hexaconazole 5EC (0.20%). 5-Propineb 50WP (0.25%). 6-Mancozeb 75WP (0.40%). 7-Mancozeb 75WP (0.30%). 8-Sulphur 80WP (0.20%). 9-Trifloxystrobin 25% + Tebuconazole 50% (0.05%). 10-Carbendazim 50WP (0.10%). 11-Carbendazim 50WP (0.20%). 12-Potassium Phosphonate 40% (0.30%). 13-Tebuconazole 250EC (0.15%)

insecticides at their recommended doses against KAU isolate of *Trichoderma asperellum*. This information will aid in selecting the appropriate combinations of fungicides or insecticides to use alongside the biocontrol agent, *Trichoderma*, in integrated pest management strategies. Additionally, the findings from the *in vitro* study should be validated through *in vivo* research in field conditions.

CONCLUSION

Integrating pesticides with biocontrol agents represents a more sustainable approach to disease management. The combined use of chemical treatments and biocontrol agents can enhance the duration of effective disease control

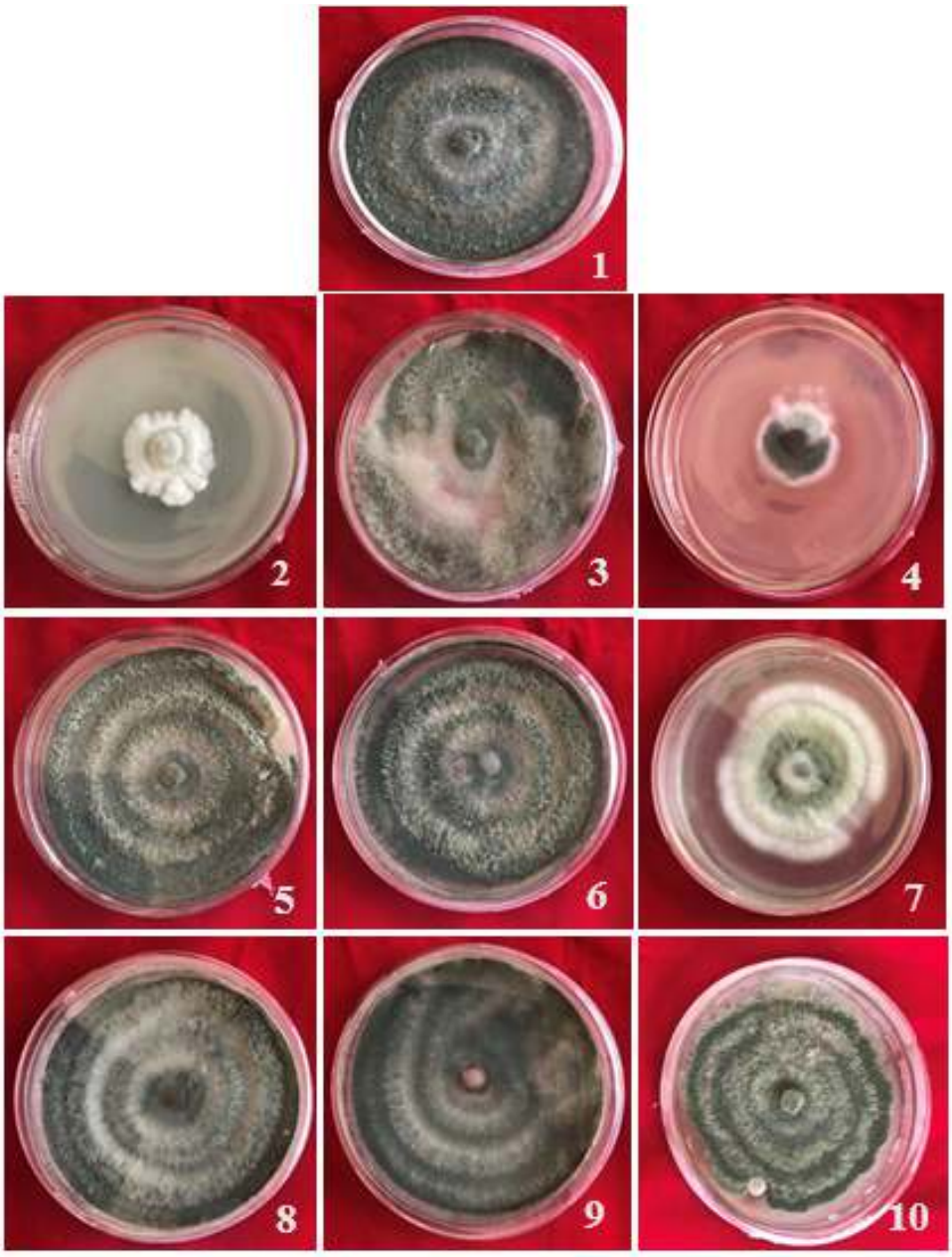

Plate 2 (1-10) Effect of selected insecticides on *in vitro* growth and sporulation of *Trichoderma asperellum*. 1-Control. 2-Quinalphos 25%EC(0.20%). 3-Spiromesifen 240SC(0.07%). 4-Dimethoate 30%EC(0.20%). 5-Flubendiamide Fame(0.01%).6-Flubendiamide Takumi(0.025%). 7-Cartap Hydrochloride(0.20%). 8-Acephate 75%SP(0.16%). 9-Thiamethoxam 25%WG(0.02%). 10-Imidacloprid 200SL(0.03%).

while also lowering crop protection costs. Therefore, assessing the compatibility of biocontrol agents with agrochemicals is essential when deciding on management strategies. This study demonstrated the compatability of the KAU isolate of *Trichoderma asperellum* with various agrochemicals, particularly fungicides and insecticides. Among the tested fungicides, Sulphur 80 WP and Copper oxychloride were found to be moderately compatible with *Trichoderma asperellum* and safe to be applied together in the system. Almost 50% of the mycelial growth of *Trichoderma asperellum* was inhibited by Potassium phosphonate, Mancozeb

and Propineb. All the systemic fungicides tested, viz., Carbendazim 50 WP and triazole fungicides were 100 per cent incompatible with *Trichoderma asperellum*. Most of the insecticides tested were compatible and safe to be used with *Trichoderma asperellum*. Among the insecticides tested, Quinalphos and Dimethoate were incompatible whereas Imidacloprid and Cartap hydrochloride were moderately compatible with *Trichoderma asperellum.* To reach definitive conclusions, it is essential to study the effects of agrochemicals on *Trichoderma asperellum* in field conditions.

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Received on 18/10/2024 Accepted on 20/11/2024

J Krishi Vigyan 2024, 12(4) : 771-774
DOI : 10.5958/2349-4433.2024.00133.6
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Constraints faced by Beneficiary Farmers in Adoption of Improved Chickpea Production Technology in Malwa Pleatue of Madhya Pradesh

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ABSTRACT

The present study was under taken in the Malwa Plateau Agro-climatic zones of Madhya Pradesh where chick pea is one of the most important pulse crops and covers highest area. A list of villages where CFLD pulses programme was implemented for the last five year was taken from the respective KVKs. 15 beneficiary farmers and 15 non beneficiary farmers were selected randomly from each village. Thus, total 120 beneficiary and 120 non-beneficiary farmers were selected for the study. An ex-post facto research design was used. It was found that, majority of the problems faced by chickpea growing farmers were related to production constraints. Majority of the chickpea grower's reported that high infestation of insect,disease (91.66%) with rank I followed by non availability of fertilizers at proper time (85%) with II rank ,unfavourable weather condition (81.66%) with III rank, incidence of weeds menace (79.16%) with IV rank, not availability of loan at proper time (55.83%) with V rank, not available of seed at time (52.50%) with VI rank, lack of proper resource and money (50.83%) with rank-VII, high cost of agricultural inputs (46.67%) with the rank-VIII, lack of good quality of seeds with the rank-IX .

Kew Words: Adoption, Improved Practices, Production Technology, Constraints.

INTRODUCTION

In India, owing to its diverse agro-climatic conditions, pulses are grown throughout the year and plays an important role in crop rotation, mixed and inter-cropping, maintaining soil fertility through nitrogen fixation, release of soil-bound phosphorus and thus contribute significantly to sustainability of the farming systems. In the production process, pulses require less water than cereals. Cluster Front Line demonstrations (CFLDs) is a unique approach to provide an direct interface between researcher and farmers as the scientists are directly involved in planning, execution and monitoring of the demonstrations. Bhargav *et al* (2018) reported that Chickpea is mainly grown during *Rabi* season in India under diverse production systems including both rain fed and irrigated, but its maximum area and production is mostly confined to Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Andhra Pradesh and Uttar Pradesh. In Madhya Pradesh chickpea occupy 2.6 M ha area which contribute 2.8 MT production, but average productivity is very low as compared to potential yield. Indian government imports large quantity of pulses to fulfill domestic requirement of pulses (Khedkar *et al* , 2017). Singh (2018) reported that decline in area under chickpea in Tal area of Patna was due to various constraints like low yield, low market price, time factor, late maturity, high infestation by insect, pest and diseases and use of local seed . Singh and Kumawat (2019) revealed that the farmers had poor knowledge about soil treatment, high yielding varieties and bio-fertilizer, while

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Table 1. Constraints faced by chickpea growers.

Sr.No.	Constraint	No. of chickpea growers	Percentage	Rank
A	**Production constraint**			
1.	High infestation of insect,disease.	110	91.66	I
2.	Non availability of fertilizers at proper time	102	85.00	II
3.	Unfavourable weather condition	98	81.66	III
4.	Incidence of weeds menace.	95	79.16	IV
5.	Not availability of loan at proper time	67	55.83	V
6.	Not availability of seed at time	63	52.50	VI
7.	Lack of proper resource and money	61	50.83	VII
8	High cost of agricultural inputs	56	46.67	VIII
9	Lack of good quality of seeds	54	45.00	IX
B	**Technical constraint**			
10.	Lack of knowledge on location specific improved varieties of chickpea	80	66.66	I
11.	Lack of knowledge about improved technology	58	48.33	II
12	Lack of trainings / demonstration for improved agriculture	55	45.83	III
13.	Lack of cooperation and demotivation of agriculture extension officer and workers for field survey.	51	42.50	IV
14.	Lack of irrigation facilities	48	40.00	V
15.	Lack of information	38	31.67	
C	**Marketing constraints**			
16.	Lack of knowledge about proper place of marketing.	110	91.67	I
17.	In sufficient storage facilities.	95	79.16	II
18.	Lack of cooperative marketing organization.	92	76.67	III
19	Lack of market facilities	90	75.00	IV
20.	Low market price of product	85	70.83	V
21.	Loading charges has to be bear by the growers.	83	69.17	VI
22.	Less transportation facilities	80	66.67	VII

majority of them had knowledge about critical stage of irrigation. The majority of the respondents had awareness regarding recommended doses of manures and fertilizer, biofertilizer, seed rate, improved varieties, spacing and method of sowing. Likewise, Teggelli *et al* (2017) revealed

variation in the yield obtained probably due to variation in agro-climatic parameters under rain-fed conditions. The highest yield of FLDs plots of chick pea achieved by adopting improved production technology was 12.87q/ha compared to farmers' practice (10.06 q/ha). Hence, the study was conducted to know the constraints faced by chickpea producers in malwa plateau agro-climatic zone of Madhya Pradesh .

MATERIALS AND METHODS

The present study was under taken in the Malwa Plateau Agro-climatic zones of Madhya Pradesh. Among all 8 KVKs in Malwa Plateau Agro-Climatic Zone *i.e.,* Indore, Dewas, Ujjain, Shajapur, Rajgarh, Ratlam, Mandsaur and Neemuch; four KVKs were selected randomly. Two villages from each KVK ,one village at nearest vicinity and other village at remote vicinity from each KVK were selected for the present study. Thus, total eight villages were selected for the study. A list of villages where CFLD pulses programme was implemented for the last five year was taken from the respective KVKs. 15 beneficiary farmers and 15 non beneficiary farmers were selected randomly from each village. Thus, total 120 beneficiary and 120 non-beneficiary farmers were selected for the study. An ex-post facto research design was used to explore or search through a problem or situation to provide insights and understanding in the investigation. The responses were scored on 4 points scales fitting to the statements as very much (4), much (3) not so much (2) and not at all (1) important. Based on mean score values, ranking was done regarding different constraints faced by the chick pea growers.

RESULTS AND DISCUSSION

The constraints analysis reported based on the opinion survey of the sample Chickpea growers. Several constraints barring the sustainable production were related to resources management, faults and stresses of a biotic and biotic nature. The farmer's opinion obtained regarding the factors affecting adversely production as well as non adoption of various improved chickpea production technology and practices are presented in table 1.

It was found that in case of production constraints majority of the chickpea grower's reported that high infestation of insect,disease (91.66%) with rank I followed by non availability of fertilizers at proper time 85% with II rank ,unfavourable weather condition 81.66% with III rank, incidence of weeds menace 79.16% with IV rank, not availability of loan at proper time 55.83% with V rank, not available of seed at time 52.50% with VI rank, lack of proper resource and money 50.83%with rank-VII, high cost of agricultural inputs 46.67%with the rank-VIII, lack of good quality of seeds with the rank-IX.

In case of technical constraints most of them had lack of knowledge on location specific improved varieties of chickpea 66.66% with the rank -I followed by 48.33% farmers had lack of knowledge about improved technology with the rack-II, lack of training/ demonstration for improve the agriculture 45.83% with the rank -III, lake of cooperation and de-motivation of agriculture extension officer and workers for field survey 42.50% with the rank-IV lake of irrigation facilities 40% with the rank-V, lake of information 31.67% with the rank -VI respectively.

Similarly in case of marketing constraints majority of farmers reported lack of knowledge about proper place of marketing 91.67% with the rank-I, followed by insufficient storage facilities 79.16% with the rank -II, lack of cooperative marketing organization 76.67% rank -III, lack of market facilities 75% rank-IV ,low market price of product 70.83% with the rank -V, loading charges has to be bear by the growers 69.17% with the rank -VI and less transportation facilities 66.67% rank-VII respectively. These results were in agreement with Asrat *et al* (2022).

CONCLUSION

It can be concluded that during the chickpea production technology farmers faced several constraints, such as- production, technical, and marketing constraints. It was found that, majority of the problems faced by chickpea growing farmers were related to production constraints. Further, it was also revealed that, majority of the innovative farmers faced issues like demotivation from others, lack of awareness

about financial support, lack of technical guidance, lack of timely guidance and unavailability of proper storage facility for produce. Hence, the findings indicated that farmers are keen to innovate more but due to various constraints improved chickpea production technologies.

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Received on 20/7/2024 Accepted on 15/11/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 775-783

DOI : 10.5958/2349-4433.2024.00134.2

Constraints Perceived by Beneficiaries in Adoption of Fisheries Development Programmes in Konkan Region, Maharashtra

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ABSTRACT

Maharashtra state has vast fisheries resources at its disposal and considered as one of the vital maritime state in India. The current study was carried out with the objective of understanding the various constraints faced by the beneficiaries in the Konkan region, Maharashtra in adoption of schemes/programmes. The constraints faced by beneficiaries were categorized as social, financial, infrastructure, core fisheries and administrative constraints. The weighted average technique was used to analyze and rank various constraints faced by beneficiaries. Information was collected from 200 fishers from 4 coastal districts of Konkan region, Maharashtra. The study revealed that core fisheries constraints ranked first with weighted average score of 81.72 followed by financial constraints (80.05) as second, infrastructure (78.76) as third, administrative (75.54) as forth and social constraints (73.89) as least ranked constraints. Among the core fisheries related constraints availability of input (diesel) was highest. In financial constraints increasing price of diesel ranked first. Highest infrastructure related constraints were poor landing and berthing facilities whereas under the social related constraints conflicts in the area of fishing ranked first. The study suggested that, more efforts are needed to address the various constraints faced by beneficiaries in adoption of schemes/programmes.

Key Words: Adoption, Beneficiaries, Constraints, Development, Konkan region.

INTRODUCTION

Aquaculture and fisheries sector is a source of income and livelihood for many people all over the world. The fisheries sector is one of the key contributors in the national economy as well as foreign exchange earnings. The sector provides livelihood to about 28 million fishers and fish farmers at the primary level and twice the number along the value chain. The sector has contributed to the extent of 1.1% to national Gross Domestics Products and 6.72% of agriculture GDP with a growth of 10.34% (DoF, Ministry of Fisheries, Animal Husbandry & Dairying, India, 2022).

Fisheries extension plays a significant role in the development of the fisheries and aquaculture sector. Department of Fisheries (DoF) plays a major role in executing the extension programs at field levels. Maharashtra is one of the important maritime state with respect to fisheries considering its vast fisheries resources at its disposal. Maharashtra has coastline of 720 km and the area suitable for marine fishing is 1.12 lakh sq. km. In addition to this, the area suitable for inland and brackish water fishing in the State is 4.19 lakh ha and 0.10 lakh ha respectively (DoF, Maharashtra, 2022). The total fish production of the state during 2021-22 was 5.89 lakh tonnes of which 4.32 lakh tonnes was from the marine sector and 1.57 lakh tonnes from the inland sector (DoF, Maharashtra, 2022). Several fisheries development programmes are implemented by the department of fisheries, Maharashtra. More numbers of stakeholders are seen to be involved as beneficiaries of schemes in fisheries sector with the implementation of schemes like Blue revolution and Pradhan Mantri Matsya Sampada Yojana (PMMSY). But often beneficiaries faced various constraints while adoption of various programmes/schemes. There are very few constraints based studies in other

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Table 1. Constraints faced by beneficiaries in adoption of schemes/programmes.

Sr. No	Constraint	WA	Rank	NMS*	Mean Rank	Chi-Square Value	Decision
1	Core Fisheries	81.72	I	0.73	3.57	77.03	Reject H_0
2	Financial	80.05	II	0.70	3.28		
3	Infrastructure	78.76	III	0.68	3.14		
4	Administrative	75.54	IV	0.63	2.61		
5	Social	73.89	V	0.62	2.40		

Table 2. Weighted average ranking and Friedman test results for social constraints.

Sr. No.	Constraint	WA	Rank	NMS*	Mean Rank	Chi-Square Value	Decision
1	Conflicts in the area of fishing	91.00	I	0.92	4.74	289.29	Reject H_0
2	Off season no employment	85.50	II	0.78	4.23		
3	Training	73.33	III	0.60	3.48		
4	Non availability of proper information	70.83	IV	0.56	3.34		
5	Awareness about rights	61.83	V	0.43	2.65		
6	Less Coordination with Government departments	60.83	VI	0.41	2.56		
	Overall	**73.89**		**0.62**			

states and Union Territories like Kumar *et al* (2017) reported lack of awareness about scientific fish culture practices as a major extension constraint faced by fish farmers in Bihar. Angral *et al* (2017) reported lack of awareness regarding fisheries programs, lack of proper training/exposure visits, and no cooperation & coordination among the implementing agencies, like departments and financial institutions, as constraints perceived by fishers of Jammu & Kashmir. Patil and Sharma (2020) revealed that, lack of regular training program, less extension and technical support as major extension constraint by shrimp farmers of Konkan region of Maharashtra. Patil and Sharma (2021) in their study reported that, less training on scientific shrimp farming practices, inadequate staff strength and insufficient infrastructural facilities as major constraint's faced by fisheries extension personnel in Konkan region, Maharashtra. Yadav (2022) reported less coordination of fishers with fisheries organizations less mobility, low literacy of fishers, gender issues and less fisheries information were major extension constraints faced by fishers in Rajasthan. Rathod *et al* (2024) reported that, financial and administrative are the major constraints perceived by beneficiaries in adoption of fisheries development programmes in Vidarbha region, Maharashtra. Patil and Sharma (2021) recorded the constraints faced among shrimp farmers of Palghar district in Maharashtra.

There are few studies in Maharashtra with reference to the constraints faced by the beneficiaries. The constraint studies particularly in Konkan region with respect to various stakeholders involved in fisheries are very meagre. Nevertheless, it seems from the studies that the beneficiaries/fishers/fish farmers faced number of constraints and these can differ as per administrative difficulties they faced in adoption/acceptance of fisheries development programmes, fisheries based technical problems, extension and training on recent technologies etc.

In view of the above, the present investigation was an attempt to analyses the constraints perceived by beneficiaries in adoption of fisheries development programmes in Konkan region, Maharashtra.

MATERIALS AND METHODS

A total of 200 fishers who were beneficiaries of fisheries development programmes/schemes from 4 coastal districts of Konkan region *i.e.* Palghar- Thane, Raigad, Ratnagiri and Sindhudurg district were selected for the study. A thorough review of literature and discussions with an expert group were done in order to list out various constraints faced by beneficiaries/fishers in adoption of fisheries development programmes/schemes. A total of 32 constraints were then categorized under five heads viz. social, financial, infrastructure, core fisheries and administrative constraints.

Reliability of scale was tested with help of test retest method. The list of constraints was given to 10 beneficiaries other than respondents to provide the scores for their level of agreement towards each constraint. The same was repeated after 15 days. Based on the two sets of scores provided by beneficiaries, correlation coefficient was calculated. Correlation coefficient can take value between 0 and 1. So the closer to 1 means the more reliable of the scale. Test-retest reliability coefficient was 0.80 indicated that whole scale was reliable.

Interview schedule was used to collect information regarding constraints perceived by beneficiaries in adoption of fisheries development programmes in Konkan region, Maharashtra. A three point Likert scale was used to test the level of agreement of beneficiaries / fishers towards the respective constraints. This scale was 1 to 3, where, 3- strongly agree, 2 – agree and 1 – Not agree. The Weighted Average (WA) technique was used to rank various constraints faced by beneficiaries. Weighted Mean Score Value was calculated for each constraint. The weighted average was calculated as given below:

Weighted average = Sum (X1.W1 + X 2.W2 + X3.W3) / sum (W1+W2 +W3)

Where,

X 1, X 2, X 3, = Frequency of the respective constraints

W1, W2, W3, = Weighted values i.e. 1, 2, 3

The Friedman rank test, a non-parametric test (distribution-free) used to compare observations repeated on the same subjects. It was used to test if there was a significant difference between each constraint.

RESULTS AND DISCUSSION

It can be seen (Table 1) that core fisheries constraints ranked first with weighed average score of 81.72, while financial constraints ranked second (80.05). This was followed by infrastructure constraints (78.76), administrative constraints (75.54) and social constraints (73.89). Friedman rank test, a non-parametric test (distribution-free) used to test if there was a significant difference between each constraint. The results of friedman rank test revealed that there was a significant difference among different constraints at a 5% level of significance and the null hypothesis (H_o) is rejected ($P< 0.05$). This indicates the constraints affected the beneficiaries differently based on the difficulty they face while adopting the fisheries development programmes/ schemes.

Social constraints

It was evident (Table 2) that among the social constraints, conflicts in the area of fishing (91.00) were ranked first by the beneficiaries of Konkan region followed by the off season no employment (85.50) and training (73.33) whereas the least ranked constraint was less coordination with government departments (60.83). The non-parametric Friedman test revealed that there was a significant difference among the constraints at a 5% level of significance and the null hypothesis (H_0) is rejected ($p < 0.05$) indicated that there was effect of social constraints on beneficiaries in adoption of fisheries development programmes/schemes. The beneficiaries revealed that there are disputes and conflicts among fishers, fishing communities, or among other stakeholders

Table 3. Weighted average ranking and Friedman test results for financial constraints.

Sr. No.	Constraint	WA	Rank	NMS*	Mean Rank	Chi-Square Value	Decision
1	Increasing price of diesel	89.33	I	0.84	4.85	132.33	Reject H_0
2	Insufficient subsidies and incentives	86.33	II	0.80	4.58		
3	High Interest rate	81.83	III	0.73	4.14		
4	Lack of institutional credit	81.00	IV	0.72	4.05		
5	High wage rate of crew	77.50	V	0.66	3.74		
6	High cost of fishing equipment's	73.00	VI	0.60	3.43		
7	High input and maintenance cost for gears and crafts	71.33	VII	0.57	3.21		
	Overall	**80.05**		**0.70**			

in fishing areas may disrupt the peaceful and productive functioning of the sector. Conflicts may arise due to competition over resources, territorial disputes, or other social and economic factors. To overcome this issue government has to make policies to overcome the conflicts among the fishers. They also revealed that the constraint of off-season unemployment highlights the lack of employment opportunities for fishers during non fishing seasons. This seasonal unemployment can result in economic hardships and instability for fishers and their families, particularly during periods when fishing activities are limited.

Studies on constraints faced by fishers/fish farmers have been reported by many workers. Patil khede *et al* (2018) while studying constraints faced by the fishermen of Konkan region reported that overexploitation of the middlemen, lack of cooperation among villagers, no schemes for welfare of fishermen also offseason no employment and conflicts in the area of fishing are the major social constraints. Angral *et al* (2017) reported lack of awareness regarding fisheries programs, lack of proper training/exposure visits, and no cooperation & coordination among the implementing agencies as constraints perceived by fishers of Jammu & Kashmir. Uttej *et al* (2023) reported that off season unemployment and conflicts in the fishing areas are the major social constraints faced by Telangana fishermen. Patil (2020) revealed lack of regular training program, less extension and technical support as major extension constraint by shrimp farmers of Konkan region of Maharashtra. Rathod *et al* (2024) also reported less training, awareness about rights and getting proper information about schemes as extension constraints faced by the beneficiaries of Vidarbha region.

Infrastructure constraints

Among the infrastructure constraints, poor landing and berthing facilities (88.50) ranked first, no market availability (84.17) ranked second. In addition, source of fresh water (81.17) was ranked third followed by no market shed facilities (79.50) as fourth-ranked and poor transportation (71.67) as the least infrastructure constraint. Further, Friedman test results revealed that there was significant difference among the sub categories of financial constraints ($p < 0.05$). Therefore, the null hypothesis (H_0) was rejected. The mean ranks of the constraints were found to be in similar pattern of weighted average.

Constraints Perceived by Beneficiaries in adoption

Table 4. Weighted average ranking and Friedman test results for infrastructure constraints.

Sr. No.	Constraint	WA	Rank	NMS*	Mean Rank	Chi-Square Value	Decision
1	Poor landing and berthing facilities	88.50	I	0.83	4.87	106.99	Reject H_0
2	No market availability	84.17	II	0.76	4.41		
3	Source of fresh water	81.17	III	0.72	4.21		
4	No market shed	79.50	IV	0.69	4.06		
5	Lack of preservation and curing facilities	74.17	V	0.61	3.65		
6	Poor storage facilities	72.17	VI	0.58	3.42		
7	Poor Transportation	71.67	VII	0.58	3.39		
	Overall	**78.76**		**0.68**			

The beneficiaries reported that poor landing and berthing facilities was the foremost problem which lead to difficulty in loading and unloading fish catch and also delay to transport fish to market within time to avoid economic loss They also reported unavailability of market facility and market sheds as a major problem. This lead to poor marketing chain and dependency on middleman or commission agents. If the market is developed near to the landing area, the fisher can sell their catch by oneself within time to avoid losses. Further, the beneficiaries reported that facility of source of water for fishing activities they paid more money for purchase of water.

Panday and Dewan (2006) also reported that the infrastructure constraints faced by the fish farmers of Uttar Pradesh, like ponds connectivity to road, cold storage, transportation facilities, markets. Rahaman *et al* (2013) revealed that the lack of storage facility, the unsuitable position of the market yard, lack of processing units are the major infrastructure constraints faced by the fishers of West Bengal. Patil (2020) also noted the lack of storage facility at pond site, lack of good roads, lack of good transportation facility, and non-availability of a cold storage facility were the major infrastructure constraints faced shrimp farmers of Maharashtra. Yadav (2022) reported lack of proper market availability in nearby areas, no regulated/organized market availability, lack of ice storage facility, lack of transportation facilities and improper roads as infrastructure constraint in Rajasthan. Rathod *et al* (2024) recorded infrastructure constraints perceived by fisher of Vidarbha region and revealed that lack of warehousing facility, lack of market availability. The results of the present study are in support to the other studies reported by researchers in other states. The fisheries infrastructure facilities in the state can be developed with the support of Fisheries and Aquaculture Infrastructure Development Fund and Pradhan Mantri Matsya Sampada Yojana, like organized/modern fish markets and ice-storage facility to reduce post-harvest losses and strengthen fish markets.

Core fisheries constraints

The availability of input (diesel) ranked as the first constraint with a weighted average score of 90.17 followed by availability of ice with a weighted average score of 83.83, which ranked second, and availability of nets and gears with a weighted average score of 71.17, which ranked third. The beneficiaries reported that the availability of input *i.e.* diesel for fishing activity in time as you know that diesel is one of the most important for the fishing activity. Most of the times the diesel was not available at the time of fishing so that fisher get delay to go for fishing. The government also giving subsidies of VAT but

Table 5. Weighted average ranking and Friedman test results for core fisheries constraints.

Sr. No.	Constraint	WA	Rank	NMS*	Mean Rank	Chi-Square Value	Decision
1	Availability of input (diesel)	90.17	I	0.85	2.31	75.19	Reject H_0
2	Availability of ice	83.83	II	0.76	2.07		
3	Availability of nets and gears	71.17	III	0.57	1.62		
	Overall	**81.72**		**0.73**			

Table 6. Weighted average ranking and Friedman test results for administrative constraints.

Sr. No.	Constraint	WA	Rank	NMS*	Mean Rank	Chi-Square Value	Decision
1	More paperwork	95.17	I	0.93	7.10	493.03	Reject H_0
2	More frequent visits to DOF to get scheme sanctioned	92.33	II	0.89	6.78		
3	Undue delay in sanction of scheme	80.67	III	0.71	5.45		
4	Inadequate information and education about the development programme	80.33	IV	0.71	5.40		
5	Lack of cooperation between government officers and beneficiaries	77.17	V	0.66	5.07		
6	Improper coordination between financial institutions and local officials	68.67	VI	0.53	4.32		
7	Lack of proper supervision	67.00	VII	0.51	4.10		
8	Literature of scheme is not available in Marathi language	62.83	VIII	0.44	3.74		
9	Undue delay in selection of beneficiaries	55.67	IX	0.34	3.06		
	Overall	**75.54**		**0.64**			

the many times subsidies were not disbursed in time which led to losses.

The non-parametric Friedman test revealed that there was a significant difference among the constraints at a 5% level of significance and the null hypothesis (H_0) is rejected ($p < 0.05$) indicated that there is effect of core fisheries constraints on beneficiaries in adoption of fisheries development programmes/schemes. Bhat and Sharma (2021) reported lack of fish storage facilities, no subsidy for crafts and gears, less availability of ice are the fishery related

constraints perceived by the fisher of Jammu. Boda et al. (2024) revealed that the diesel prices, catch reduction, labour cost, supply of diesel are the main challenges faced by the fishermen of west Bengal.

Administrative constraints

The result revealed that among administrative more paperwork (95.17) was ranked first by beneficiaries followed by the more frequent visits to DOF to get scheme sanctioned (92.33) and undue delay in sanction of scheme (80.67) whereas the least ranked administrative constraint undue delay in selection of beneficiaries with weighted average score of 55.67. The non-parametric Friedman test revealed that there was a significant difference among the constraints at a 5% level of significance and the null hypothesis (H_0) is rejected ($p < 0.05$) indicated that there is effect of administrative constraints on beneficiaries in adoption of fisheries development programmes/schemes.

Beneficiaries reported that more paperwork is required for the submission of scheme applications. Some beneficiaries also mentioned using an online process to submit their applications, but such a provision or online system has not yet been developed by the Department of Fisheries. Beneficiaries also reported that they must visit the department office on a regular basis to receive application updates. Many beneficiaries have expressed concern about obtaining accurate information about schemes.

Panday and Dewan (2006) studied constraints in fish farming practices in Uttar Pradesh, India. The study reported that inadequate subsidy, lack of knowledge and extension support, non-existence/inactive cooperative societies are the major administrative constraints. Panday *et al* (2014) reported poor implementation of the fisheries development scheme, lack of policy support, inadequate extension contacts, lack of a need-based program for any organization as major administrative constraints faced by fish farmers of Manipur. Patilkhede *et al* (2018) reported that inefficient execution & implementation of government programs, government grants not being properly distributed, lack of package of fish production, no training facilities and infrastructural facilities were the main constraints in sustainable livelihood activities of fisherman of Konkan region of Maharashtra. Yadav (2022) reported that administrative constraints had a very high severity such as delay in sanction of scheme by fisheries organizations, less supervision by officials and improper coordination between fisheries institutions are major administrative constraints faced by fishers of Rajasthan. Rathod *et al* (2024) reported that administrative constraints had a verry high severity such as more paperwork, more frequent visits to DOF to get scheme sanctioned are the major administrative constraints faced by the fishers of Vidarbha.

CONCLUSION

The beneficiaries faced various constraints while adoption of fisheries development programmes/schemes. However, among these, core fisheries constraints ranked first while financial constraints ranked second. This was followed by infrastructure constraints, administrative constraints and social constraints. The non-parametric friedman test revealed that there was a significant difference among the constraints. Highest severity was found in the constraints such as conflicts in the area of fishing, offseason employment, increasing price of deiseal, insufficient subsidies, poor landing and berthing facility and more paperwork. The beneficiaries revealed that there are disputes and conflicts among fishers, fishing communities, or among other stakeholders in fishing areas also off-season unemployment highlights the lack of employment opportunities for fishers during non-fishing seasons. It was also reported that increasing cost on diesel which may increase the cost on fishing which can have the significant implications on the profit of fishers. Insufficient subsidies and incentives also one of the major financial constraints that fishers may believe that they are not receiving enough support and incentives from the government to enhance their fishing activities. They also reported that the availability of input i.e. diesel for fishing activity in time in this context, timely disbursement of subsidies from government department will be more helpful for beneficiaries. One of major

constraints reported by the beneficiaries was more paperwork required for the submission of scheme application. It is recommended that fisheries cooperatives should get training on new forms of marketing like online and fast home delivery methods to compete with modern trends. In order to achieve the relevant and cost effective solutions to all the constraints of the fishers, a multi-organizational approach is highly required which will help in the implementation of new policies and strategies considering the opportunities and constraints prevailing to fishers.

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Received on 24/8/2024 Accepted on 10/11/2024

J Krishi Vigyan 2024, 12(4) : 784-789
DOI : 10.5958/2349-4433.2024.00135.9
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Constraints in Usage of ICT and Sea Safety Tools by Trawler Operators of Ratnagiri, Maharashtra

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ABSTRACT

The study was carried out to assess the constraints faced by trawler operators in usage of ICT and sea safety tools by trawler operators of Ratnagiri block, Maharashtra. For the study trawler operators from the seven different landing centers of Ratnagiri block were randomly selected. Information was collected from 102 trawler operators with the help of structured interview schedule. Descriptive statistical tool was used to study the socio-personal information and weighted average technique were used to assess the constraints faced by trawler operators in usage of ICT and sea safety tools. Result of the study revealed that, majority of trawler operators (66.67%) belongs to middle age group (41-60 years). About 78.43% trwaler operators had annual income between ₹ 100001-250000. It was observed that lack of tarining/ awareness programs, high price of ICT tools, low durability of sea safety tools was the main reasons for limiting the usage of ICT and sea safety tools among the trawler operators. Threfore it was necessary to enforce rules such as Maharashtra Marine Fishing Regulation Act, 1981 and rules, Merchant Shipping Act and Marine Fishing Policy etc in a participatory mode so as to increase usage of ICT and sea safety tools among trawler operators.

Key Words: Constraints, Usage, ICT, Sea Safety Tools, Trawler Operators, Ratnagiri

INTRODUCTION

Marine fisheries are very important to the economy and well-being of coastal communities, providing food security, job opportunities, income and livelihoods as well as traditional cultural identity (Guguloth *et al*, 2018). The transformation of the marine fishing sector in our economy into a thriving one has been largely attributed to modern technical equipment. Technologies that facilitate communication, processing, and transmission of information by electronic means is called as information communication.Modern technical externalities like ICTs in marine fisheries have significantly changed the way of life of the population of fishermen, both personally and in terms of their livelihood activities as the global fishing community plays a vital role in economic advancement(Guguloth *et al,* 2017). ICT as a basic resource for development, a number of ICT tools such as mobile phone, television, radio, GPS and sonar, can bring significant changes in the development and reduction in the level of poverty of different communities including the fishermen (Kularatne, 1997).

The world's most vulnerable profession is fishing at the sea. The majority of tragedies in the fishing sector were because of mistakes committed or because of human error (Patil *et al,* 2017). Safety at sea consistently remains an inseparable component of fisheries management, both directly and indirectly. Under the open access system, the intense competition to capture fish has spurred advancements in fishing vessels and equipment, but unfortunately, this has led to a lack of emphasis on enhancing the safety of fishermen working at sea. Consequently, very few fishing boats are equipped with even the basic life-saving tools such as lifebuoys, life jackets, and flares (Patil *et al,* 2017).

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Table 1. Socio-personal Information. **N = 102**

Sr. No.	Socio-personal Characteristic	Frequency	Percentage
A.	**Age in years**		
	< 40	31	30.4
	41 – 60	68	66.7
	> 61	3	2.9
B.	**Education**		
	Illiterate	4	3.9
	Primary	66	64.7
	Secondary	27	26.5
	Higher Secondary	5	4.9
C.	**Annual Income**		
	< 100000	3	2.9
	100001 – 250000	80	78.4
	250001 – 500000	19	18.6
D.	**Religion**		
	Hindu	53	51.9
	Islam	49	48.0
E.	**Fishing Experience in years**		
	< 15	11	10.8
	15 – 30	67	65.7
	31 – 46	21	20.6
	47 – 62	3	2.9
F.	**Source of Information**		
	Employer/ Owner	62	60.8
	Boat driver	81	79.4
	Senior	80	78.4
	Relatives	11	10.8

The appropriate and timely use of ICTs can positively impact fishing costs as well as the improvement of fishers' quality of life (Marciniak, 2010). Similarly, it is important to use life-saving equipment on boat for emergency purpose like life jackets, ring buoy, life rafts, fire safety measures (Fire extinguisher and fire bucket) and first aid kit. Proper use and periodic maintenance of safety equipment are carried out as per the recommendations (NETFISH-MPEDA, 2020).To prevent maritime disasters, fishermen need to be educated in safety and navigational requirements. Fishermen can work at sea without worry if they have knowledge about communication and safety technologies (NETFISH-MPEDA, 2020).

There are different ICT and sea safety tools used for the different purposes but it is essential to understand the level of awareness of ICT and sea safety tools for filling the gap between knowledge and usage which can further helps to improve sea safety practices. This study also helps to know the emergency response mechanisms of trawler operators as they are well equipped with communication devices. Also, improved communication, navigation and access to the market information can enhance the efficiency of fishing, contributing to the economic development of fishermen community. Assessing the gaps between knowledge and usage of ICT and sea safety tools can help to construct policies and regulation in future by considering needs as well

as challenges of trawler operators of Ratnagiri block. Hence, the study was undertaken to understand the constraints related to usage of ICT and sea safety tools among the trawler operators of Ratnagiri block, Maharashtra.

MATERIALS AND METHODS

The study was carried out in Ratnagiri block, Ratnagiri district, Maharashtra which is situated between 17018'48.69" N latitude and 73011'38.14" E longitude and 16048'24.76" N latitude and 73018'48.85" E. Data was collected from the 7 landing centers in Ratnagiri block namely Mirkarwada, Rajiwada, Kasarveli, Sakhartar, Kalbadevi, Jaigad and Purnagad. An interview schedule was developed as a data collection tool to elicit information in the current study. Trawler operators (tandel) were the targeted respondents during data collection. Data were collected from 102 randomly selected trawler operators. Questions were asked in local language to get accurate information about knowledge and usage ICT tools. Total 8 ICT tools selected for study such as Magnetic Compass (MC), Global Positioning System (GPS), echo sounder, RADAR, wireless set, mobile phone, Emergency Position Indicating Radio Beacon (EPIRB), Very High Frequency radio (VHF) and Two-band transistor radio as well as total 9 sea safety tools were selected for study such as life jacket, life buoy, first aid kit, fire extinguisher, fire bucket, signalling flame, self-igniting light, oil lamp and signalling torch and batteries.

Descriptive analytical tool such as percentage analysis was used to analyse socio-personal information. Weighted average technique was used to understand and rank various constraints faced by trawler operators in usage of ICT and sea safety tools (Patil and Sharma, 2021).The weighted average for each constraint was determined by multiplying the frequency of each constraint by its corresponding weight or score. The weights used for calculating the weighted average were assigned as follows: 2 for "agree," 1 for "neither agree nor disagree," and 0 for "disagree." The formula for calculating the weighted average can be expressed as follows:

Weighted Average = Sum (X1.W1 + X 2.W2 + X3.W3 / Sum (W1+W2 +W3)

Where,

X1, X2, X3= Frequency of the respective constraints/motivations

W1, W2, W3= Weighted values i.e., 2,1,0

RESULTS AND DISCUSSION

Socio-personal Information

Results revealed that, maximum (66.7%) trawler operators of Ratnagiri block belong to the middle age group (41–60 years). Similar results were reported by Sethulakshmi (2017) in her study in Kerala and reported that 48% fishers belong to the middle age group (41-60 years). Anusaya *et al* (2014) reported that, large number of fishermen (52.5%) in Udupi district, Karnataka had age between 20 to 30 years.

Maximum trawler operators of Ratnagiri block (64.7%) had primary level education. Sethulakshmi (2017) observed that majority of fishermen (53%) of Kerala had secondary level of education. Sabu and Shaijumon (2014), observed that, around 35% and 40% of fishermen from Munambam and Pozhiyoor village of Kerala had primary level of education respectively. It was observed that, 78.4% trwaler operators of Ratnagiri block had annual income in between ₹ 100001-250000. Anusaya *et al* (2014) reported that monthly income of 47.5% fishermen from Udupi district, Karnataka was between 5001 to 10000 rupees.

Majority of interviewed trawler operators (51.9%) of Ratnagiri belongs to Hindu religion followed by Islam (48.04%). Sethulakshmi (2017) reported that Hindus (39%) were maximum in Kerala followed by Christians (34%) and Muslims (24%). Anusaya *et al* (2014) reported that, 97.5% fishermen from Udupi district of Karnataka were Hindus. It was observed that 86.3% trawler operators of Ratnagiri had an experience of 15-46 years. Similar type of results was reported by Sethulakshmi (2017) in her study in Kerala mentioned that 97% of the fishers had an experience of 15-46 years.

It was observed that trawler operators from Ratnagiri block were getting information regarding use of ICT tools from different sources

Table 2. Constraints faced by trawler operators in usage of ICT tools

Sr. No.	Constraint	Weighted average	Rank
1.	High price of device	2	I
2.	Damage due to humid air	1.57	II
3.	Low durability	1.34	III
4.	Lack of training	0.95	IV
5.	Lack of space in vessel	0.95	V
6.	Lack of confidence	0.69	VI

Table 3 Constraints faced by trawler operators in usage of sea safety tools

Sr. No.	Constraint	Weighted average	Rank
1.	Hindrance in work	2	I
2.	Damage due to salt water	1.68	II
3.	Lack of training	1.47	III
4.	Low durability	1.17	IV
5.	Lack of space in vessel	0.74	V
6.	Size of device	0.72	VI

such as employers/owners (60.8%), boat driver (79.4%), seniors/elderly person (78.4%) and relatives of respondents who were also engaged in fishing. Sometimes owners provide information regarding application of ICT tools Anusaya *et al* (2014) reported that fishermen of Udupi district got information about safety measures from employer (2.5%), driver (8.8%), senior (6.2%) and relatives (10%).

Constraints faced by trawler operators in usage of ICT toolsand sea safety tools

The major constraints faced by the trawler operators in usage of ICT and sea safety were studied and results were presented in Table 2 and Table 3.

The results revealed that, high price of device was the first ranked constraint faced by the trawler operators in usage of ICT devices (weighted average 2.0). It was observed that maximum trawler operators were not using all ICT tools due to its high price. Similarly, Guguloth *et al* (2017) reported that fishermen of Andhra Pradesh faced constraint like financial inability to purchase high-cost ICT instruments. Sharma and Sethulakshmi (2019) reported that fishers of Kerala were also facing financial constraint while getting ICT devices.

The damage due to humid air was the second ranked constraint faced by the trawler operators (weighted average 1.57). Trawler operators were not using ICT tools as it malfunctions due to high level of humidity in coastal environments.

Third ranked constraint was low durability of device with weighted average of 1.34. Low durability of ICT tools was the reason for non-usage of all ICT tools by trawler operators.

Lack of training and lack of space on vessel to fit and install these devices was the fourth ranked constraint with weighted average 0.95. Sharma and Sethulakshmi (2019) reported that lack of training/awareness programme was the major reason for low or no use of ICT tools among the fishers of Kerala. Qureshi *et al* (2014) reported that no proper guidance with respect to use of communication tools was the reason for no usage of communication devices. Sabu and Shaijumon (2014) observed that fishers of Kerala were facing technological gap due to which they were not using ICT tools such as GPS. Sharma and Sethulakshmi (2019) also reported that lack of space in fishing vessel was major constraint among fishers of Kerala.Lack of confidence in case of usage of ICT tools was the fifth ranked constraint with weighted average 0.69.

It was observed that the first and foremost constraint faced by trawler operators in usage of sea safety tools was hindrance in work (weighted

average: 2). It was difficult for them to carry fishing operation and related activities while wearing sea safety tools like life jackets, however it is necessary to have continuous training and practice of using SSTs while working onboard to manage the marine risk.

The damage due to salt water was second ranked constraint faced by trawler operators (weighted average: 1.68). Sea safetytools such as oil lamp, malfunctioned when comes in contact with saltwater leading to frequent repairs and maintenance.

Lack of training was the third ranked constraint with weighted average of 1.47 in the use of sea safety tools. Sharma and Sethulakshmi (2019) observed that, lack of training/awareness programme among the fishers of Kerala was the major constraint.

The fourth ranked constraint faced by trawler operators in usage of sea safety tools was low durability of sea safety tools (weighted average: 1.17).It was found that, good quality sea safety tools were having the higher price, so instead of buying the costly sea safety tools fishermen tends to buy low quality sea safety tools which were affordable to them. These low-quality sea safety tools were having low durability therefore some trawler operators refuse to use SSTs.

Lack of space on fishing vessel was the fifth ranked constraint with weighted average score of 0.74 was recorded in the present study. Sharma and Sethulakshmi (2019) reported that fishermen from Kerala were not using sea safety tools due to lack of space on fishing vessel.

CONCLUSION

Sufficient knowledge and proper usage of ICT and sea safety tools brings safety and development in trawler fishing. But still there was low usage of ICT and sea safety tools among the trawler operators of Ratnagiri block, Maharashtra such as, most of the trawler operators were not aware about use of new ICT (EPIRB and RADAR) and sea safety tools (signalling flame, self-igniting light, signalling torch and batteries). The reasons for non-usage of ICT and sea safety tools were lack of training, lack of awareness programs, high prices of devices and lack of space on board fishing vessel. To increase usage of ICT and sea safety tools among the trawler operators, it is necessary to enforce Maharashtra Marine Fishing Regulation Act, 1981 and rules thereof, Merchant Shipping Act, Marine Fishing Policy in a participatory mode, and not by force.

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Received on 25/3/2024 Accepted on 15/10/2024

J Krishi Vigyan 2024, 12(4) : 790-794
DOI : 10.5958/2349-4433.2024.00136.5
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Constraints of Technical Staff at Rythu Bharosa Kendras in Delivering Agricultural Services

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ABSTRACT

Effective extension models are vital for empowering farmers and enhancing both productivity and profitability. Rythu Bharosa Kendras (RBKs), an innovative initiative launched by the Andhra Pradesh government, aim to provide an integrated platform addressing farmers' needs from seed to sale at the village level. RBKs represent a significant advancement in agricultural support at the grassroots level, understanding and addressing the constraints faced by the technical staff was essential. This investigation offered insights into the required corrective measures to ensure the effective operation and service delivery of RBKs to the farmers. The study investigated the constraints encountered by RBK staff in delivering agricultural services using ex-post facto research design and multistage sampling approach, collecting data from 120 respondents across four districts of Andhra Pradesh. Constraints were analyzed through Garret ranking technique, revealed that discrepancies between old survey records and e-Panta geo-coordinates complicate accurate e-crop booking by staff, Village Agricultural Assistants (VAAs) involvement in unscientific activities mandated by higher authorities compromised the quality of services to farmers and delay in releasing soil testing reports undermine farmers' trust in VAA at RBKs were the predominant constraints. These constraints collectively impact the effectiveness of RBKs in delivering agricultural services. Tackling these diverse constraints with specific interventions is therefore essential for optimizing RBK operations, improving service delivery, and increasing agricultural productivity.

Key Words: Agriculture, Constraints, Economics, Service ,Technical.

INTRODUCTION

The agricultural sector plays a pivotal role in ensuring economic stability and food security for rural communities, especially in regions where farming constitutes the primary livelihood. Over the years, agricultural extension systems have evolved significantly, enhancing the transfer of technology and support to farmers (Saifuddin *et al*,2024). Despite advancements from the pre-green revolution era to the present, several challenges remain pervasive. Farmers often grapple with limited access to extension services, a disproportionate extension worker-to-farmer ratio of 1:1162, difficulties in acquiring agricultural inputs, selling their produce, and insufficient facilities for testing agricultural inputs. These issues contribute to considerable economic losses for farmers (Anuhya *et al*,2022). In response to these challenges, the state government of Andhra Pradesh launched a transformative initiative by establishing 10,641 Rythu Bharosa Kendras (RBKs) during 2020. These RBKs are strategically positioned across villages in the state to deliver a comprehensive range of services designed to address various needs of the agricultural community (Reddy, 2020). Services provided by RBKs include input delivery, technical advisories, soil testing, training, crop insurance, market intelligence, health clinics, and expert consultations via digital platforms. Additionally, RBKs facilitate the procurement of farmers' produce (Saifuddin *et al*, 2022; Chowdary *et al*, 2022). Each RBK is staffed by qualified professionals based on the primary cultivation

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Table 1. Operational and resource management constraints faced by technical staff. (n= 120)

Sr.No.	Operational and Resource Management Constraints	Garret Mean Score	Rank
1.	Discrepancies between old survey records and e -Panta geo-coordinates complicate accurate e -crop booking by staff	66.87	I
2.	Non- availability of micronutrient fertilizers and pesticides at RBK prevents VAAs from supplying essential inputs to farmers	55.57	II
3.	Insufficient government funding for the regular maintenance of RBK	50.56	III
4.	Lack of government funding for labour in crop cutting experiments and soil sampling forces VAAs to pay personally	47.77	IV
5.	Delays in animal feed provision from RBKs hinder the timely support provided by technical staff	42.33	V
6.	Insufficient supporti ng staff during seed distribution makes it challenging for VAAs to manage alone	34. 28	VI

practices in the region, Village Agricultural Assistants (VAAs) or Village Horticulture Assistants (VHAs), or Village Fisheries Assistants (VFAs), alongside a Village Animal Husbandry Assistant (VAHA) to address animal health concerns (Saifuddin *et al*, 2023). These technical staff members play a crucial role in delivering RBK services that span from seed to sale, which are vital for enhancing agricultural productivity, sustainability, and the overall well-being of farming communities.

Despite their critical role, the technical staff at RBKs encounter various constraints that can impede their effectiveness in supporting farmers. Identifying and analysing these constraints systematically was essential for understanding the barriers faced by the RBK staff. This study aimed to elucidate these constraints in detail to inform the development of strategies that can enhance the effectiveness of RBKs. The research will provide insights into operational inefficiencies, policy gaps, resource allocation issues, and areas need capacity building. The findings from this study are expected to guide improvements in operational efficiency, inform policy formulation, optimize resource allocation, and identify key areas for capacity building (Saifuddin *et al,* 2024). By addressing these constraints, the study aims to contribute to a more robust agricultural support system, yielding better outcomes for farmers and promoting greater agricultural sustainability in Andhra Pradesh. Ultimately, the insights gained will support the development of targeted interventions to strengthen RBK operations, enhance service delivery, and improve the overall impact of agricultural extension services on rural livelihoods.

MATERIALS AND METHODS

The study was conducted in four districts of Andhra Pradesh *i.e.*, East Godavari, Chittoor, West Godavari, and Prakasam by adopting an *ex-post facto* research design to identify the constraints faced by the technical staff of Rythu Bharosa Kendras (RBKs) in delivering services to the farmers. The research employed a multistage sampling approach integrating both purposive and random sampling methods to select the technical staff of RBKs. Initially, the four districts were purposively chosen due to their highest number of RBKs. Subsequently, within each district, three mandals were selected purposively, again based on the number of RBKs present. From each selected mandal, ten RBKs were randomly chosen. Within each RBK, one Village Agricultural Assistant (VAA) was selected, resulting in a total sample size of 120 Village Agricultural Assistants. To identify the constraints hindering the effective delivery of RBK services, a pre-tested structured schedule was used to gather data on various constraints faced by the technical staff. These constraints were categorized into three main categories: operational and resource management, training and technical capability, and farmer engagement and trust. Respondents were asked to rank the constraints within each

Table 2. Training and technical capability constraints faced by technical staff of RBK (n = 120)

S. No.	Training and Technical Capability Constraints	Garret Mean Score	Rank
1.	VAAs' involvement in unscientific activities mandated by higher authorities compromises the quality of services to farmers	61.84	I
2.	Insufficient trainings for RBK technical staff on the latest agricultural technologies limits their effectiveness	54.40	II
3.	Pressure from higher authorities on RBK technical staff to increase input sales	52.00	III

Table 3. Farmer engagement and trust constraints faced by technical staff of RBK (n=120)

Sr.No.	Farmer Engagement and Trust Constraints	Garret Mean Score	Rank
1.	Delays in releasing soil test reports undermine farmers' trust in VAAs at RBKs	64.18	I
2.	Engagement of VAHAs in non -veterinary tasks limits their ability to deliver timely emergency services to farmers	55.57	II
3.	Lack of credit for fertilizers at RBKs deters farmers, increasing VAAs' burden and causing excess stock	50.56	III
4.	Farmers' lack of interest in the polambadi program leads to VAA decreased motivation to conduct it	47.31	IV
5.	Delay in the delivery of Rythu Bharosa magazine causes lost subscriptions and hinders staff from achieving targets	44.08	V

category based on their perceived severity and impact. The ranking data was analyzed using Garret ranking technique. For this analysis, each respondent's rank for a given constraint was converted into a percent position using the formula:

$$\text{Percent Position} = \frac{100\ (R_{ij} - 0.5)}{N_J}$$

Where,

R_{ij} = Rank given for the i^{th} attribute by j^{th} respondent

N_j = Number of attributes ranked by j^{th} respondent

Using Garret's table, the percent positions were then converted into scores. The scores for each constraint were aggregated across all respondents to calculate the total score and mean score for each constraint. This methodology was followed by Deepika *et al* (2024). The constraints were then ranked based on their mean scores, with the highest mean score indicating the most critical constraint. This methodology allowed for a comprehensive evaluation of the constraints faced by the RBK technical staff, providing a clear understanding of the most pressing issues impacting the delivery of RBK services.

RESULTS AND DISCUSSION

Operational and resource management constraints

The data (Table 1) revealed that the most significant constraint, with the highest Garret Mean Score of 66.87, was the discrepancy between old survey records and e-Panta geo-coordinates. This misalignment complicates accurate e-crop booking, a crucial process for linking farmers with essential RBK services. The inconsistency between outdated land records and current GPS data not only hampers precise field mapping but also undermines the effectiveness of various support services provided by RBK, emphasizing the need for urgent resolution.

Following this, the non-availability of micronutrient fertilizers and pesticides at RBK centres was ranked second. This shortage prevents Village Agricultural Assistants (VAAs) from supplying essential inputs, directly affecting agricultural productivity and the support available

to farmers. The inability to provide these critical resources disrupts the essential services that VAAs are supposed to offer. The findings were in accordance with the Madhuri *et al* (2024). The third-ranked constraint was insufficient government funding for the regular maintenance of RBK. This financial shortfall impacts the operational readiness and upkeep of RBK facilities, potentially leading to reduced service quality. Adequate maintenance is crucial for ensuring the smooth operation of these centers and sustaining the quality of services offered to farmers.

Pressure from higher authorities on RBK technical staff to increase input sales was ranked as third, this pressure potentially shifted the focus from providing unbiased technical support to meeting sales targets, which might have compromised the quality of the advice and services offered to farmers. Although ranked lower than the other two issues, this constraint still represents a considerable challenge, as it introduces a conflict between sales objectives and the goal of delivering high-quality agricultural guidance.

Farmer engagement and trust constraints

It was observed that delay in releasing soil test reports, ranked first, was found to undermine farmers' trust in VAAs at RBKs. This issue was primarily due to the lack of on-site equipment at RBKs, necessitating that soil samples be sent to block-level laboratories for testing. This procedural delay resulted in extended waiting periods for soil reports, thereby eroding farmers confidence in the services provided by VAAs. In contrast, the second major constraint is the engagement of Village Animal Husbandry Assistants (VAHAs) in non-veterinary tasks. This misallocation of resources limited their ability to provide timely emergency services, affecting the overall effectiveness of the support provided to farmers. The third constraint was the lack of credit facilities for fertilizers at RBKs, which deterred farmers from purchasing, leading to unsold stock and increased burdens on VAAs to manage and protect the inventory. This issue highlighted the need for implementing credit options to better engage farmers and manage stock effectively.

Farmers' lack of interest in the polambadi program, ranked fourth, results in decreased motivation among Village Agricultural Assistants (VAAs) to conduct the program effectively. This diminished engagement suggested that revitalizing the program or enhancing its appeal could be beneficial for improving both participation and effectiveness. Delay in delivering the Rythu Bharosa magazine to farmer subscribers, ranked fifth, results in lost subscriptions and hampers staff from achieving their targets. This issue is likely due to the magazine often being delivered three to four months late, which stems from delays in the publication process. Addressing these delays was crucial for maintaining subscriber engagement and enabling staff to meet their objectives.

CONCLUSION

This study elucidated the constraints encountered by technical staff at Rythu Bharosa Kendras (RBKs) in delivering agricultural services, categorized into operational and resource management, training and technical capability, and farmer engagement and trust issues. Key operational constraints identified include discrepancies between land records, shortages of micronutrient fertilizers, and inadequate maintenance funding. Training deficiencies were characterized by insufficient updates on contemporary agricultural technologies and the assignment of unscientific tasks to staff. Issues related to farmer engagement encompass delays in soil testing reports, lack of credit facilities for fertilizers, and diminished interest in programs such as Polambadi. These constraints collectively impair service delivery, erode trust, and hinder productivity. To enhance RBK operations, it is crucial to address these multifaceted issues through targeted interventions that improve operational efficiency, staff training, and farmer engagement. Implementing these solutions will strengthen the agricultural support system, resulting in better outcomes for rural communities and more effective extension services.

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Received on 29/8/2024 Accepted on 22/10/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 795-801

DOI : 10.5958/2349-4433.2024.00137.1

Database of Miyawaki Forest Unit Established at KVK Palakkad: A Green Initiative for Climate Change Mitigation

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ABSTRACT

Miyawaki forest creation, a methodology developed by Japanese botanist Prof. Akira Miyawaki, involves planting trees per square meter which is a promising approach for maximization of green cover and to support biodiversity locally. The present investigation on Miyawaki Model forest unit created at KVK Palakkad was envisaged in preparing a database for 47 different species of saplings that were planted randomly which includes flowering, fruiting, ornamental and medicinal plants. Database prepared represents the native plant species, plant type, life form, tree layer and survival rate that can be used for recommending for a particular locality for further creations of Miyawaki forest. Based on this study, *Ficus racemosa* (T4), *Ficus religiosa* (T5), *Cassia fistula* (T10), *Annona squamosa* (T15) and *Terminalia elliptica* (T9) with excellent and good performance came out as candidates for Miyawaki forest. For forest restoration projects, these plants can be recommended as a suitable and proper species to plant in Palakkad district.

Key Words : Database, Miyawaki forest, forest restoration, green spaces, canopy layer.

INTRODUCTION

Forests form the basic resource for adaptation to climate change owing to their capacity for carbon sequestration, providing means of keeping the carbon trapped in long-term use as wood, harbouring genetic resources, and providing ecological services in terms of soil and water conservation. By promoting agroforestry and urban forestry, we can significantly increase the number of trees outside forests and, consequently, their contribution to climate change mitigation. For augmenting the greenery of the state, social forestry has been given a thrust by introducing innovative programmes in schools, colleges, coastal area, and roadside by labour unions etc. This will also help improving the profile and productivity of the forests.

Haritha Keralam Mission, Government of Kerala has launched a new project called 'Pachathuruthu'on June 5, World Environment Day 2019 which aims to grow “miniature forests”. It just takes a minimum of one cent of land and a love for greenery to set up a 'Pachathuruthu' (an islet of greenery). From five cent plots to huge acres of land belonging to the government, institutions, private parties and puramboke will be used for the project with the help of the Kerala State Biodiversity Board, Agriculture Department, MGNREGA workers, Forest Department and voluntary organisations. The Green Kerala Mission has formed a team in every district to implement the project.

One effective and reliable way to restore forests is to plant native trees in the area, following the principles of plant ecology developed by Professor Miyawaki (Padilla and Pugnaire, 2006). This approach was first used in Japan during the 1980s. This method comprises of layers of a forest like shrubs, trees and canopies which are laid on small plots of land, turning them into tiny forests (Khouzami, 2015). The Miyawaki model is successfully implemented in about 550 locations around the world, including Japan, Southeast Asia, Chile, Malaysia, Brazil and some parts of China where the method has helped to quickly restore damaged environments (Schirone *et al*, 2011).

The effective adaptation strategies as well as proactive steps to protect our communities and

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ecosystems can be developed by understanding the interconnectedness of climate change, vulnerability, and risk since climate change is a significant driver for environmental destruction (Das, 2023). Knowledge of the composition of species and the diversity of tree species is significant not only for understanding the structure of Miyawaki forest community but also for planning and implementing community conservation approaches. This has prompted to come-up with a database with authentic list of tree species describing tree species diversity of Miyawaki forest demo unit established at KVK Palakkad so as to support conservation and development initiatives in this district. Hence the present investigation was undertaken with the objective of preparing a database in Miyawaki model forest unit created at KVK Palakkad and hopes to develop such green spaces in Palakkad district.

MATERIALS AND METHODS

The experimental material was young Miyawaki model forest unit created at KVK Palakkad aged 1.8 years which was planted as per Miyawaki method (Miyawaki *et al*, 1998). The experiment plot area is 871.2 Sq.ft. In the Miyawaki forest unit, 47 different species of tree saplings were planted randomly which includes flowering, fruiting, ornamental and medicinal trees. No two trees of the same kind are placed next to each other. Totally 188 saplings were planted very closely at a distance of 1 x 1 m^2.

As part of the study, a database was created with an updated checklist of all plant species native to the Palakkad district identified for establishment of Miyawaki forest demo unit at KVK Palakkad. The data base prepared on plant species gives an overview of the composition, plant group, plant life form, tree type, layer and survival percentage.

RESULTS AND DISCUSSION

Database is the cornerstone for ensuring sustainable and efficient forest sector planning and management. This authentic database is a systematic documentation on tree diversity, habit (deciduous/evergreen) and abundance of plant species across life-forms in Miyawaki forest demo unit established at KVK Palakkad. In this database, baseline information on tree and shrub diversity have been prepared and this document can be useful for diverse stakeholders as 'Miyawaki forest' envisages to grow “miniature forests” in every vacant space available in every local body in a systematic and useful manner.

The data base prepared on plant species gives an overview of the composition, plant group, plant life form, tree type, layer, advantage and survival percentage. The parameters studies were tabulated in Table 1.

Tree species composition

Forty seven plant species belonging to 26 different family and 39 genus are exhibited in the species composition, which compete to each other, prevent extinction and increase their diversity. Similar results were reported by Shankar (2001). Fabaceae (6 species), Moraceae (5) and Rutaceae (5) were the families recording highest species number.

Plant group

All plant species present in the Miyawaki forest was Angiosperms. The angiosperm diversity in Miyawaki forest was divided into dicotyledons and monocotyledons. Among the total of 47 species, 25 families, 38 genera, 45 species are dicotyledons and the remaining 1 family, 1 genera and 2 species are monocotyledons.

The most abundant plant species in the Miyawaki forest were *Mangifera indica, Ficus benghalensis, Syzygium samarangense, Saraca indica, Annona squamosa, Bambusa vulgaris, Pongamia pinnata,Polyalthia longifolia, Allamanda cathartica* and *Hydnocarpus pentandrus*. The variability in the floristic composition of the different forests could be attributed to the nature of the geological substrates and climatic variability. The limitations in use of species which are native include uncertainty with respect to growth rates, lack of genetic improvement as well as adaptability to various soil conditions and variability in performance.

Plant life form

Forest comprises of a community of plants having trees, shrubs, herbs and climbers. With regard to representation of various life forms, 36 species form framework tree species. 7 species are shrubs, 2 taxa are climbers and 2 taxa are herbs. Life form analysis shows that 76.59% are trees, 14.89% are shrubs, 4.25% are herbs and 4.25% are climbers. Hence this model forest is achieving a multi layered structure because vegetation is luxuriant with plant life forms of all kinds. Among the climbers, golden trumphet and garlic vine are fast-growing which survived and flourished during the past 20 months after planting.

Economic importance of Plant species

The use value of plant species of study area was also incorporated and they are identified in the demo unit with medicinal, industrial and economical values. Out of 47 plant species, 26 are medicinally important and can serve as the feedstock for many drugs. Four species are timber yielding plants. In addition to above economics there are plant species that give pleasure by providing us flowers and fruits. Thirteen species are fruit yielding and four species are flowering respectively. Mathur (2017) reported that in JIET college, Jodhpur, Rajasthan, above 150 plant species were found having environmental, medicinal, economical, ethical and industrial values.

Tree type

Out of 47 plant species in Miyawaki forest 25 species are evergreen (53.13%), 14 species are deciduous (29.78%) and 8 species are perennial (17%). Evergreen trees are dominant in Miyawaki forest. According to ecologists, long-lived evergreen leaves potentially have longer photosynthetic period than deciduous leaves. This state reduces quantity of nutrients to be absorbed from soil every year. Several reports are there regarding association of leaf habit with seasonal drought, tolerance as well as avoidance (Givnish, 2002; Markesteijn and Poorter, 2009; Ackerly, 2004). Tolerance to drought can be linked with evergreen types because leaves are retained through out dry season. This activity helps them to be active at transition phase between dry and wet period, otherwise proceed at lower activity in dry period.

Trees by layer

Forest stratification refers to different layers of plants in forest. Distinct vegetation layers starting from forest floor to tree canopy can be observed in mature forest. Clear separations of layers cannot be found in young forests. Formation of layering can be found visible only when the forests become aged and tall canopy created by growth of trees.

Trees in Miyawaki forest were grouped into 4 layers namely shrub layer, sub-tree layer, tree layer as well as canopy layer. Canopy layer represents top layer in Miyawaki forest model and this layer contains trees above 40 feet in height. The layer is composed of 25 species out of 47 species. Tree layer is within the height range of 20-40 feet and it includes 8 species. Sub tree layer contains trees about 6-12 feet in height which is having lowest number of species and is composed of 5 species. Shrub layer contains trees about 6 feet in height. This layer is composed of 9 species. Canopy layer has highest number of plants whereas minimum number of plants were noted in sub tree layer with 53.191% and 10.63% respectively (Figure 1).

The structure of forest canopy differs among forests due to factors like tree arrangement, availability of nutrients and difference in biological species. So plants must be selected from potential native vegetation of respective region so that restoration of multi layer natural or quasi-natural forests can be done.

The distribution of plant life forms is regulated by micro environmental features such as soil moisture, light and nutrients in their habitat. As trees grow into tall canopy, they block sunlight almost completely, preventing weeds and shorter plants from growing. Baruah and Ramakrishnan (1989) considered shade stress as fatal factor for determining whether plants can establish themselves in a given habitat of forest. Plants with perennial leaves dominate in habitat with high shade intensity and in this study, perennials occupy 17% of the plant type population survived.

Percent Survival rate

Table 1. Database description of plant species present in Miyawaki forest unit at KVK Palakkad

Treatment No.	Botanical Name	Vernacular Name in malayalam	Common English Name	Family	Type	Advantage	Layer	Survival rate
T1	*Mangifera indica* L.	Maavu	Mango tree	Anacardiaceae	Evergreen tree	Fruiting	Canopy	100
T2	*Phyllanthus emblica* L.	Nelli	Indian Gooseberry	Phyllanthaceae	Deciduous tree	Fruiting	Canopy	50
T3	*Artocarpus heterophyllus* Lam.	Plavu	Jack	Moraceae	Evergreen tree	Fruiting	Canopy	75
T4	*Ficus racemosa* L.	Atthi	Cluster Fig	Moraceae	Deciduous tree	Medicinal	Sub Tree	50
T5	*Ficus religiosa* L.	Arayal	Peepal tree	Moraceae	Semi-evergreen tree	Medicinal	Canopy	75
T6	*Ficus benghalensis* L.	Peral	Banyan Tree	Moraceae	Evergreen tree	Medicinal	Canopy	100
T7	*Wrightia tinctoria* R.Br.	Dhanthappala	Pala Indigo	Apocynaceae	Deciduous tree	Medicinal	Canopy	50
T8	*Tamarindus indica* L.	Puli	Tamarind tree	Fabaceae	Evergreen tree	Fruiting	Canopy	50
T9	*Terminalia elliptica* Willd.	Matti/ Karimaruthu	Indian laurel	Combretaceae	Deciduous tree	Timber	Canopy	50
T10	*Cassia fistula* L.	Kanikkonna	Indian Laburnum	Fabaceae	Deciduous tree	Flowering	Tree	50
T11	*Syzygium samarangense* (Blume) Merr. and L.M.Perry	Panineer Chamba	Java apple	Myrtaceae	Evergreen tree	Fruiting	Sub Tree	100
T12	*Madhuca longifolia* (J. Koenig ex L.) J.F. Macbr.	Ilippa	Indian Butter Tree	Sapotaceae	Deciduous tree	Medicinal	Canopy	75
T13	*Syzygium cumini* (L.) Skeels	Njaval	Indian Blackberry	Myrtaceae	Evergreen tree	Fruiting	Canopy	75
T14	*Saraca indica* L.	Ashokam	Ashok tree	Fabaceae	Evergreen tree	Medicinal	Canopy	100
T15	*Annona squamosa* L.	Seethapazhm	Custard apple	Annonaceae	Semi-evergreen tree	Fruiting	Sub Tree	100
T16	*Mimusops elengi* L.	Elenji	Asian bullet wood	Sapotaceae	Evergreen tree	Medicinal	Canopy	75
T17	*Azadirachta indica* A.Juss.	Aryaveppu	Neem tree	Meliaceae	Deciduous tree	Medicinal	Canopy	50
T18	*Strychnos nux-vomica* L.	Kanjiram	Strychnine Tree	Loganiaceae	Deciduous tree	Medicinal	Canopy	50
T19	*Citrus medica* L.	Ganapathi narakam	Citron	Rutaceae	Perennial	Fruiting	Shrub	50
T20	*Bambusa vulgaris* Schrad.	Mula	Common bamboo	Poaceae	Evergreen herb	Timber	Canopy	100
T21	*Zanthoxylum brachyacanthum* F. Muell.	Kazhani	Thorny yellow wood	Rutaceae	Thorny evergreen tree	Timber	Canopy	50
T22	*Pongamia pinnata* (L.) Pierre	Ungu	Indian beech tree	Fabaceae	Evergreen tree	Medicinal	Tree	100
T23	*Polyalthia longifolia* (Sonn.) Thwaites	Aranamaram	Mast Tree	Annonaceae	Deciduous tree	Medicinal	Tree	100
T24	*Simarouba amara* Aubl.	Lekshmi tharu	Paradise tree	Simaroubaceae	Evergreen tree	Medicinal	Canopy	50
T25	*Citrus limon* (L.) Osbeck	Cheru narakam	Lemon	Rutaceae	Perennial	Fruit	Shrub	75
T26	*Pimenta dioica* (L.) Merr.	Sarvasugandi	Allspice	Myrtaceae	Evergreen tree	Medicinal	Tree	50
T27	*Garcinia gummi-gutta* (L.) Roxb.	Kudam puli	Malabar tamarind	Clusiaceae	Evergreen tree	Fruiting	Tree	50
T28	*Bambusa tuldoides* Munro	Budha mula	Buddha belly bamboo	Poaceae	Evergreen tree	Medicinal	Sub Tree	50
T29	*Murraya paniculata* (L.)	Mara mulla	Orange jasmine	Rutaceae	Evergreen tree	Flowering	Shrub	50
T30	*Citrus maxima* (Burm.) Merr.	Babloos naranga	Pummelo	Rutaceae	Perennial	Fruiting	Shrub	50
T31	*Justicia adhatoda* L.	Adalodakam	Malabar nut	Acanthaceae	Perennial	Medicinal	Shrub	50
T32	*Myristica fragrans* Houtt.	Jathi	Nutmeg	Myristicaceae	Evergreen tree	Fruiting	Tree	50
T33	*Allamanda cathartica* L.	Kolambi	Golden trumpet	Apocynaceae	Perennial	Flowering	Shrub	100
T34	*Spondias pinnata* (L. f.) Kurz	Ambazham	Hog plum	Anacardiaceae	Deciduous tree	Fruiting	Canopy	50
T35	*Hydnocarpus pentandrus* (Buch. -Ham.) Oken	Maroti	Jangli almond	Achariaceae	Evergreen tree	Medicinal	Tree	100
T36	*Vitex negundo* L.	Karinochi	Chaste tree	Verbanaceae	Perennial	Medicinal	Sub Tree	50
T37	*Gardenia jasminoides* J. Ellis	Gandaraja	Cape jasmine	Rubiaceae	Perennial	Flowering	shrub	50
T38	*Cinnamomum verum* J. Presl	Karuvapatta	Cinnamon	Lauraceae	Evergreen tree	Medicinal	Canopy	50
T39	*Mansoa alliacea* (Lam.) A.H. Gentry	Veluthulli chedi	Garlic vine	Bignoniaceae	Evergreen vine	Medicinal	Shrub	50
T40	*Couroupita guianensis* Aubl.	Nagalingam/ Nagapoomaram	Cannon ball tree	Lecythidaceae	Deciduous tree	Medicinal	Canopy	75
T41	*Dalbergia latifolia* Roxb.	Veeti	Black rosewood tree	Fabaceae	Deciduous tree	Timber	Canopy	50
T42	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Neermaruth	Arjun tree	Combretaceae	Evergreen tree	Medicinal	Canopy	50
T43	*Helicteres isora* L.	Edampiri - Valampiri	East-Indian screw tree	Sterculiaceae	Perennial	Medicinal	Shrub	50
T44	*Carallia brachiata* (Lour.) Merr.	Vallabham	Corkwood	Rhizophoraceae	Evergreen tree	Medicinal	Canopy	50
T45	*Magnolia champaca* (L.) Baill. ex Pierre	Chembakam	Champaca	Magnoliaceae	Evergreen tree	Medicinal	Canopy	50
T46	*Ficus tsjahela* Burm. f.	Kaaral	Karal Fig	Moraceae	Deciduous tree	Medicinal	Canopy	50
T47	*Pterocarpus santalinus* L.f.	Raktachandanam	Red sandalwood	Fabaceae	Deciduous tree	Medicinal	Tree	50

Table 2. Survival rate of plants in Miyawaki forest after 6 months and 20 months

Treatment No.	No. of plants survived after 6 months	Survival rate (%) after 6 months	No. of plants survived after 20 months	Survival rate (%) after 20 months
T1	4	100	4	100
T2	3	75	2	50
T3	3	75	3	75
T4	2	50	2	50
T5	4	100	3	75
T6	4	100	4	100
T7	2	50	2	50
T8	2	50	2	50
T9	2	50	2	50
T10	3	75	2	50
T11	4	100	4	100
T12	3	75	3	75
T13	3	75	3	75
T14	4	100	4	100
T15	4	100	4	100
T16	3	75	3	75
T17	4	100	2	50
T18	3	75	2	50
T19	4	100	2	50
T20	4	100	4	100
T21	2	50	2	50
T22	4	100	4	100
T23	4	100	4	100
T24	4	100	2	50
T25	4	100	3	75
T26	4	100	2	50
T27	4	100	2	50
T28	2	50	2	50
T29	4	100	2	50
T30	3	75	2	50
T31	4	100	2	50
T32	3	75	2	50
T33	4	100	4	100
T34	3	75	2	50
T35	4	100	4	100
T36	4	100	2	50
T37	3	75	2	50
T38	3	75	2	50
T39	2	50	2	50
T40	3	75	3	75
T41	2	50	2	50
T42	2	50	2	50
T43	2	50	2	50
T44	3	75	2	50
T45	2	50	2	50
T46	2	50	2	50
T47	2	50	2	50

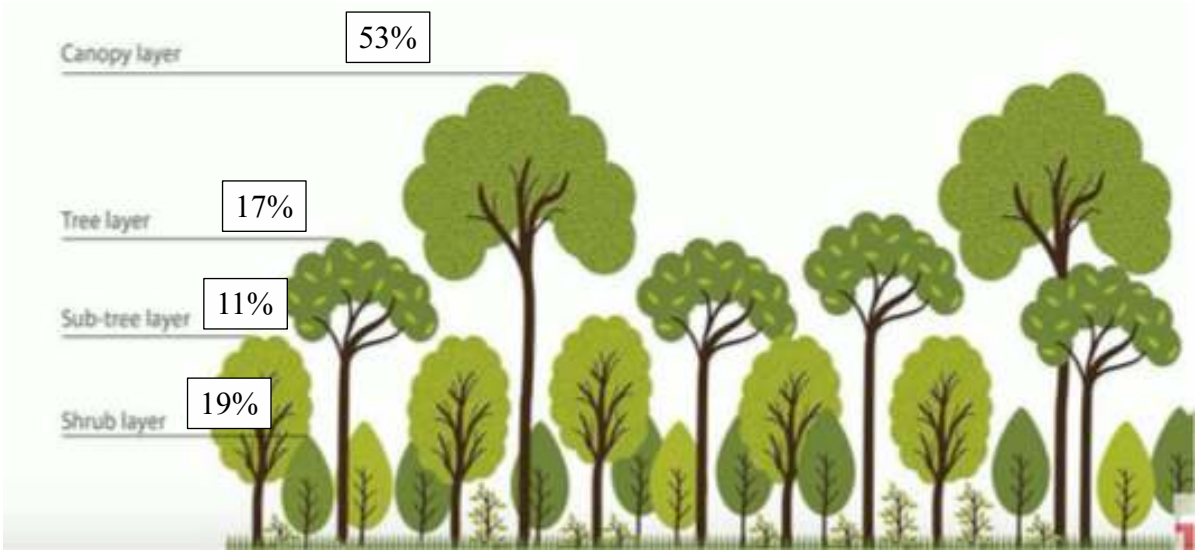

Fig.1. Tree layer stratification in Miyawaki forest unit

Ensuring the survival of the plant is critical for Miyawaki forests and steps to be taken to increase the survival rate are selecting the right species and sapling size in right site with availability of sustainable water source. Miyawaki method has reflected in better survival of plants as compared to the traditional method, improved density and growth without maintenance. Bhuyan et al. (2021) reported that diverse plankton and favorable hydrological conditions in a Himalayan region indicate a healthy water body, supporting snow trout and nutritional security for local communities.

The percent survival rate of 47 plant species in Miyawaki forest (Table 2) after 6 months of plantation observed that 20 species have showed 100% survival rate. These species include *Mangifera indica, Ficus religiosa, Ficus benghalensis, Syzygium samarangense*, *Saraca indica*, *Annona squamosa*, *Azadirachta indica, Citrus medica, Bambusa vulgaris, Pongamia pinnata*, *Polyalthia longifolia*, *Simarouba amara, Citrus limon, Pimenta dioica, Garcinia gummi-gutta*, *Murraya paniculata*, *Justicia adhatoda, Allamanda cathartica, Hydnocarpus pentandrus* and *Vitex negundo*. About 14 species showed 75% survival rate and 13 species have lower survival rate (50%).

The percent survival rate after 20 months of plantation noticed that 10 species of plants have 100% survival rate. It includes *Mangifera indica, Ficus benghalensis, Syzygium samarangense, Saraca indica, Annona squamosa, Bambusa vulgaris, Pongamia pinnata, Polyalthia longifolia, Allamanda cathartica* and *Hydnocarpus pentandrus*. Seven species have survival rate of 75% and the remaining 30 species of plants have showed only 50% survival rate.

According to Dhanorkar *et al* (2023), survival percentage of 1,060 plants belonging to 58 different species planted in two plots at afforestation site exhibits 100 percent survival and follows natural pattern in growth performance. Pareliussen et al (2006) investigated survival rate of seedlings of five native tree and shrub species which was planted in grass land at various distance from forest within the RS Ambohitantely. The results showed that species survival ranged from 40 % to 51 % during time span of fifteen months after planting.

CONCLUSION

Miyawaki model forest unit created at KVK Palakkad represents habitat or biome with high tree density. Most of native tree species planted in study area were in good health and growing fast. Twenty months after planting, reduced diversity of flora species initially was observed because canopy of planted trees get closed, resulting in shading and this decreased its opportunity for development of some herbs and trees among flora.

Selection of inappropriate trees at wrong places may trigger situations such as erosion, landslide, monoculture and in long run may neither provide biodiversity as well as ecological nor economic outputs to society. So dynamic strategy which has to be updated at regular time intervals based on research works and ground level validations is necessary. Hence the preparation of database representing the native plant species, plant type, life form, tree layer and survival rate can be used for recommending for a particular locality for further creations of Miyawaki forest.

Based on this study, *Ficus racemosa* (T4), *Ficus religiosa* (T5), *Cassia fistula* (T10), *Annona squamosa* (T15) and *Terminalia elliptica* (T9) with excellent and good performance came out as candidates for Miyawaki forest. They can be recommended as suitable, proper species to plant for forest restoration projects throughout Palakkad district.

ACKNOWLEDGEMENT

Directorate of Environment and Climate change (DoECC) under Kerala Government for providing all necessary funds during the course of investigation.

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Received on 12/8/2024 Accepted on 10/10/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 802-807

DOI : 10.5958/2349-4433.2024.00138.8

Determinants of Non-farm Diversification in Central Zone of Punjab

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ABSTRACT

This study investigated the determinants of non-farm diversification among agricultural households in Punjab. The research used a logistic regression model to identify factors influencing non-farm participation, analyzed data from a multistage random sample of 180 agricultural households from central zone of Punjab. Key determinants included household heads' age, skill development training and access to institutional credit. The findings highlighted the need for targeted policies to support skill development, improve access to credit and create opportunities for non-farm employment to enhance rural livelihoods in Punjab.

Key Words: Agriculture, Determinants, Diversification, Household, Livelihood.

INTRODUCTION

Diversification in rural livelihoods is a focus of conceptual and policy-oriented research due to the increasing strain on farming income caused by population growth (Barrett *et al,* 2001; Bryceson, 1999). It has been acknowledged for some time that rural individuals no longer limit themselves to agricultural farming, fishing, forest management, or livestock keeping, but instead integrate many occupations to create a varied portfolio of operations (Dercon and Krishanan, 1996; Ellis, 2000; Unni, 1996). Livelihood diversification is a process by which rural households develop a varied portfolio of enterprises and social support mechanisms to enhance their survival and increase their living standards (Ellis, 1998). A recent research by the Food and Agriculture Organization (FAO) on farming systems and poverty indicates that diversification is the paramount strategy for alleviating poverty among small farmers in South and Southeast Asia (FAO/World Bank, 2001). In India, the land-based livelihoods of small and marginal farmers are increasingly unsustainable, as their land can no longer provide the food needs of their families and the fodder requirements for their livestock (Hiremath, 2007). Consequently, rural households are compelled to seek alternative income sources.

The Situation Analysis Study of Indian Farmers, conducted by the National Sample Survey Organization (NSSO), indicates that approximately 27 per cent of farmers find farming unprofitable, and nearly 40 per cent would opt for alternative livelihood activities if given the opportunity (Kumar et al., 2006). The agricultural economy of Punjab once experienced high growth during the green revolution era, but now it has reached a plateau with agricultural growth becoming stagnant (Joshi, 2004). The Green Revolution in the mid-1960s triggered significant growth in Punjab's agricultural sector, particularly through wheat and rice cultivation. However, this growth has slowed in recent decades. In the early 1990s, Punjab was India's third-richest state in terms of per capita income, trailing only Maharashtra and Haryana. Today, it has fallen to the 10th position, reflecting a decline in agricultural growth. Historically, Punjab's agriculture thrived during the Green Revolution of the 1960s and 1970s. However, since the 1990s, the sector's growth rate has been diminishing. The contribution of agriculture to Punjab's Gross State Value Added (GSVA) has dropped significantly, from 48 per cent in the early 1980s to about 28.94 per cent in 2022-23 (GOI, 2023). Many factors have led to this precautious situation in Punjab agriculture. Rising input costs, less or no increase in MSP of main crops, thus shrinking profit

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margins, no technological breakthrough in agricultural sector in recent times, soil degradation, overuse of ground water resources, prevailing monoculture all this has led to dwindling crop incomes. On the other hand, inflated aspirations based on post growth has caused higher consumption expenditure including that on social ceremonies, housing and durables. The rising input cost and inflationary pressure at the macroeconomic level led to the agricultural crisis, which provoked the susceptibility of rural livelihoods even to a greater extent. This present scenario has encouraged rural households to have all the greater reasons to generate multiple income and employment activities. The prominence of non-farm income has been increasingly significant for marginal and small farmers, as noted by Vatta *et al* (2008). This trend highlighted the growing reliance on non-agricultural activities to supplement income and enhance economic stability among smaller-scale farming households. What are the factors that determine the non-farm diversification of the rural households in Punjab? The present study was an attempt to answer this question.

MATERIAL AND METHODS

The present study was conducted in Punjab state during 2020-21. The state is divided into three different agro-climatic zones. The sub mountainous/Kandi zone (Zone I) covers nearly 10 per cent of the total area of the state. The central zone (Zone II) is largest zone comprising more than 60 per cent area of the state. The south western zone/cotton belt (Zone III) is the third agro-climatic zone with about 30 per cent area of the state. It is low rainfall region with arid conditions. A multistage random sampling technique was used for the selection of sample agricultural households. In the process, one district from sub-mountainous zone, six districts from central zone and three districts from south-western zone were selected on random basis comprised ten districts from all zones according to area covered by each zone. Then, two blocks were selected from each sampled district and then one village from each block was selected randomly. At the final stage, 15 agricultural households were selected from each sampled village. In this study, a sample of 180 agricultural households from central zone were selected for the further analysis.

Analytical techniques

Logistic Regression: In this study, households engaged in agriculture that generate income from sources other than farming in a given year are referred to as 'mix-income households'. Individuals who derived their income solely from the agricultural sector were commonly known as "agricultural households". A binary logistic regression model was used to determine the factors influencing rural non-farm diversification. The model was selected based on the fact that the dependent variable is a binary outcome variable. The binary variable used in the logit model was Yi = 1 if farmer i had access to non-farm income and 0 otherwise.

The probability of adoption (P) for a given set of values of variables can be expressed in the form of given logit model

$$\ln\left(\frac{P}{1-P}\right) = \beta o + \sum_{i=1}^{n} \beta i Xi + \varepsilon$$

Where β_is are logit coefficients for the n variables X_is, βo is intercept and ε is the error term. In both types of variables sign of coefficient reveals the direction of change. Independent variables used for this model were following:

X1 = Age of head of the family (years)

X2 = Education qualification of head of the family (years of education)

X3 = Highest educated member of the family (dummy variable graduation and above or below graduation)

X4 = Family size (number of members)

X5 = Asset value per acre (Rs.)

X6 = Any training related to skill development (dummy variable yes or no)

X7 = Operational holding (acres)

X8 = Distance from town (Access dummy within 10 km from town or more than 10 km away from town)

X9 = Access to institutional credit (dummy variable yes or no)

Table 1. Socio-economic profile of the farmers .

Sr. No.	Particular	Category	Frequency (%)
1.	Age (years)	20-30	11 (6.11)
		30-40	36 (20.00)
		40-50	48 (26.67)
		50-60	60 (33.33)
		>60	25 (13.89)
2.	Education	Illiterate	4 (2.22)
		Primary	3 (1.67)
		Middle	20 (11.11)
		Matric	62 (34.44)
		Senior Secondary	66 (36.67)
		Graduate	25 (13.89)
3.	Highest educated member	Up to primary	1 (0.55)
		5^{th} to 10^{th}	21 (11.67)
		Sen. Sec.	59 (32.78)
		Graduation and above	99 (55.00)
4.	Operational Land Holding (ha)	Marginal (< 1.0)	24 (13.33)
		Small (1-2)	36 (20.00)
		Semi-medium (2-4)	60 (33.33)
		Medium (4-10)	48 (26.67)
		Large (> 10)	12 (6.67)
5.	Family size	Small (Up to 4 members)	96 (53.33)
		Medium (>4 to 6)	72 (40.00)
		Large (>6)	12 (6.67)

The figures in the brackets represents the percentage

X10 = Dependency ratio (percentage)

X11 = Value of livestock (Rs./farm)

X12 = Crop income per capita

RESULTS AND DISCUSSION

Based on a sample of 180 respondents, the socio-economic profile of farmers in Punjab highlighted a diverse and insightful set of characteristics. The age distribution revealed that a majority of farmers fell within the 30 to 60-year age range, with 33.33 per cent of them aged between 50 and 60 years. A significant portion, 26.67 per cent, was aged between 40 and 50, showing that most farmers were middle-aged. Younger farmers (aged 20-30 years) accounted for only 6.11 per cent of the sample, indicating a potential generational gap in agricultural participation. Meanwhile, farmers above 60 years constituted 13.89 per cent, reflecting an aging population within the farming sector. Education played an important role in shaping the profile of these farmers. While only a small percentage (2.22%) were illiterate, the majority had completed at least secondary education. Specifically, 34.44 per cent of farmers had attained matriculation, and 36.67 per cent had completed senior secondary education. A notable 13.89 per cent of the respondents held a graduate degree, reflecting the growing importance of education even in rural areas. The educational background of the households as a whole further supported this trend. Over half (55%) of the families had a member who had completed graduation or higher education, while 32.78 per cent had someone who had completed senior secondary education. This suggested that even if not all farmers were highly educated, their families were increasingly prioritizing higher education.

Table 2. Determining the Participation of Households in the Rural Non-farm Sector.

Explanatory variable	Odds. Value	Coefficient
Age of head	1.089*	0.085
Education of head	1.247	0.221
Highest educated family member	4.362**	1.473
Family size	1.383	0.324
Asset value per acre	0.999**	-0.00002
Any training related to skill	4.855**	1.580
Operational holding	0.967	-0.034
Access to town	0.736	-0.305
Access to institutional credit	9.673*	2.269
Dependency ratio	0.932*	-0.070
Livestock value	0.999	$-2.36e^{-06}$
Crop income per capita	0.999	$-2.97e^{-06}$
Constant	0.180	-1.712
Model information		
Pseudo R^2	0.5627	
Chi-Square	135.36*	

* denotes significance at 1 per cent level.
*** denotes significance at 5 per cent level*
Estimates of Logistic Regression analysis.
Dependent Variable = Non-farm Participation (Agriculture = 0, Agriculture + non-farm = 1)

The operational landholding sizes among the farmers were varied, with the largest group (33.33%) falling into the semi-medium category (2 to 4 ha). Medium-sized landholders, those with 4 to 10 ha, accounted for 26.67 per cent of the farmers, while small (1 to 2ha) and marginal farmers (less than 1 ha) together made up 33.33 per cent of the total sample. Only a small proportion of farmers (6.67%) owned large tracts of land exceeding 10 ha. This distribution pointed to the prevalence of small and semi-medium farming operations, which remained the backbone of Punjab's agricultural sector.

In terms of family size, most of the respondents belonged to small families, with 53.33 per cent having up to four members. Medium-sized families (comprising more than four but up to six members) represented 40 per cent of the sample, while large families with more than six members were relatively rare, constituting just 6.67 per cent. This shift toward smaller family units reflected broader socio-economic changes, such as the nuclear family structure becoming more common in rural areas. Overall, this socio-economic profile of Punjab's farmers illustrated a community that was primarily middle-aged, moderately educated, and operating small to medium-sized farms. The increasing focus on education within farming households suggested a shift toward greater awareness and perhaps diversification of income sources. Meanwhile, the predominance of small and semi-medium landholdings highlighted the challenges of land fragmentation, a critical issue in ensuring the long-term sustainability of farming in the region.

Factors affecting non-farm livelihood diversification

In the logistic regression analysis aimed at determining household participation in the rural non-farm sector, several significant factors emerged, as presented in Table 2. The study examined various household characteristics and their influence on non-farm participation, revealing important insights. Age of the household head proved to be a notable factor, with each additional year increasing the odds of engaging in non-farm activities by approximately 8.9 per cent. This finding suggests that as household heads age, they are more likely to

diversify into non-farm activities, possibly due to accumulated experience or a shift away from physically demanding agricultural work.

The education level of the household head also played a role, though it was not statistically significant. However, the presence of a highly educated family member had a substantial effect on non-farm participation. Households with the most educated family member were over four times more likely to engage in non-farm activities, highlighting the importance of education in promoting diversification into the rural non-farm sector. Training related to skill development had a profound impact, with households where members had received any form of training being nearly five times more likely to participate in non-farm activities. This underscores the crucial role of skill enhancement in enabling households to explore non-agricultural income sources. Similarly, access to institutional credit significantly boosted non-farm participation, with households having access to credit being almost ten times more likely to engage in non-farm activities, reflecting the importance of financial resources in supporting livelihood diversification. Asset value per acre had a marginal yet significant negative impact on non-farm participation, suggesting that households with higher land asset values were slightly less likely to diversify into non-farm activities. This may indicate that wealthier households, who rely more heavily on agricultural income, have less incentive to seek non-farm opportunities.

Other variables, such as family size, operational landholding size and access to town were not found to have significant effects on non-farm participation. The dependency ratio had a slight negative effect, indicating that higher dependency ratios reduced the likelihood of non-farm participation, potentially due to the burden of supporting non-earning family members. Livestock value and crop income per capita were found to have non-significant effects on household engagement in non-farm activities. The model's Pseudo R^2 value of 0.5627 indicated moderate explanatory power, accounting for about 56.27% of the variability in household non-farm participation. The Chi-Square statistic of 135.36, significant at the 1% level, validated the overall robustness of the model in predicting household engagement in the rural non-farm sector based on the selected explanatory variables. The findings of this study align with previous research by Devi and Ranganathan (2021) and Saini and Kaur (2022), who also emphasized the importance of education, training, and access to institutional credit in enhancing rural non-farm income. These results reinforce the need for targeted interventions in education, skill development, and financial inclusion to promote non-farm participation in rural areas. Additionally, the findings corroborate the conclusions drawn by Khatun and Roy (2012), who highlighted the role of education, training, and credit access in diversifying rural livelihoods, while variables such as asset value and family size showed minimal influence.

CONCLUSION

This study examined the determinants of non-farm diversification among agricultural households in central Punjab, revealing that older age, higher education levels, skill training and access to credit significantly increase non-farm participation. Wealthier households with higher asset and livestock values are less likely to diversify. Policy recommendations include enhancing educational and training programs, improving credit access, conducting on going research and monitoring to support non-farm activities and improve rural livelihoods.

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Received on 20/9/2024 Accepted on 4/11/2024

J Krishi Vigyan 2024, 12(4) : 808-814
DOI : 10.5958/2349-4433.2024.00139.4
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Economics of Women-led Sericulture Enterprise in Chikkaballapur District of Karnataka

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ABSTRACT

Sericulture plays important role in empowerment of women and this study emphasized on calculating the cost and return of cocoon production and reeling unit. The study was carried out in Chikballapur district of Karnataka state. Multistage sampling was done in Sidlaghatta and Chintamani taluks based on highest area under mulberry cultivation. Sixty women entrepreneur were selected from both the taluka undertaking both enterprises (15 each). Total cost involved in cocoon production was Rs. 0.548/- lakh per batch which comprises of Rs. 0.076/- lakh fixed cost and Rs. 0.472 lakh variable cost. Gross return accounted to Rs. 0.803 lakh/per batch and 6.826 lakh/year. Price of cocoon was Rs. 550/-kg. Returns per rupee invested was 1.40 for cocoon production. Capital requirement of multi end reeling unit was Rs 6.308 lakh comprised of reeling house, boiler and reeler .Cost involved in raw silk production was Rs. 0.405 lakh and annual expenditure was Rs. 106.059 lakh and returns from raw silk production was Rs. 119.054 lakh/year and Rs. 0.458 lakh/day. Returns per rupee investment was 1.13.

Key Words : Cocoon production, Gross income**,** Rearing units, Silk Reeling Units, Women Entrepreneur,

INTRODUCTION

Women entrepreneurs play a significant role in the industry, particularly in countries like India and China, where sericulture is a traditional and important economic activity. Their involvement not only empowers them economically but also plays a vital role in preserving cultural heritage and promoting sustainable development. Mulberry is widely distributed with different species (> 68 species), and major silk-producing countries have collected, evaluated, and conserved a good number of mulberry germ plasm accessions for their utilization in a targeted breeding program for evolving superior varieties (Saini, 2023).

After china India is the second largest producer of silk in world. It employs about 9.2 million people as on 2022-23. It produced 36,582 MT of silk. The major silk-producing states in the country are Andhra Pradesh, Assam, Bihar, Gujarat, Jammu and Kashmir, Karnataka, Chhattisgarh, Maharashtra, Tamil Nadu, Uttar Pradesh, and West Bengal. Karnataka contributed around 32.3% of the total silk. In FY23, India's exports of silk and silk products stood at US$ 220.58 million. Mysore and north Bangalore contribute to nearly 70 percent of mulberry silk production (Minhas, 2023). The study focused on calculating cost and returns of cocoon production and multi-end reeling unit undertaken by women entrepreneurs.

MATERIALS AND METHODS

Chikkaballapur is a major silk producing district in Karnataka so was purposively selected. Two taluks were selected namely Sidlaghatta and Chintamani based on high mulberry area. Multistage sampling technique was adopted for

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Table 1. Expenditure of cocoon production. (n=30)

Sr No.	Particular	Rs./batch (lakh)	Rs./Year (lakh)	Per cent
A.	Variable cost			
1.	Hired human labour			
	Male	0.025	0.213	4.54
	Female	0.024	0.204	4.36
2.	Family labour			
	Male	0.010	0.085	1.81
	Female	0.018	0.153	3.27
3.	Disease free layings (DFLs)	0.049	0.412	8.80
4.	Mulberry leaves	0.210	1.785	38.11
5.	Hired Mountages	0.013	0.106	2.27
6.	Disinfecting material	0.009	0.094	2.00
7.	Newspaper	0.003	0.022	0.47
8.	Jute gunny bags	0.006	0.051	1.09
9.	Electricity	0.003	0.028	0.61
10.	Miscellaneous	0.060	0.513	10.96
11.	Marketing cost	0.009	0.072	1.54
12.	Interest on working capital @ 8 %	0.035	0.299	6.39
	Total variable cost (A)	0.472	4.038	86.22
B.	Fixed cost			
1.	Depreciation on rearing house	0.050	0.425	9.07
2.	Depreciation on equipments	0.018	0.151	3.23
3.	Interest on fixed capital@12%	0.008	0.069	1.48
	Total fixed cost (B)	0.076	0.645	13.78
	Total cost(A+B)	0.548	4.684	100.00

the selection of sample women entrepreneurs. 15 respondents were selected from each taluka for cocoon production and reeling which makes a sample size of 60 (30 cocoon producing women entrepreneurs and 30 women reelers). The primary data were collected through a survey of individual sericulture women entrepreneurs with structured questionnaires through the personal interview method regarding the cost of production and output, return from the output, marketing of cocoons, marketing costs. The cost and returns earned by the women entrepreneurs were worked out by using the costs *i.e.* variable costs and fixed costs. The returns were worked out by using gross returns and net returns. In cocoon production an average women undertook 8 crops per year in the study area. Based on this per year cost and returns of cocoon production was worked out.

RESULTS AND DISCUSSION

Cost and returns of cocoon production

Costs and returns of cocoon production among 30 women entrepreneurs were calculated and are represented in Table 1 and Table 2. The total variable and fixed cost incurred per year was Rs. 4.038/- lakh and Rs. 0.645/- lakh. Cocoon production requires a significant quantity of mulberry leaves as the primary food source for silkworms. It was observed that per batch the highest cost was incurred on mulberry leaves with Rs. 0.210/- lakh followed by miscellaneous cost of Rs. 0.060/- lakh. The high cost was because mulberry leaves are a staple feed for silkworms and it must be of good quality. Thus, the highest

Table 2. Returns obtained from cocoon production. (n=30)

Sr. No.	Particular	(Rs. lakh/Batch	(Rs. lakh/Year	Per cent
1.	Main produce (cocoon)	0.770	6.545	96.15
2.	By produce (silk worm manure)	0.033	0.281	3.85
3.	Gross returns	0.803	6.826	100
4.	Net profit (GR-TC)	0.255	2.142	
5.	Returns per rupee investment (GR/TC)	1.46	1.46	
6.	Total quantity of cocoon output	140 kg	1,190 kg	
7.	Total quantity of silk waste output	1,100 kg	9,350 kg	
8.	Price of cocoons (Rs./ kg.)	Rs.550 per kg		
9.	Price of silk waste (Rs./q)	Rs. 300 per quintal		

proportionate share of expenditure was contributed by the mulberry leaves with 38.11 per cent followed by miscellaneous cost with 10.96 per cent, respectively. The expenditure on hired male and female labour was Rs. 0.025/- lakh and Rs. 0.024/- lakh per batch and per year was Rs. 0.213/- lakh and Rs. 0.204/- lakh respectively. Whereas, the family labour expenditure was Rs. 0.010/- lakh and Rs. 0.018/- lakh for male and female. However, the yearly expenditure was Rs. 0.085/- lakh and Rs. 0.153/- lakh respectively.

Female labour was encouraged more than male labour, possibly due to the specific skills women possess which is required for cocoon production. The proportionate expenditure on DFLs was Rs. 0.049 lakh per batch accounting for 8.80 per cent share of the total cost. This cost represents the price of acquiring high-quality silkworm eggs, which is critical to ensure healthy and productive silkworms.

The expenditure on disinfecting material, hired mountages, jute gunny bags were Rs. 0.009 lakh, Rs. 0.013 lakh , Rs. 0.006 lakh per batch and per year it was Rs. 0.094 lakh, Rs. 0.106 lakh and Rs. 0.051 lakh, respectively. Disinfecting materials like vijetha powder, lime powder and bleaching powder were used for maintaining a clean and disease-free environment for the silkworms. Ensuring a healthy environment is crucial for cocoon production. The cost incurred by newspaper, electricity and marketing cost was Rs. 0.022 lakh, Rs. 0.028 lakh and Rs. 0.072 lakh per year. The marketing cost associated with promoting and selling cocoon products. It's relatively low, indicating that marketing may not be a primary focus of this enterprise.

The cost incurred on depreciation cost of capital asset and depreciation on equipment was Rs. 0.050 lakh and Rs. 0.018 lakh per batch and per year was Rs. 0.425 lakh and Rs. 0.151 lakh, respectively. This expense reflects the annual depreciation of the rearing house and equipment used in cocoon production. The equipments were given to women with subsidies at 90 per cent for SC/ST and 70 per cent for OBC and minorities. The interest on working capital and fixed capital was Rs. 0.035 lakh and Rs. 0.008 lakh per batch and per year it was Rs. 0.299 lakh and Rs. 0.069 lakh, respectively. The proportionate expenditure on variable cost was 86.22 per cent. The share of expenditure on fixed cost was 13.78 per cent which indicates that long term investment was very small as compared to current investment.

The total income generated from main produce per batch and per year was found to be Rs. 0.770 lakh and Rs. 6.545 lakh, respectively. The per cent return of 96.15 indicates that a significant portion of the total returns comes from main produce, making it the primary income source in this venture. The income generated was Rs. 0.033 lakh/ batch and per year it was Rs. 0.281 lakh

Table 3. Capital requirement for establishing the multi-end reeling unit (Unit- 6 basin)

Sr. No	Item	Units	Cost/ Unit (Rs. lakh)	Total cost (Rs. lakh)	Life span (years)	Depreciation (Rs. lakh)/year)
1.	Reeling House (50*30 Sq. ft)	1	-	5.4	30	0.18
2.	Boiler	1	0.22	0.22	8	0.0275
3.	Reeler (Multiend) 6 basins	2	0.32	0.64	8	0.08
4.	Water storage tank	1	0.0475	0.0475	20	0.0024
	Total			6.308		0.2898

through the silkworm manure. Although, this contribution is relatively small compared to cocoon sales, it still adds to the overall returns and can be considered as an additional source of income. The net returns estimated per batch was Rs. 0.255 lakh and per year was Rs. 2.142 lakh with benefit- cost ratio of 1.46 per batch and 1.46 per year suggesting that the returns from cocoon and silkworm manure production exceed the costs, making it a financially viable business.

The results of the study were in line with the studies conducted by Roopa Hosali and Murthy (2015) and Manjunatha *et al* (2017).

The depreciation cost per year represents the capital requirements for establishing a multi end reeling unit is calculated based on the initial cost of the item and its expected lifespan. The reeling house is expected to last for 30 years and its value will gradually decrease over this period due to factors like maintenance costs and normal wear and tear. Therefore, it's reasonable to allocate Rs 0.18 lakh/ year as the depreciation cost. Boilers typically have a shorter lifespan due to the high-temperature operation and wear and tear associated with their function. Depreciating the boiler at Rs. 0.0275 lakh/year over 8 years accounts for the accelerated wear and tear and the need for potential replacements or repairs during this period.

Reelers are essential equipment in a reeling unit, and they are subject to regular use and potential maintenance. Depreciating them at Rs 0.08 lakh/ year over 8 years acknowledges the wear and tear they will endure and allows for potential upgrades or replacements as technology evolves. Water storage tanks generally have a longer lifespan compared to machinery or equipment. They are subject to corrosion and wear, but proper maintenance can extend their lifespan. Hence, the annual depreciation cost was Rs 0.0024 lakh per year which is relatively lower. Therefore, the depreciation cost of fixed assets was Rs. 0.2898 lakh per year.

Multi- end reeling machines developed to increase the quality of raw silk reeled and to overcome inadequacy in the quality of silk reeled in the traditional method of reeling. In the research area, majority of silk reelers were using multi-end reeling machines with 6 basins for reeling silk from cocoon. This versatile technology enables the efficient and high-quality reeling of silk from multiple cocoons simultaneously, significantly increasing productivity and income for women silk producers. Hence, they were selected for the study. The average cost for production of mulberry raw silk was presented in Table 4. The total cost of raw silk production was divided into variable costs and fixed costs per six reeling basins annually.

The total cost of mulberry raw silk production per six basins was Rs. 106.059 lakh annually (Table 4). Amongst, the major share of cost was accounted by variable cost of Rs. 105.334 lakh (99.32%) and fixed cost accounts to Rs. 0.363 lakh (0.34%). Cocoons were the most expensive in variable cost, accounting for Rs. 85.8 lakh (80.90%). They are important aspect in the reeling industry since the amount of raw material directly affects production costs. The other expenses were labour charges for men and women were of Rs. 2.34 lakh (2.21%) and Rs 3.12 lakh (2.94%) per annum, respectively. The labour charges for women and men were same but more women labours were involved in reeling than men labours. The

Table 4. Cost incurred on mulberry raw silk production.

Sr. No.	Particular	Requirement	Price (Rs. lakh)	Total (Rs. lakh)	Annual expenditure (Rs. lakh)	Per cent
A.	Variable cost					
1.	Cocoon (Kg/day)	100	0.0033	0.3300	85.800	80.90
2	Labour Charge/ day					
a.	Women	4	0.0030	0.0120	3.1200	2.94
b.	Men	3	0.0030	0.0090	2.3400	2.21
4.	Fire wood / (Kg)	180	0.0001	0.0108	2.8080	2.65
5.	Miscellaneous expenses			0.0065	1.6900	1.59
6.	Interest on working capital@10%			0.0368	9.5758	9.03
7.	Total variable cost (A)			**0.4051**	**105.3338**	99.32
B.	Fixed cost					
8.	License fee	-	-	-	0.006	0.01
9.	Depreciation cost / year	-	-	-	0.290	0.27
10.	Repair and maintenance / year	-	-	-	0.028	0.03
11.	Interest on fixed capital@12%	-	-	-	0.039	0.04
12.	Total fixed cost (B)	-	-	-	0.363	0.34
13.	Total cost (A+B)	-	-	0.405	106.059	100.00

miscellaneous expense which accounts for Rs. 1.690 lakh (1.59%) and comprises of expenses incurred on distilled water requirements for boilers, fuel costs, electrical charges, and transportation costs. The cost of fire wood accounted for about Rs. 2.808 lakh (2.65%), and interest on variable cost accounted for Rs. 9.576 lakh (9.03%) annually. Among the fixed costs, major contribution was from depreciation accounting to Rs. 0.290 lakh (0.27%) and repair and maintenance cost accounted to Rs0.028 lakh (0.03%). It was also evident that the total cost incurred for mulberry raw silk production per day was Rs. 0.405 lakh.

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Table 5. Returns from mulberry raw silk production (per year). (n=30)

Sr. No.	Particular	Quantity		Returns (Rs. lakh)		
		Per day	Per year	Per day	Per year	%
	A. Main product					
1	Raw silk production (Kg)	11.8	4,307	0.431	111.982	94.06
	B. By-products					
2	Silk waste (Kg)	2.75	1,003.75	0.018	4.719	3.96
3	Dead pupae (Kg)	38.50	14,052.5	0.006	1.502	1.26
4	Defective cocoon (Kg)	1.82	664.3	0.003	0.852	0.72
	Gross returns (Rs. lakh)			0.458	119.054	100
	Net returns (GR-TC)			0.053	13.720	
	Returns per rupee investment (GR/TC)			1.13	1.13	
	Renditta (Kg)	7.8	7.8			

accounts for Rs. 1.690 lakh (1.59%) and comprises of expenses incurred on distilled water requirements for boilers, fuel costs, electrical charges, and transportation costs. The cost of fire wood accounted for about Rs. 2.808 lakh (2.65%), and interest on variable cost accounted for Rs. 9.576 lakh (9.03%) annually. Among the fixed costs, major contribution was from depreciation accounting to Rs. 0.290 lakh (0.27%) and repair and maintenance cost accounted to Rs0.028 lakh (0.03%). It was also evident that the total cost incurred for mulberry raw silk production per day was Rs. 0.405 lakh.

The data(Table 5) presented the annual returns from mulberry raw silk production, providing a breakdown of both the main product (raw silk) and its by-products. In a given year, the production of raw silk amounts to 4,307 kg, generating a substantial revenue of Rs. 111.982 lakh which constitutes approximately 94.06% of the gross returns. Additionally, there are three by-products: silk waste, dead pupae, and defective cocoons contributing 3.963%, 1.261%, and 0.715% to the gross returns, respectively. The total gross returns for the year and per day were Rs 119.054 lakh and Rs. 0.458 lakh respectively. After deducting the total cost provided in the table 12 from the gross returns, the net returns amount per year and per day is Rs 13.720 lakh and Rs. 0.053 lakh resulting in a benefit-cost ratio of 1.13 and 1.13 respectively. This data underscored the economic viability of mulberry raw silk production, with a focus on both the primary product and the associated by-products, indicating a positive economic outcome. The results of economics of reeling units were in line with the results of Rama Kumar *et al* (2008)

CONCLUSION

In Karnataka, Sericulture is main occupation which provides employment opportunity from egg production, chawki rearing, mulberry cultivation, cocoon production and reeling. The women's play an important role in sericulture because of their inherent characteristics and dedication. This study emphased on cost and returns of cocoon production and establishing the multi-end reeling unit. The results showed that major cost on cocoon was from mulberry of Rs. 1,78,500/year i.e, for 8 crops per year other cost involved in cocoon production were labour, Disease free layings (DFLs), hired mountages etc. The return from cocoon was Rs. 6.545 lakh/year so returns per rupee investment is 1.46. Capital requirement for

establishing the multi-end reeling unit was 6.308 lakh and cost for production of raw silk was Rs106.059 lakh and returns was 111.982 lakh with returns per rupee investment 1.13. This states that undertaking both the enterprise are profitable. The enterprises not only generates income but also empowers women, improves their livelihoods and promotes regional economic growth. Women's participation in this sector can motivate more women to join in sericulture and contribute to their communities' prosperity.

ACKNOWLEDGMENT

Authors sincerely thank Institute of Agribusiness Management, University of Agricultural Sciences, Bangalore for providing all the support to conduct research. My special thanks to Dr. Nethrayini K. R. (Chairperson) and all the committee members for guiding me in conducting the research .

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Received on 30/8/2024 Accepted on 20/11/2024

J Krishi Vigyan 2024, 12(4) : 815-823
DOI : 10.5958/2349-4433.2024.00140.5
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Effect of Biosynthesized Nano Zinc on Growth Performance, Nutrient Utilization and Tissue Mineral Concentration in Vanaraja Chicken

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ABSTRACT

This study evaluated the effects of feeding biosynthesized zinc nanoparticles (ZnNPs) on growth performance, nutrient utilization, and tissue mineral concentrations in Vanaraja chickens. Birds were divided into six groups: a zinc-negative control, a positive control receiving 60 ppm inorganic zinc, and four groups supplemented with 15 ppm, 30 ppm, 45 ppm, and 60 ppm ZnNPs. Over an 8-week period, parameters such as feed consumption, growth rates, feed conversion ratio (FCR), nutrient utilization, zinc bioavailability, and tissue zinc concentrations were recorded. Feed intake during the starter phase remained stable, averaging 461.96 to 472.58 g, while significant decreases were observed in the finisher phase (2320.65 to 2447.93 g), indicating enhanced feed efficiency associated with ZnNPs. Growth rates improved significantly during the finisher phase (953.11 to 1036.06 g) and overall (1162.21 to 1246.67 g), highlighting the potential of ZnNPs to optimize nutrient absorption. FCR values ranged from 2.24 to 2.51, with ZnNP groups achieving efficiencies comparable to the positive control, suggesting that ZnNPs can replace conventional zinc sources. Although nutrient utilization effects were statistically insignificant, higher ZnNP doses increased zinc retention in bone (up to 347.28 ppm) and liver tissues. These findings indicate that ZnNP supplementation can enhance growth efficiency and zinc bioavailability in poultry.

Key Words: Bioavailability, Bone Zinc, FCR, Growth, Mineral Retention, Poultry

INTRODUCTION

Zinc supplementation is achieved using inorganic zinc sources, such as zinc oxide and zinc sulphate. However, recent advancements in nanotechnology have introduced biosynthesized nano zinc particles as a potential alternative due to their enhanced bioavailability and unique physicochemical properties (Khan *et al*, 2020; Rani *et al*, 2018). Nano zinc particles, which range in size from 1 to 100 nano meters, have shown to offer improved absorption and utilization compared to their conventional counterparts (Wang *et al*, 2019; Zhang *et al*, 2020). In poultry nutrition, nano zinc has been investigated for its effects on growth performance, nutrient utilization, and tissue mineral concentrations. Several studies have reported that nano zinc supplementation can lead to significant improvements in body weight gain and feed conversion ratio (FCR) in broilers (Ibrahim *et al*, 2017) and layers (Saleh *et al*, 2018). For instance, Mohammadi *et al* (2015) observed that nano zinc at specific dosages significantly enhanced growth parameters compared to conventional zinc sources. Similarly, Bami *et al* (2018) found that nano zinc supplementation led to improved feed

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Table 1. Ingredient and chemical composition of basal diets.

Ingredient (kg)	Chick diet (0-3 Week)	Grower Diet (4-8 week)
Maize	58.07	65.54
Soybean meal	37.32	29.85
Stone grit	1.60	1.6
Dicalcium phosphate	1.90	1.90
Common Salt	0.35	0.35
Sodium bicarbonate	0.10	0.10
DL-Methionine	0.19	0.19
Lysine	0.04	0.04
Trace mineral mix (without copper) *	0.10	0.10
Vitamin ADK pre mix**	0.015	0.015
Vitamin B-Complex mix***	0.015	0.015
Choline Chloride	0.10	0.10
Toxin binder	0.10	0.10
Tylosine	0.05	0.05
Coccidiostat	0.05	0.05
Total	100.00	100.00
Chemical composition		
ME (kcal kg-1)	2803	2881
Crude protein (%)	22.45	20.12
Ether extract (%)	1.78	1.92
Crude fibre (%)	3.12	3.26
Calcium (%)	1.02	1.03
Available phosphorus (%)	0.45	0.42
Lysine[1]	1.36	1.28
Methionine[1]	0.60	0.52

*Contains Ca-32%, P-9%, Fe-2000 ppm, I-0.01%, Mn-0.4% and Zinc-0.4%.
Each gram contains Vitamin A-82500 IU, Vitamin B_2-50 mg, Vitamin D_3-12000 IU and Vitamin K-10 mg. * Each gram contains Vitamin B_1-4 mg, B_6-8 mg, B_{12}-40 mg, E-40 mg, Calcium pantothenate-40 mg, Niacin-60 mg.

efficiency in broilers. The bioavailability of zinc is crucial for its effectiveness in poultry diets. Research has demonstrated that nano zinc particles were more readily absorbed and utilized by poultry compared to larger zinc particles or inorganic zinc compounds (Asheer *et al*, 2018; Zhao *et al*, 2014). This enhanced bioavailability has been linked to improvements in tissue zinc concentrations, particularly in bones and liver, which are vital for overall poultry health and productivity (El-Katcha *et al*, 2017; Kumar *et al*, 2020). Moreover, the impact of nano zinc on tissue mineral concentrations has been reported to be dose-dependent, with higher dosages generally leading to increased mineral content (Cai *et al*, 2021; Muralisankar *et al*, 2017). Despite these promising findings, the effects of nano zinc on various aspects of poultry production are not entirely consistent. Some studies have reported no significant differences in growth performance or nutrient utilization between nano zinc and conventional zinc sources (Lina *et al*, 2009; Mao and Lien, 2017). These discrepancies may be attributed to variations in experimental

Table 2. Zinc concentration in different dietary treatments.

Treatment	Zinc Source	Zinc added (mg/kg)	Analysed Zinc concentration # (mg/kg)
Zn_0	-	0	57
Zn_60	Zinc	60	128
ZnNP_15	Biosynthesised nano zinc	15	74
ZnNP_30	Biosynthesised nano zinc	30	91
ZnNP_45	Biosynthesised nano zinc	45	108
ZnNP_60	Biosynthesised nano zinc	60	129

#Values based on triplicate analysis

conditions, such as dosage, feed formulation, and environmental factors (Gopi *et al*, 2019; Liu *et al*, 2020). This study aimed to investigate the effects of biosynthesized nano zinc on growth performance, nutrient utilization, and tissue mineral concentration in Vanaraja chickens. By assessing these parameters, the research will provide valuable insights into the potential benefits and limitations of using nano zinc as a feed additive in poultry nutrition.

MATERIALS AND METHODS

The experiment was conducted at the ICAR-Directorate of Poultry Research, Hyderabad, Telangana, India, from December 2021 to February 2022. All experimental procedures complied with the institution's animal ethics committee guidelines. A total of 324-day-old Vanaraja chicks, with an average body weight of 37.35±0.14 g, were randomly assigned to one of six dietary treatment groups, each comprising nine replicates. The chicks were wing-banded and housed in three-tier battery brooders. The dietary treatments included a basal diet without supplemental zinc (control, Zn_0), a basal diet supplemented with 60 mg Zn/kg from zinc oxide (Zn_60), and four diets supplemented with nano-zinc at levels of 15, 30, 45, and 60 mg Zn/kg (ZnNP_15, ZnNP_30, ZnNP_45, ZnNP_60), respectively. All diets were formulated to meet nutrient requirements based on BIS (1992) standards for poultry, except for zinc, which was supplemented as per treatment specifications. The nano-zinc powder, synthesized from Azadirachta indica (Neem) leaf extract using the method outlined by Bhuyan *et al* (2015), was hand-mixed into the feed using standard procedures. Formation of nano particles were checked using particle size analysis and transmission electron microscopy (TEM) and ensured that particles were below 100nm. The ingredient composition and nutrient composition of chick feed and grower feed are presented in the Table: 1. Zinc content of different treatment feeds is presented in Table 2.

Chicks were provided with supplementary heat via incandescent bulbs until they reached four weeks of age. Vaccination against Newcastle disease and Infectious Bursal Disease was carried out according to the standard vaccination protocol. Daily feed intake and weekly feed residues were recorded alongside weekly body weight measurements, which were used to calculate feed consumption, weight gain, and feed conversion ratio (FCR) using standard formulas. A metabolic trial was conducted during the 6th week to assess the impact of nano-zinc on nutrient utilization. Three replicates per treatment were selected, where the daily feed intake, leftover feed, and feces excreted were measured precisely over three consecutive days. Approximately 100 g of feces from each replicate were collected daily, dried at 70°C for 20 hours, 90°C for 3 hours, and finally at 102°C for 1 hour before being weighed and stored for further analysis.

On the 56th day, one bird per replicate, with body weight closest to the mean of that replicate, was selected for slaughter, resulting in nine birds per treatment. Samples, including the right femur bone, the whole liver, and 100 g of

Table 2. Effect of feeding zinc nanoparticles on weekly feed intake, phase-wise feed intake and overall feed intake (g) of Vanaraja chicken.

Treatment	Week								Starter phase	Finisher Phase	Overall
	1	2	3	4	5	6	7	8			
Zn_0	71.56	180.30	210.28	329.33	441.31 [b]	563.80 [b]	546.93	566.56 [b]	462.14	2447.93 [b]	2910.06 [b]
Zn_60	73.77	181.45	198.87	321.39	420.65 [ab]	513.72 [ab]	566.93	514.37 [a]	454.10	2337.06 [a]	2791.15 [a]
ZnNP_15	74.89	175.89	216.98	329.28	406.83 [a]	511.41 [ab]	561.06	541.46 [ab]	467.76	2350.04 [a]	2817.80 [ab]
ZnNP_30	73.34	176.54	212.07	320.50	415.56 [ab]	520.33 [ab]	575.69	562.37 [b]	461.96	2394.45 [ab]	2856.40 [ab]
ZnNP_45	72.65	177.05	219.35	313.57	406.19 [a]	504.87 [a]	569.69	526.33 [ab]	469.05	2320.65 [a]	2789.70 [a]
ZnNP_60	72.76	178.48	221.35	321.07	411.85 [ab]	517.59 [ab]	547.74	537.30 [ab]	472.58	2335.56 [a]	2808.14 [ab]
SEM	0.68	1.69	3.35	2.68	3.19	5.66	4.11	4.55	3.85	10.62	11.66
P Value	0.829	0.932	0.445	0.555	0.011	0.034	0.239	0.002	0.808	0.002	0.016

[a,b] *Figures within a column bearing different superscripts differ significantly.*

Table 3. Effect of feeding zinc nanoparticles on weekly growth, phase-wise growth and overall growth (g)of Vanaraja chicken

Treatment	Week								Starter phase	Finisher Phase	Overall
	1	2	3	4	5	6	7	8			
Zn_0	47.87	93.85	67.37	143.50	179.8	203.13	210.43	216.2	209.10	953.11 [a]	1162.21 [a]
Zn_60	47.33	94.77	68.52	153.96	193.3	204.48	235.24	249.0	210.61	1036.06 [b]	1246.67 [b]
ZnNP_15	48.65	93.80	68.91	138.56	183.3	210.85	218.95	246.7	211.35	998.35 [ab]	1209.71 [ab]
ZnNP _30	49.00	95.02	65.33	130.61	186.2	222.32	208.78	267.2	209.35	1015.15 [ab]	1224.50 [ab]
ZnNP _45	46.75	91.29	72.81	134.09	171.6	207.63	201.57	246.2	210.86	975.98 [ab]	1187.17 [ab]
ZnNP _60	48.95	98.72	65.65	129.85	178.5	222.06	214.55	243.4	213.32	988.43 [ab]	1201.74 [ab]
SEM	0.51	1.27	2.19	3.13	4.46	3.75	5.07	6.30	2.09	7.53	9.31
P Value	0.756	0.721	0.944	0.219	0.829	0.535	0.532	0.351	0.995	0.020	0.044

[a,b] *Figures within a column bearing different superscripts differ significantly*

breast muscle, were collected to analyze tissue mineral concentrations. Feed, feces, liver, and muscle samples were dried and then ashed at 600°C for 2 hours using a muffle furnace for zinc analysis. Bone samples were prepared by autoclaving, followed by overnight soaking in petroleum ether, and then dried in an oven at 102°C for 6 hours. Bone ash was obtained by heating the bone at 600°C in a muffle furnace for 4 hours. The resulting ash was dissolved in 0.5M nitric acid and diluted to 100 ml for zinc analysis, which was conducted using an Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Feed consumption

The impact of feeding nano zinc on the feed consumption of Vanaraja chickens is shown in Table 2. The average weekly feed consumption (g) for the 1–8-week period ranged from 71.56 to 74.89, 175.89 to 181.45, 198.87 to 221.35, 313.57 to 329.33, 406.19 to 441.31, 504.87 to 563.80, 546.93 to 575.69, and 526.33 to 566.56, respectively. During the starter phase, feed consumption ranged from 461.96 to 472.58 g. In the finisher phase, it ranged from 2320.65 to 2447.93 g, and for the overall period, feed consumption varied between 2789.70 to 2910.06 g. The results demonstrated the impact of nano zinc supplementation on feed consumption in Vanaraja chickens across different growth phases. During the starter phase, feed consumption showed minor variations among different treatments, with the Zn_60 and ZnNP_60 groups showing the lowest and highest consumption, respectively. However, these differences were not statistically significant, indicating that nano zinc supplementation at various levels did not drastically alter feed intake during the early growth phase. In the finisher phase, significant differences were observed, with the Zn_0 group consuming the highest quantity of feed and the ZnNP_45 group consuming the least. This suggested that higher levels of nano zinc supplementation may lead to more efficient feed utilization during the later stages of growth, potentially due to better nutrient absorption and metabolism (Ibrahim *et al*, 2017; Asheer *et al*, 2018).

Table 4. Effect of feeding zinc nanoparticles on weekly feed conversion ratio (FCR) phase-wise FCR and overall FCR of Vanaraja chicken

Treatment	Week								Starter phase	Finisher Phase	Overall
	1	2	3	4	5	6	7	8			
Zn_0	1.50	1.94	3.33	2.32	2.48	2.91	2.90	2.69	2.21	2.57[b]	2.51[b]
Zn_60	1.57	1.93	3.10	2.22	2.48	2.66	2.54	2.27	2.16	2.26[a]	2.24[a]
ZnNP_15	1.55	1.88	3.33	2.42	2.22	2.43	2.57	2.20	2.22	2.36[a]	2.33[a]
ZnNP _30	1.51	1.86	3.45	2.47	2.26	2.35	2.78	2.19	2.22	2.37[a]	2.34[a]
ZnNP _45	1.56	1.94	3.04	2.35	2.42	2.44	2.84	2.16	2.23	2.38[a]	2.35[a]
ZnNP _60	1.49	1.83	3.48	2.50	2.32	2.34	2.57	2.23	2.22	2.37[a]	2.34[a]
SEM	0.02	0.02	0.11	0.05	0.06	0.07	0.08	0.07	0.02	0.01	0.01
P Value	0.885	0.628	0.831	0.515	0.785	0.122	0.710	0.140	0.926	0.001	0.001

[a,b] *figures within a column bearing different superscripts differ significantly.*

Table 5. Impact of Zinc Nanoparticle Supplementation on Nutrient Utilization in Vanaraja Chickens

Treatment	DM	OM	CP	EE	CF	NFE
Zn_0	66.76	69.52	57.69	64.74	10.03	77.64
Zn_60	68.85	71.52	58.26	70.45	10.50	80.02
ZnNP_15	68.88	71.64	60.78	72.22	10.13	79.27
ZnNP _30	66.73	69.59	57.51	63.68	10.30	77.80
ZnNP _45	67.48	70.20	58.32	63.17	10.08	78.40
ZnNP _60	66.72	69.53	57.70	66.97	10.00	77.58
SEM	0.56	0.52	0.87	2.04	0.08	0.50
P Value	0.777	0.749	0.929	0.792	0.587	0.717

Overall, the total feed consumption over the entire period also showed significant variations, with the Zn_0 group having the highest intake and the ZnNP_45 group the lowest. These results align with the observed trends in the finisher phase, reinforcing the idea that nano zinc can enhance feed efficiency (Mohammadi *et al*, 2015; Lee *et al*, 2021). The significant differences in feed consumption during weeks 5, 6, and 8, as well as in the finisher and overall periods, highlight the potential of nano zinc to influence feeding behaviour and efficiency. The reduced feed intake in nano zinc-supplemented groups without compromising growth performance suggests improved nutrient utilization and better

overall health (Fathi *et al*, 2018; Xia *et al*, 2019). These findings supported the hypothesis that nano zinc supplementation can optimize feed consumption patterns in poultry, particularly during the finisher phase, contributing to more efficient poultry production.

Growth

The impact of feeding zinc nanoparticles to Vanaraja chicken on growth was presented in Table 3. The respective average weekly growth (g) ranged during the 1-8 weeks, between 46.75 to 49.00, 91.29 to 98.72, 65.33 to 72.81, 129.85 to 153.96, 171.6 to 193.3, 203.13 to 222.32, 201.57 to 235.24, and 216.2 to 267.2. The growth during starter phase ranged between 209.10 to 213.32, during finisher phase it ranged between 953.11 to 1036.06 and for the overall period, the growth ranged between 1162.21 to 1246.67. The data revealed that overall growth of negative control group was significantly (P=0.044) lower than the positive control group, while the nano zinc fed four groups did not differ significantly with any group. Similar trend was observed during finisher phase (P=0.020) with Zn positive control group significantly (P<0.05) higher growth compared to Zn negative control, while the nano Zn fed groups showed statistically similar growth with all other groups.

The weekly growth data indicate no significant differences among treatments across all weeks, suggesting that the presence of nano zinc did not drastically alter weekly growth patterns. This aligned with the findings of Mao and Lien (2017), who also reported no significant impact on weekly growth parameters with nano zinc supplementation. During the starter phase,

Table 6. Impact of Zinc Nanoparticle Supplementation on Zinc Bioavailability and Concentration in the Bone, Liver, and Muscle of Vanaraja Chickens

Treatment	Bio-availability (%)	Bone (ppm)	Bone ash (ppm)	Wet liver (ppm)	Dry liver (ppm)	Liver ash (ppm)	Fresh muscle (ppm)	Dry muscle (ppm)	Muscle ash (ppm)
Zn_0	49.58	99.08 [a]	224.31 [a]	32.34	114.01	465.37	9.26	36.74	906.88
Zn_60	54.72	216.87 [ab]	488.83 [ab]	35.55	123.36	563.96	10.23	38.44	987.99
ZnNP_15	50.60	240.19 [ab]	523.34 [ab]	37.30	133.66	538.51	10.77	41.28	949.35
ZnNP _30	57.89	249.86 [b]	567.47 [b]	38.92	136.48	585.51	10.48	38.59	962.23
ZnNP _45	55.21	330.15 [b]	732.50 [b]	43.15	156.13	503.84	10.40	38.60	930.54
ZnNP _60	45.19	347.28 [b]	762.04 [b]	44.27	155.59	598.64	11.18	40.62	896.49
SEM	1.82	17.86	38.60	1.33	4.80	18.64	0.77	2.99	82.45
P Value	0.396	0.01	0.01	0.081	0.060	0.303	0.991	0.999	1.000

growth performance did not significantly differ among the treatments, indicating that the initial growth phase was not markedly affected by the supplementation of nano zinc. This aligned with previous research (Ibrahim *et al*, 2017; Asheer *et al*, 2018) which found that initial growth responses to zinc supplementation were often subtle and less pronounced.

In the finisher phase, significant differences were observed, with the Zn_60 group showing the highest growth. This suggested that higher levels of zinc supplementation may lead to better growth performance during the later stages of growth, likely due to enhanced nutrient absorption and metabolism (Fathi *et al*, 2018; Xia *et al*, 2019). This is supported by the improved feed efficiency noted in the finisher phase for nano zinc-supplemented groups. Overall growth performance also showed significant differences, with the Zn_60 group outperforming others. This indicates that nano zinc supplementation can have a cumulative positive effect on growth over the entire production period. These findings align with those of Lee *et al* (2021) and Mohapatra *et al* (2019), who reported improved overall growth performance with nano zinc supplementation in poultry. The significant improvements in growth during the finisher and overall periods highlight the potential of nano zinc to enhance growth efficiency and overall productivity in poultry. Earlier investigations (Wang *et al*, 2020; El-Hack *et al*, 2020; Yousefi *et al*, 2021) also concluded that by nano zinc not only improves feed utilization but also supports better growth performance, likely through improved mineral absorption and utilization.

Feed conversion ratio

The impact of feeding zinc nanoparticles (ZnNPs) to Vanaraja chicken on feed conversion ratio (FCR) was presented in Table 4. The average weekly FCR during the 1-8 weeks ranged from 1.49 to 1.57, 1.83 to 1.97, 2.22 to 2.50, 2.22 to 2.50, 2.22 to 2.48, 2.34 to 2.91, 2.54 to 2.90, and 2.16 to 2.69. The FCR during the starter phase ranged from 2.16 to 2.23, during the finisher phase it ranged from 2.26 to 2.57, and for the overall period, it ranged from 2.24 to 2.51. The data suggested that the FCR of the zinc-negative control during the overall period was significantly (P=0.001) higher (or less efficient) compared to all other groups. A similar trend was observed during the finisher phase (P=0.001). Nano zinc-fed groups and the positive control did not differ significantly. Data related to feed consumption, growth, and FCR suggested that if feed is devoid of added zinc, the birds' growth and FCR would be negatively affected. The results of nano zinc-fed groups, which were similar to the zinc-positive control, suggest that dose reduction is possible without compromising these parameters. The data indicated that the lack of supplemental zinc adversely affects growth and feed conversion ratio (FCR), highlighting the critical importance of zinc in poultry nutrition. Ibrahim *et al* (2017) reported significant improvements in body weight gain and FCR with nano zinc supplementation in broilers. The similarity in performance between nano zinc-fed groups and the positive control suggested that nano zinc can potentially replace conventional zinc sources without compromising growth or feed efficiency (Bami *et al*, 2018). Previous studies have reported mixed results. For instance,

Lina *et al* (2009) found no significant difference in overall growth with nano zinc supplementation, but feed consumption decreased significantly with zinc nanoparticles at 40 mg/kg. Muralisankar *et al* (2017) and Saleh *et al* (2018) reported improved growth performance and immune response with nano zinc at 40 mg/kg and 30 mg/kg, respectively.

Muralisankar *et al* (2017) and Saleh *et al* (2018) reported improved growth performance and immune response with nano zinc at 40 mg/kg and 30 mg/kg, respectively. Conversely, Zhao *et al* (2014) found significant differences in early body weights with nano zinc but no long-term benefits at higher doses. El-Katcha *et al* (2017) found that nano zinc at 30, 45, and 60 mg/kg improved growth, but at 15 mg/kg, growth was poorer than control. Ibrahim *et al* (2017) concluded that nano zinc benefits broiler diets by improving body weight gain and FCR without changing feed intake. Mohammadi *et al* (2015) found no significant differences overall due to naturally occurring zinc in the basal diet. Alkhtib *et al* (2020) observed significant early growth improvements with nano zinc but no effects from 21-35 days. Kumar *et al* (2020) found that hot melt extruded zinc significantly improved feed efficiency over 0-35 days. Cufadar *et al* (2020) and Olgun and Yildiz (2017) reported no significant differences with nano zinc in layer birds and production parameters. Mao and Lien (2017) found no significant effects on egg production with nano zinc in laying birds.

Nutrient utilization

The impact of zinc nanoparticle supplementation on nutrient utilization in Vanaraja chickens is displayed in Table 5. Feeding zinc nanoparticles had no significant effect on the utilization of dietary components, including dry matter, organic matter, crude protein, crude fiber, ether extract, and nitrogen-free extract, as shown in Table 4. Digestibility of dry matter and organic matter remained similar across the treatment groups, with no significant differences observed (P>0.05). The ZnNP_15 group had the highest values for digestibility of both DM (68.88%) and OM (71.64%), slightly higher than the Zn_60 group. The improved digestibility in the ZnNP_15 group aligns with findings by Ibrahim *et al* (2017), who reported enhanced nutrient absorption with nano zinc supplementation.

The study found that crude protein (CP) and ether extract (EE) digestibility were highest in the ZnNP_15 group, with CP digestibility reaching 60.78% and EE at 72.22%, although the differences were not statistically significant (P>0.05). These results suggest that nano zinc, especially at lower doses, may enhance protein and lipid utilization. Findings are consistent with Asheer *et al* (2018) and Saleh *et al* (2018), who reported benefits in protein efficiency and lipid metabolism with nano zinc supplementation. Similarly, nitrogen-free extract (NFE) digestibility was highest in the Zn_60 and ZnNP_15 groups, supporting carbohydrate metabolism. Although crude fiber (CF) digestibility and other results were unaffected, the improved protein and fat digestibility with nano zinc, particularly at 15 ppm, highlights its potential to enhance nutrient utilization in Vanaraja chickens. This aligns with prior research, such as Ibrahim *et al* (2017) and Gopi *et al* (2019), who observed similar improvements in nutrient retention and utilization with nano zinc.

Bioavailability and Tissue content of zinc

The impact of feeding zinc nanoparticles (ZnNPs) to Vanaraja chickens on zinc bioavailability and tissue concentrations is detailed in Table 6. Although bioavailability differences were not statistically significant (P>0.05), the ZnNP_30 group recorded the highest bioavailability at 57.89%, aligning with Ibrahim *et al* (2017), who also observed enhanced bioavailability with nano zinc. Significant increases in bone and bone ash zinc content were found, with the highest values in the ZnNP_60 group (347.28 ppm in bone and 762.04 ppm in bone ash), suggesting a notable impact of ZnNPs on zinc deposition in skeletal tissues. These findings are consistent with Asheer *et al* (2018), who reported similar results in broilers. Zinc levels in liver tissues, while not statistically significant, were also highest in the ZnNP_60 group, indicating enhanced zinc retention. This aligns with El-Katcha *et al* (2017), who found increased tissue zinc levels with nano zinc. Muscle tissue showed no significant differences,

echoing the findings of Mohammadi *et al* (2015). Overall, higher ZnNP doses significantly improved zinc content in bone, with potential benefits in liver zinc retention.

CONCLUSION

The results in terms of growth and FCR indicated that, feeding of nanoparticles at lower doses (25, 50, and 75%)) was as beneficial as that of feeding inorganic zinc at full dose. The positive control group and all the four nano zinc fed groups have shown significantly ($P < 0.05$) better performance in terms of growth and FCR. Nanoparticles of zinc at lower levels compared to inorganic zinc, were found to be beneficial in reducing the dietary doses. These findings supported the use of ZnNPs as a viable alternative to conventional zinc sources in poultry diets, potentially allowing for reduced zinc supplementation levels without compromising tissue zinc levels.

ETHICAL STATEMENT

The animal experiment followed the guidelines set by the Committee for the Purpose of Control and Supervision of Experimentation on Animals (CPCSEA) for the use of animals in scientific research in India. The experimental protocol was reviewed and approved by the Institute's Animal Ethics Committee, with the approval number IAEC/DPR/21/01.

ACKNOWLEDGEMENT

The authors express their gratitude to the Director of the ICAR-Directorate of Poultry Research, Hyderabad, for providing the necessary farm, laboratory, and logistical support for conducting this study.

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Received on 22/8/2024 Accepted on 19/10/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 824-826

DOI : 10.5958/2349-4433.2024.00141.1

Effect of Different Spacing on Yield of Summer Moong Variety SML 1827

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ABSTRACT

Summer moong is emerging as cash crop in Punjab where paddy-wheat rotation is followed on a large area. An experiment was conducted to find out the most suitable spacing for sowing of summer moong in order to get higher benefits by increasing grain yield. The trial was laid out in factorial RBD with 3 X 2 factors. In this trial, three row to row spacing and two plant to plant spacing were taken with three replications. Row to row spacing of 20cm, 22.5cm and 25 cm were taken along with spacing of 7.5cm and 10 cm. The grain yield obtained was 12.68q/ha and 13.05q/ha of the crop sown at 22.5cm X 7.5cm and 22.5cm X 10.0 cm spacing, respectively. Therefore, it was inferred that summer moong variety SML 1827 could be sown at a row to row spacing of 22.5 cm with plant to plant spacing of 7.5 to10.0 cm.

Key Words: Cash crop, Spacing, Summer moong, Yield.

INTRODUCTION

Moong(*Vigna radiata* L.) is one of the important leguminous crops grown for its nitrogen fixation properties . It is primarily a rainy season crop but also suitable as a summer crop under irrigated conditions. It is grown both in summer and rainy seasons, although, it is more popular among farmers during summer season. Summer moong is a versatile crop with major emphasis on it as a cash crop, in between two main crops such as paddy and wheat, as far as Punjab agriculture in concerned. Summer mungbean is usually sown from the late February to first week of April after the harvest of potato in Punjab. The growth and yield of mungbean is mainly influenced by planting density so proper row spacing needs to be standardized. some high-yielding, photo-insensitive varieties of mungbean have been developed and released in last two decades in the country, which need to be tested for their adoption under different agro- climatic situations. Kundu *et al* (2021) reported that mungbean sown at close row spacing (25 cm) resulted in greater grain (583.0 kg/ha) and straw yield (2415.7 kg/ha) than wider spaced crop (30 cm).

Mung bean plant fixing atmospheric N2 and enriches the soil with N nutrient for the growth of succeeding crops . On the other hand, the crop can be successfully grown on marginal lands where other crops perform poorly and most suitable for green manure use (Dainavizadeh and Mehranzadeh, 2013). The crop is a short-duration and low input required legume crop. Mung bean is a quick or very early maturing crop, which requires 75–90 days to mature. Mung bean has special features such as its earliness in maturity, supply good yield, drought resilient property makes highly responsive in scanty rainfall. Siraje *et al* (2020) reported that the yield and yield components parameters such as number of seeds per pod, thousand seeds weight, grain and biomass yields and harvest index were significantly affected by main and interaction effects of intra and inter row spacing. However, days to emergence non-significantly affected by main and interaction effects meanwhile days to flowering and maturity, plant height, pod number per plant and straw yield were high significantly ($p < 0.01$) influenced by main effects only.

Green gram is a high-quality protein source (25%) with a good digestibility, also high in Riboflavin, Thiamine, and Vitamin C. Sprouts of green gram seeds produces significant amount of ascorbic acid (Sachan *et al*, 2023). Green gram is a rich source of protein (14.6– 33.0 g/100 g) and

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Table 1. Yield of summer moong (SML 1827) sown at different spacing.

Sr. No.	Spacing (R -R x P -P)	Yield (q/ h a)
1.	20.0 x 7.5 cm	12.35
2.	20.0 x 10 cm	12.03
3.	22.5 x 7.5 cm	12.68
4.	22.5 x 10 cm	13.05
5.	25.0 x 7.5 cm	11.90
6.	25.0 x 10 cm	11.72
7.	CD	0.43

iron (5.9–7.6 mg/100g). Green gram contains 1-3% fat, 50.4% carbohydrates, 3.5-4.5% fibers and 4.5-5.5% ash, while calcium and phosphorus are 132 and 367 mg per 100 grams of seed, respectively (Dahiya *et al*, 2015).

Variety SML 1827 of moongbean was released during 2019 by the Punjab Agricultural University, Ludhiana is becoming popular among farmers as compared to earlier variety SML 668 due to its thin grain size and shining grains, that helps farmers to fetch better price in the market. Summer moong is grown mainly after potato/wheat crop, although it gives better yield if sown during last week of March as compared to first fortnight of April and after that. Farmers are considering it as subsidiary crop and generally go for broadcasting of the seed but that in turn reduces the yield drastically. Hence, the study was conducted to find out proper row to row and plant to plant spacing in order to get higher yields.

MATERIALS AND METHODS

The yield of summer moong depends upon different agronomic aspects such as date of sowing, spacing and fertilizer application. Out of these agronomic aspects, the spacing is one character that varies the most in the farmers' fields because of adoption of different sowing methods such as broadcasting and drill sowing etc. Taking these inputs into consideration, a study was conducted during summer 2022 on spacing of summer moong variety SML 1827. In this trial, three row to row spacing and two plant to plant spacing were taken with three replications. Row to row spacing of 20cm, 22.5cm and 25 cm were taken along with spacing of 7.5cm and 10 cm.

The experiment was conducted at the University Seed Farm, Usman, Tarn Taran by using factorial RBD design. The soil type was clay loam with pH of 7.5. The trial was sown on 4th April, 2022. The seed was treated with *rhizobium* and then sown after half an hour. Fertilizers were applied at the time of sowing at the rate of 27.5 kg/ha urea and 250 kg/ha SSP fertilizers. Weeding was done manually twice on 4th and 6th week after sowing. The crop was sown under irrigated conditions with first irrigation after 20 days and last at 60 days after sowing; with a total of 4 irrigations. Summer moong being an indeterminate crop, so harvesting was done at 80 per cent pod maturity. The yield data were recorded and analysed statistically by using Opstat online software.

RESULTS AND DISCUSSION

The data (Table 1) revealed that maximum yield was obtained under 22.5 x 10 cm spacing, which was significantly superior to all other treatments except 22.5 x 7.5 cm. It also revealed that if the row to row spacing varies from 4-5 cm to any side, result in yield loss, this confirms that broadcasting of seed will drastically reduce the yield. It has been emphasized that optimal plant density and spacing are critical for

maximizing legume productivity. Overcrowding can lead to competition for resources, while too wide spacing can result in under utilization of available resources. Proper plant spacing ensures adequate light interception, air circulation, and nutrient uptake, promoting healthy plant growth and higher yields (Saini *et al*, 2024). Likewise Msimbira and Smith (2020) showed that soil pH affects nutrient availability and microbial activity in the soil. Most legumes prefer a slightly acidic to neutral pH range (6.0-7.5). Acidic or alkaline soils can limit nutrient uptake and hinder the growth of nitrogen-fixing bacteria, reducing the plant's ability to fix atmospheric nitrogen and thus impacting productivity. In the present study, pH of the experimental plot was around 7.5 thus was suitable for legume production. Further, the study proved that properly spaced plants face less competition for essential resources like water, nutrients and sunlight. This allows each plant to access a larger share of available resources, leading to better growth, higher biomass accumulation and thus improved yield components such as pod number and seed size.

CONCLUSION

After the harvesting of wheat crop , farmers generally sow moongbean crop by following broadcasting method of sowing. This method results in uneven plant spacing whereas there is no question of row to row spacing. As a result of which farmers are not able to harvest full potential of yield as recommended by the research institutes. Therefore, this experiment clearly showed that farmers must be made aware regarding adoption of proper spacing while sowing moongbean crop in order to get maximum yield. It can be concluded that farmers should go for 22.5 x 10 cm (row to row and plant to plant spacing,) for maximizing productivity of summer moong variety SML 1827.

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Received on 30/10/2024 Accepted on 23/11/2024

J Krishi Vigyan 2024, 12(4) : 827-830
DOI : 10.5958/2349-4433.2024.00142.8
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Effect of Plant Growth Regulators Effect on Grape Cutting (*Vitis vinifera* L.) cv. Flame Seedless

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ABSTRACT

The present investigation was conducted at Guru Kashi University Research Farm during 2022-2023, Punjab on evaluating the effect of plant growth regulator on grape cv. Flame seedless cutting. These cutting was treated with different concentration of indole-3-butyric acid (T_1: 1000, T_2: 1500 and T_3: 2000 ppm) and gibberellic acid (T_4: 50, T_5: 100 and T_6:150 ppm) along with control (T_0) using prolonged dipping method. The result revealed that T_6: gibberellic acid @150 ppm (9.33) showed minimum numbers of days taken for first emergence of nodes whereas, T_2: indole-3-butyric acid @ 1500 ppm (8.67) showed minimum days of the first roots emergence. The maximum survival percentage was recorded in the cutting treated with T_3: indole-3-butyric acid 2000 ppm (80.00%). Hence, T_2: indole-3-butyric acid @ 1500 ppm was showed good vegetative and root growth in selected root cutting of grape (***Vitis*** *vinifera* L.) cv. Flame Seedless.

Key Word: Cutting, Grape, Growth regulators, Root growth, Survival.

INTRODUCTION

Grape (*Vitis vinifera* L.), belongs to family *Vitaceae* is important commercial fruit crops with extraordinary taste and flavor cultivated in temperate and topical regions of World (Gowda *et al,* 2008; Nowshehri *et al*, 2015). The major grape-growing states in India, are Maharashtra (70.67%), Karnataka (24.49%), Tamil Nadu (1.43%), Andhra Pradesh (1.34%), Madhya Pradesh (1.02%), and Mizoram (0.50%), collectively contributes to nearly (99%) of the total grape production (NHB, 2019).Out of total production of grapes (74.5%) is used as table purpose, (23.5%) used as resin, (15%) used as wine and (0.5%) used for juices according to Adsule *et al* (2012). It possesses high nutrient content (10.2%) carbohydrates, (0.8%) proteins, (0.1%) minerals and (85.5%) water, fiber (1.4 g), vitamin C (27%), vitamin K (28%), thiamine (7%), riboflavin (6%), vitamin B6 (6%), potassium (8%), copper (10%), manganese (5%) and flavonoids (flavonoids, anthocyanins, and flavonols) as an important source of antioxidants (Andjelkovic *et al*, 2013; Somkuwar *et al*, 2018). This nutrient content used in curing jaundice, asthma, joints pains, piles, diabetes, cancer and heart diseases (Kanagarla *et al,* 2013; Dohadwala *et al*, 2009).

Flame seedless cultivar is heavy bearing, crimson red colour, sweet flavour berries and most tolerant to pre monsoon rains as well as less susceptible to diseases according to Chanana *et al* (2008). The hard wood cutting is most common way of propagation of grape. In this method the treatment of cuttings with plant growth regulators play an important role in regeneration. Many scientists had already reported the role of these plant growth regulators in stem elongation, apical dominance, root initiation, increasing the root number and length (Ling *et al*, 2015) So, The present study was undertaken with objectives to evaluate the effect of Gibberellic Acid (GA_3) and Indole Butyric Acid (IBA) on the survival percentage and vegetative growth of grapes cutting (*Vitisv inifera* L.) cv. Flame seedless.

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MATERIALS AND METHODS

The experiment was conducted at agriculture field of Guru Kashi University Research Farm, Talwandi sabo, Punjab in 2022-2023. It is located at latitude 29°59'0" N and longitude 75°5'0" East, has semiarid climate with wide variations of summer and winter temperatures. 20-25cm long grape (*Vitis vinifera* L. cv. Flame seedless) healthy, well nourished, and mature wood was used for trial. Basal 3-4 cm portion of hard wood cuttings were dipped for 24 h in indole-3-butyric acid (T_1: 1000, T_2: 1500 and T_3: 2000 ppm) and gibberellic acid (T_4: 50, T_5: 100 and T_6:150 ppm) solution along with water as control (T_0). It was allowed to dry for 15 minutes and then transplanted in field. The research trail was laid out in Randomized Block Deigns (RBD). The treatments in experiment were replicated three times and each plot consisted of 30 cuttings. Further observations was recorded from parameters i.e. first emergence of node, first emergence of roots, survival percentage, average number of leaves, average number of roots from selected plants. All data from the experimental field were analyzed separately for each experiment for different growth characters and yield attributes with the help of OPSTAT (Statistical Software Package for Agricultural Research Workers) (Sheoran *et al*, 1998). The critical difference at 5% level of implication was calculated to equate the mean different treatments.

RESULTS AND DISCUSSION

The result revealed that in T_6: GA_3@150 ppm (9.33) least numbers of days taken for first emergence of nodes followed by T_5: GA_3@100 ppm (11.33) and T_4: GA_3@ 50 ppm (14.33) and T_0: control (20.67) maximum number of days was taken for first emergence of nodes. The result also revealed that T_2: IBA @ 1500 ppm (8.67) least numbers of days taken for first emergence of roots followed by T_3: IBA @ 2000 ppm (11.67), T_1: IBA @1000 ppm (14.33), T_6: GA_3@150 ppm (19.33), T_4: GA_3@ 50 ppm (18.67) and maximum number of days was taken for first emergence of roots in T_0: control (21.33). The maximum survival percentage was recorded in the cutting treated with T_3 IBA @ 2000 ppm (80.00%) followed by T_2 IBA @ 1500 ppm (78.33%), T_1: IBA @1000 ppm (73.33%), T_6: GA3@150 ppm (72.33%), T_5: GA_3 @ 100 ppm (71.33%) and T_4: GA_3 @ 50 ppm (69.00%) and whereas, the minimum survival percentage was recorded in T_0: Control (58.33%). However, Patil *et al* (2000) reported the cuttings for 6 hours either in IBA (100 ppm) recorded maximum survival percentage (86.33 and 76.00) in the cutltivars Tas-A-Ganesh and Kismish Chorny.

The maximum average number of leaves at 60 and 90 DAP was observed in T_2: IBA @ 1500 ppm (20.67 & 25.33), followed by T_1: IBA @1000 ppm (13.67 & 22.33), T_3: IBA @ 2000 ppm (10.67 & 18.33), T_5: GA_3 @ 100 ppm (10.00 & 15.67), T_6: GA_3@150 ppm (9.33 & 13.67), T_4: GA_3@50 ppm (9.33 & 12.67), Whereas, the minimum average number of leaves was recorded in T_0: Control (8.67 & 9. 67) at 60 DAP and at 90 DAP. Many researchers work on the effect of plant growth regulators on the grapes cutting growth. Chalapathi *et al* (2001) who reported superior result in shoot length, number of branches, number of leaves and root length, survival percentage and sprouting percentage after cuttings treated with IBA.

The maximum average number of roots was recorded in the cutting treated with T_2: IBA @ 1500 ppm (31.67), followed by T_3: IBA @ 2000 ppm (30.00), T_1: IBA @1000 ppm (27.33), T_6: GA_3@150 ppm (23.33), T_5: GA_3 @ 100 ppm (22.33), and T_4: GA_3 @ 50 ppm (20.33). Whereas, the minimum average number of roots was recorded in T_0: Control (9. 67). Patil *et al* (2001) also reported the better survival percentage and higher number of primary roots with IBA treatments. Similarly, Song *et al* (2001) reported good rooting when the base of the cuttings was soaked in a solution of 150 ppm IBA for 24 hours. Rao (2004) reported IBA, 2000 ppm for hardwood cuttings was good for highest percentage of rooting and number of roots and longest root length per cutting in Dogridge and 1613C rootstocks. The maximum numbers of roots were obtained in grapes (V. *vinifera*) with 4000 mg/l IBA. The study showed the significant positive effect of both IBA and GA_3 plant growth regulator on growth and survival of grapes cutting cv. Flame seedless. The IBA @ 1500 ppm has shown good

Table I. Effect of plant growth regulators on total numbers of days taken for first emergence of node and roots (Days), survival percentage (%), average number of leaves / cutting (No.) and average number of roots/ cutting (No.) on grapes cutting (*Vitis vinifera*L.) cv. Flame Seedless.

Treatment	Number of days taken for first emergence of node (Days)	Numbers of days taken for first emergence of roots (Days)	Survival percentage (%)	Average Number of leaves / cutting (No.)		Average Number of roots/ cutting (No.)
				60 DAP	90 DAP	
T0	20.67	21.33	58.33	8.67	9.67	15.33
T1	19	14.33	73.33	13.67	22.33	27.33
T2	16.33	8.67	78.33	20.67	25.33	31.67
T3	18.33	11.67	80	10.67	18.33	30
T4	14.33	18.67	69	9.33	12.67	20.33
T5	11.33	16.67	71.33	10	15.67	22.33
T6	9.33	19.33	72.33	9.33	13.67	24.33
CV%	6.82%	3.44%	3.77%	9.59%	4.34%	2.95%
SE±	0.62	0.35	1.61	0.52	0.32	0.41

vegetative growth, less number of days taken for first emergence, average number leaves and root growth in root cutting of grape (*Vitis vinifera* L.) cv. Flame seedless.

CONCLUSION

It was concluded that the maximum data observed of cutting survival percentage in IBA 2000 ppm treatments. Moreover both plant growth regulators IBA and GA_3 showed significant effect on the growth and development of grapes as compared to control.

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Received on 24/8/2024 Accepted on 12/10/2024

J Krishi Vigyan 2024, 12(4) : 831-836
DOI : 10.5958/2349-4433.2024.00143.4
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Employment and Income Generation Capabilities of Duck Farming : Experience From Kuttanad Wet Land Ecosystem

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ABSTRACT

Duck farming is a customary livelihood option utilizing the topographical peculiarities of Kuttanad wetland ecosystem and is important for income generation and employment opportunities .Present study was conducted to analyse labour utilization pattern and income generation from duck farming in Kuttanad region of Kerala. Multistage random sampling was employed for selection of respondents and comprised of total of 150 farmers. Four systems of rearing viz., Back yard rearing, semi intensive, nomadic and nursery rearing were identified and majority followed semi intensive system of rearing. The labour utilization pattern and income generation varied among different systems of rearing. Backyard rearing was found to provide an average daily employment of nearly 22.8 days per annum for the family. All other systems of duck rearing in Kuttanad region utilized both family labour and hired labour. The nomadic farming system found to be providing full time employment to the labourers throughout the season of flock migration and generated highest income. The gross income from backyard rearing system ranged from Rs. 300 to Rs.21,000 with an average of Rs. 5036/annum. The gross income from duck nurseries ranged from Rs. 15,990 to Rs. 3, 75,000 with an average income of Rs. 93,077/annum. The gross income from semi-intensive rearing system ranged from Rs. 5,000 to Rs.5, 26,000 with an average of Rs. 2, 30,119/annum. The gross income from nomadic rearing system ranged from Rs. 2, 50,000-7,40,000 with an average of Rs. 3,50,750/annum. The annual family income of farm families were concomitant with their respective income from duck farming.

Key Words: Duck farming , Income generation, Labour utilization pattern, Kuttanad ecosystem

INTRODUCTION

The wetland ecosystems worldwide are rich in biodiversity. These wetland systems contribute to the livelihood needs of the communities dependent on it. The Kuttanad Wet Land Eco System (KWLES) of Kerala, India is not an exception. KWLES has considerable ecological, economic and social significance. The KWLES has its unique ability to support agricultural activities like paddy cultivation, aqua culture and livestock production. Further it is a home to various flora and fauna contributing to the biodiversity of the state. Among the various models of livestock rearing viz. intensive-arable farming systems, mixed-crop-livestock models, integrated or rotational farming systems, duck rearing is the one which is operated in all with different extend of resource utilization in Kuttanad. As in any Asian countries, duck farming here still follows the primitive practice of trans-human nomadic pastoralism. Integrating duck farming with paddy cultivation, piggery, aquaculture etc. are also well accepted here. It needs no mention that duck farming has been a source of income and employment to the farmers of Kuttanad for many generations now. But, unfortunately the impact of changing agricultural pattern, man made changes to ecology, climate change and resource exhaustion has adversely

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Table 1. General profile of farmers. (N= 150)

Sr. No	Particular	Frequency	Percentage
1	Age		
	Young(<30years)	02	01.34
	Middle aged (30 – 40 years)	26	17.33
	Upper middle aged (41 - 50 years)	57	38.00
	Old (> 50 years)	65	43.33
2	Education		
	No formal education	04	02.67
	Primary	30	20.00
	Secondary	91	60.67
	Higher secondary	20	13.33
	College	05	03.33
3	Occupation		
	Self-employment	19	12.67
	Daily wages	10	06.67
	Agriculture along with animal husbandry	15	10.00
	Duck farming	106	70.67
4	Experience		
	<1 year	04	02.67
	1 – 5 years	13	08.67
	6- 10 years	08	05.33
	> 10 years	125	83.33
5	Land holding		
	Landless	03	02.00
	Marginal	146	97.33
	Small	01	0.67

affected the farming system in general and duck farming in particular. Duck production is important in employment generation and providing additional income to the resource-poor farmers because of its on-farm and off-farm employment opportunities. Relying on these premises, a study was conducted with the objectives to assess the general profile of duck farmers in Kuttanad region, to identify the different rearing systems of duck farming in Kuttanad region and to analyse the employment and income generation abilities of duck farming in various rearing systems

MATERIALS AND METHODS

Kuttanad Wet Land Eco System (KWLES) is spread over three districts Alappuzha was purposefully selected considering it being highest duck population in the state, the population being 161422 birds (Livestock census, 2019). Further more Seventy five per cent of the duck farming is carried out in and around Vembanadu Lake and are mainly propagated in Alappuzha district. Since parts of both upper and lower Kuttanad regions fall in Alappuzha district, the panchayaths where duck rearing is predominant in both Lower and Upper Kuttanad regions were initially listed. For studying the profile of duck farmers of Kuttanad region, three panchayaths each were selected at random from both Upper and Lower Kuttanad regions (stage I). From each panchayath 25 duck farmers were selected at random (stage II) so that farmers engaged in all different systems of duck rearing were sufficiently represented. Thus the sample comprised of a total of 150 duck farmers for studying the general profile

The farmer profile was analysed using structured schedule with special emphysis on economic

Table 2. Range and average flock size in different rearing systems.

Sr. No.	Flock size	Rearing patt ern			
		Backyard	Nursery	Semi -intensive	Nomadic
1	Average flock size	29	9340	5469	11410
2	Range	5-200	2000 -30000	369 -23000	5000 -30000

profile. Economic profile included land holding, income, income from duck farming, utilization of family labour and hired labour.

RESULTS AND DISCUSSION

General profile of the farmers

Analysis of the personal profile of duck farmers (Table 1) revealed that duck farmers of old age predominated even as the participation of younger age group was negligible. This necessitates appropriate policies and programs to attract entrepreneurs from among the younger generation. The involvement of youth in duck farming was meager in Tamil Nadu also where majority of farmers were above 45 years age and were highly experienced (Thilakar *et al*, 2021). The finding that most of the duck farmers had more than ten years of experience in duck farming was in line with the former finding. The major occupation of the majority of duck farmers was duck farming itself and most of the farmers were with secondary education. However, majority of farmers in Tripura (Das *et al,* 2020) and most of Bangladeshi farm women involved in duck farming (Khanum and Mahadi, 2015) had only primary education. Regarding dependence on income from duck farming, differing from the present observation,Oluwafemi (2015) observed that the poultry farmers of Edo state of Nigeria 86 per cent of the farmers were engaged in other jobs apart from poultry farming and for them poultry rearing was a subsidiary occupation.

Systems of rearing Four different rearing systems were found to be existing in the study area. These systems, even though not mutually exclusive, vary in the income generation and labour utilization patterns. The rearing systems identified were,

Backyard rearing - Duck rearing system in which the ducks are kept in the homestead allowing scavenging and are fed with little supplementary feed.

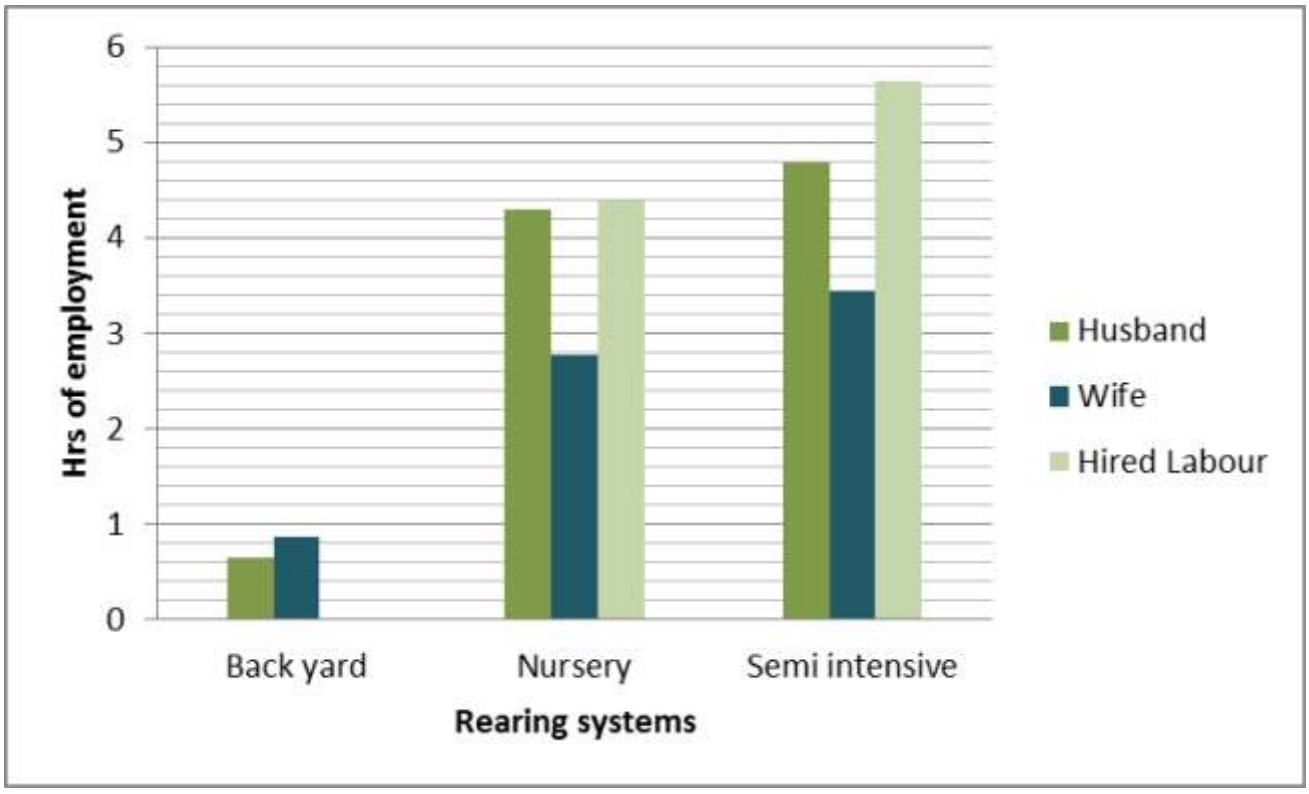
Nursery rearing - Ducklings are housed in sheds during day and night and are handfed. Day old ducklings are bought, brooded and reared up to 30 to 45 days and are mainly handfed with little foraging

Semi-intensive duck rearing - In this system, the birds are allowed to forage in the nearby water bodies and fields during day and are provided with a night shelter. The birds are also supplemented with shell grit and dried fish whenever necessary.

Trans-human Nomadic Duck farming- Trans-human nomadic duck farming is the seasonal migration of people with their ducks in search of foraging land and feed sources. Usually only the duck flocks travel with owners and laborers to lead them and they later return to their native village with or without the flock In the present study, that majority of the duck farmers (44.00%) were practising semi-intensive rearing in which ducks are allowed to forage. Similarly three rearing systems, viz. Range system , restricted system and internal system were identified by Srikanth *et al* (2018) in Kerala itself. In nigerian situations, duck farmers practiced ranging pattern of rearing of ducks with a night shelter ((Enoch e*t al,* 2022) similar to that observed as foraging system in present study. Naga Raja Kumari and Subrahmanyeswari (2014) also observed that in the southern states of India, the farmers were adopting backyard and small scale poultry farms due to high economic viability when the feeding was sufficient from the foraging itself.

The flock size of backyard rearing systems ranged between 5 to 120 birds with an average of 29 birds per household. The flock size of duck

Plate 1. Employment generation in the different systems of duck farming



nursery farms ranged from 2000 to 30000 ducklings with an average of 9340 ducklings per farm. The flock size of semi-intensive rearing systems ranged from 369 birds to 23000 birds with an average flock size of 5469 birds. The flock size of nomadic rearing system ranged from 5000 to 30000 ducks with an average flock size of 11410 ducks (Table 2). However, the average flock size in Tamil Nadu farm holdings was reported as 2000 ducklings by Gopinathan *et al*.(2015).

Income and employment generation through duck farming

It was found that both men and women of the families were involved in duck farming in a majority of houses. However, men were involved in more households than women. It was also found that in most of the houses hired labourers were engaged too. Similar finding was reported in Tamil Nadu where mostly men formed major labour force for duck farming while women were equally involved in decision making. (Thilakar *et al,* 2021). All four systems identified in Kuttanad region utilizes family labour. However, hired labour was not seen utilized in backyard system. The employment generation abilities of duck farming when studied among Bangladesh painted a different picture where utilization of family labor was very low. (Jha *et al,* 2015). Among the four systems of duck rearing studied, backyard system provided on an average 38.75 minutes and 51.85 minutes of gainful employment to men and women respectively. The duck nurseries provided on an average 240.80 minutes and 86.03 minutes of gainful employment to men and women respectively. The duck nurseries provided on an average 237.77 minutes of gainful employment to hired labourers. The semi-intensive rearing system provided on an average 224.49 minutes and 79.31minutes of gainful employment to men and women respectively. The semi-intensive rearing systems provided on an average 338.38 minutes of gainful employment to hired labourers. The duration of engaging hired labour in the case of semi-intensive systems in the present study was found to be more than in duck nurseries, in a day because ducks have to be taken out for foraging. Nonetheless, the nomadic farming system, unlike other systems of rearing was found providing full

Table 3. Range and average of annual gross family income and income from duck farming

Sr. No		Rearing pattern			
		Backyard (Rs.)	Nursery (Rs.)	Semi- intensive (Rs.)	Nomadic (Rs.)
1	Annual gross family income				
	Average income	63,706.90	1,35,907.14	2,49,407	3,59,250
	Range	20,000-1,90,000	58,500- 3,75,000	85,000- 5,26,000	2,50,000-7,40,000
2	Income from duck farming				
	Average income	5,036.55	93,077.65	2,30,119	3,50,750
	Range	300-21,000	15,990-3,75,000	5,000-5,26,000	2,50,000-7,40,000

time employment to the labourers throughout the season of flock migration. Pangemanan *et al* (2014) also reported that the farm families of Indonesia the labour generated fluctuated with the size of duck farms.

The income generation from duck farming was worth analyzing as this might throw light on the profitability and productivity of this enterprise in this region. Further, the income generated from duck farming would act as a powerful motivational factor as reported by Saleh and Lumintag (2012) in their study in Indonesia. There was a markable difference in the income generated from different rearing systems. This might be due to the variations in flock size and the differences in the recurrent expenditure involved in the different systems of rearing. The average annual income generated from backyard duck rearing units was Rs.5036. Majority of farmers in Tripura were considering duck farming as a subsidiary income source and had an average annual income was 2692/household/year.(Das *et al*, 2020). A similar scenario reported by Jha *et al* (2017) where average annual income was farming was 2663.30/household/year . It was worth mentioning that the highest income generated was from nomadic duck farming in Kuttanad area. This might be due to the low cost or no cost feeding strategies adopted which are based much on foraging as compared to other systems of rearing. The average annual income derived from this system was Rs. 359250. However Tamizhkumaran *et al* (2013) reported that average annual income of nomadic farmers of Puduchery was Rs. 1, 30,000 from a 1000 birds unit. The annual family income of the families involved in various systems of duck farming viz. backyard, nursery, semi-intensive and nomadic was found to be Rs. 63706, Rs.135907, Rs. 249407 and Rs. 3590215 respectively which was concomitant with the gross annual income derived from various systems of duck farming in that order(Table 3). According to Pangemanan *et al* (2014) total family income of duck farming households of Indonesia was 43,118,899 IDR. i.e, Rs. 2,14,0521. Another study from South Sulawesi province, Indonesia found that the average income of duck farms was found to be IDR 1,273,102 per month (Lestari and Siregar,2015). The present study documented the income generated solely from duck farming although various reports have demonstrated an increase in income generation when integrated with other crops viz. fish and rice. (Saika *et al, 2020)*

CONCLUSION

Much wider opportunities like that of integration of traditional farming practices and farm tourism await the duck production system of Kuttanad. Even though duck industry in Kuttanad is being commercialized with changing agricultural patterns of the region, the traditional nomadic and foraging systems of farming is preferred due to their high economic feasibility. However, the recurrence of zoonotic diseases like

avian flu, for which the migrating flocks held responsible for , has impacted the acceptance of this highly relevant livelihood option. Policies focusing on maximizing strengths vis-a-vis exploiting the opportunities of this no or low input farming system along with efforts to remove social stigma associated with health risks and societal status of farmers might prove beneficial.

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Received on 30/8/2024 Accepted on 19/10/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 837-844

DOI : 10.5958/2349-4433.2024.00144.0

Evaluation of Banana Germplasm under Sodic Soil

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ABSTRACT

Banana can be grown in a wide range of soils. Soil and land parameters are one of the important requirements deciding the production and productivity of the crop. Sodic soils are those which have an exchangeable sodium percentage (ESP) of more than 15.The present study was conducted at Horticultural college and Research Institute for women, Trichy for Evaluation of banana germplasm under sodic soil. The experiment was laid out in Randomized block Design (RBD). The treatments comprised eleven types of germplasm or varieties *i.e.,* Kaveri Kalki (ABB), Adukku Monthan (ABB), CO2 (AB), Kaveri Saba (ABB), Monthan (ABB), Udhayam (ABB), Poovan (AAB), Karpooravalli (ABB), Kaveri Haritha (ABB), Ney Poovan (AB), and Vayal Vazhai (ABB). Among the 11 treatments screened Udhayam (T6) recorded highest bunch weight, followed by Kaveri Saba (T4) and Karpooravalli (T8). Highest yield was recorded in the cultivars having ABB genome in them, such as Udhayam (T6), Kaveri Saba (T4) and Karpooravalli (T8). The germplasm/varieties like Udhayam, Kaveri Kalki and Karpooravalli showed maximum number of hands. The maximum number of fingers was observed in Udhayam (T6) and Karpooravalli (T8). From the above study the germplasm/varieties having the *Musa balbisiana* genome were found to perform well under the sodic soil conditions, when compared to the *Musa acuminata* species due to their physiological characteristics to survive under adverse climatic conditions.

Key Words: Banana, Exchangeable sodium , Germplasm, Screening, Soil, Sodic soil.

INTRODUCTION

The banana is considered to be one of the most important cultivated tropical fruits in India. Banana (*Musa spp*.) belongs to the family Musaceae and is the leading fruit crop in tropical and subtropical regions of the world. It is the second most important fruit crop of India. Banana plants refer to Biblical legend as Tree of wisdom for good and evil in the Garden of Eden. Banana by virtue of its multiple uses is popularly known as Kalpataru (a plant with virtue).

Edible bananas are mostly hybrids of the two species from *M. acuminata* and *M. balbisiana*. They set fruits by parthenocarpy. It is called as Apple of paradise and Adam's fig. It is equally suitable both for large scale cultivation as well as for home scale cultivation. Banana mostly cultivated wide range of soils. Soil and land parameters are one of the important requirements deciding the production and productivity of the crop. Sodic soils are characterized by excess level of sodium ion (Na+) in the soil solution phase as well as on cation exchange complex, exhibiting unique structural problems as a result of certain physical processes (slaking, swelling, and dispersion of clay) and specific conditions (surfacing, crusting and hard setting). The growth rate of banana crop under the sodic soil condition may vary according to the genotype. In order to study and identify the well performing genotype, 11 germplasm/varieties were selected and observed for its suitability under sodic soil conditions. Considering the effect of the soil properties in the plant growth and establishment depending upon the genotype of the species, the present investigation was undertaken to assess the variations in yield and fruit quality, physiological and biochemical activities and to identify the salt tolerant genome in banana germplasm.

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Table 1. Treatment details of Banana germplasm/varieties

Treatment	Germplasm/ Varieties	Genome
T 1	Kaveri Kalki	ABB
T 2	Adukku Monthan	ABB
T 3	CO2	AB
T 4	Kaveri Saba	ABB
T 5	Monthan	ABB
T 6	Udhayam	ABB
T 7	Poovan	AAB
T 8	Karpuravalli	ABB
T 9	Kaveri Haritha	ABB
T 10	Ney Poovan	AB
T 11	Vayal Vazhai	ABB

Fig. 1. Banana germplasm/varieties in experiment field

MATERIALS AND METHODS

The experiment was conducted at Horticultural College and Research Institute for Women, Trichy during 2022-2023 (Fig.1) . The experiment was laid out in a Randomized Block Design with 11 treatments combinations (Table 1). For the 11 germplasm/varieties planted in the field, plants were selected randomly and an average weight of the bunch was recorded for each germplasm/variety using a weighing machine. A cluster of bananas are known as hands and each hand consists of a total of 10 to 20 bananas or fingers. The number of hands present in a bunch for all the 11 germplasm/ varieties were calculated randomly and an average value was calculated.

Total number of bananas/fingers present in a bunch was calculated by taking an average value of fingers present in the plant for every germplasm/variety. The length of the banana fingers was measured using a measuring tape. The breadth of each germplasm/variety was taken using a measuring tape and an average value is taken from the randomly selected fingers of the bunch.

Physiological and Biochemical analyses

Soil pH

The soil samples were taken randomly from sodic soil area and all the impurities were removed from the sample. The sample of air

dried on clean surface for few days and crushed into fine material. Then, a small portion of crushed soil is mixed with distilled water in 1:1 ratio and allowed to settle for about 30 minutes to let any suspended particles settle at the bottom. Using a pH meter, the pH of the supernatant liquid is measured. Potentiometry (soil-water suspension) Jackson (1973).

Soil EC

Soil Electrical Conductivity (EC) is an indicator of the soil's ability to conduct an electrical current. It is commonly used to assess soil salinity, nutrient availability, and overall soil health. Its value is expressed in deci Siemens per meter (dS/m) or milliSiemens per meter (mS/m). The soil sample was collected and air dried at room temperature. It is then sieved to remove the debris present in the sample. The sieved soil was mixed with distilled water at a ratio to maintain a proper moisture content. Then using a EC meter, the electrical conductivity of the soil-water extract was measured as per method suggested by Jackson (1973).

Exchangeable Sodium Percentage (ESP)

Exchangeable Sodium Percentage is the measurement of the amount of sodium in relation to other cations in the soil. It is used to assess the Sodicity level of soil, which refers to the presence of excess sodium ions that can cause soil structure degradation and reduced plant growth.

$$ESP = \text{Exchangeable } \{(Na) / (Ca + Mg + K + Na)\} \times 100$$

The soil sample was air dried, sieved and ground into a fine powder. The obtained soil powder was mixed with the solution of Ammonium acetate to extract the exchangeable sodium from soil. Next, the mixture was filtered using a filter paper or a sieve to separate soil particles from the liquid extract. The filtrate was collected in the beaker and used to measure the concentration of sodium using Flame photometer (Schollenberger *et al*, 1930).

Leaf chlorophyll content (mg/g)

Total chlorophyll contents were estimated using 80 per cent acetone as per the method suggested by Arnon (1949). The nitrogen content in soil samples was estimated by Micro-Kjeldhal (Piper, 1966) and the mean values expressed in percentage. The potassium content in soil samples was estimated by using Flame Photometer (Piper, 1966) and expressed in percentage.

RESULTS AND DISCUSSION

Banana (*Musa spp*.) plant typically grows in tropical regions and is characterized by large, elongated leaves (Lebot *et al,* 1993). *Musa acuminata* and *Musa balbisiana* are most commonly cultivated species of banana. *Musa acuminata* are slenderer than of cultivated banana, 3-8 m high, 6-25 cm diameter at base and stools moderately. The pseudostem colour is heavily marked with brown or black blotches. Their petiolar canal have erect margin or spreading with serial wings below; not clasping pseudostem. The bract shoulder is usually high and the bracts roll back after opening. In male flower, the free tepal is variably corrugated below the tips, about half as long as compound tepal. The seeds of this species are dull black in colour, minutely tuberculate.

Musa balbisiana are robust, 6-7 m high, 7-30 cm diameter at base and stools freely. The pseudostem colour is predominantly green or yellowish green, often with black blotches in upper part. Their petiolar canal have enclosed margin, not winged below with clasping pseudostem. The bract shoulder is usually low with lifted bracts but they are not rolled back like *Musa acuminata.* In male flower, the free tepal is rarely corrugated. About boat shaped, obtuse or truncate at base, about half as long as compound tepal. The seeds are black in colour, irregularly globose, minutely warty such that they are 5-6 cm in size across and 4-5 mm high.

Bunch weight

In a breeding programme, yield is one of the most important traits by which a genotype or variety will be evaluated. In banana, varieties with more fruits/fingers in a bunch are generally preferred, as it generates more yield in given area. The variation in bunch weight was high under the experimental field conditions. Sodic soil significantly reduced the phenological characters

Fig. 2. Yield characters of the germplasm/varieties

(Abdel, 2011). From the germplasm/varieties studied, Udhayam (T6), Kaveri Saba (T4) and Karpooravalli (T8) was high (Fig. 2) had the genome ABB, where the plants have thick pseudostem and can withhold heavy bunch amidst adverse weather conditions due to their clasping nature of pseudostem. The treatments such as CO2 (T3) and Ney Poovan (T10) gave minimum yield among all the treatments, with ABB as their genome (Table 2). AB genome species have relatively weak pseudostem, which makes the plant vulnerable to adverse climatic conditions.

Average yield per hectare

The average yield per hectare was greatly influenced by the nutritional and environmental factors available in experimental field. Sodic soil, drastic reductions in yield of wheat occurred at EC less than 4 dS/m in Na sensitive cultivars (Choudary *et al,* 1996). The species of *Musa balbisiana*, having a shorter pseudostem can withhold bunches with more weight during adverse climatic conditions, which reduces the loss occurring through the breaking of pseudostem . Thus, the yield observed was maximum in the cultivars having ABB genome in them, such as Udhayam (T6), Kaveri Saba (T4) and Karpooravalli (T8) Table 2. *Musa acuminata* clones are considered sensitive to sodic soil (Israeli *et al*, 1986). The general ranking of the banana varieties for salt tolerance was FHIA -1 > Saba > Karpooravalli > Bangrier > Ash Monthan > Veneetu Mannan > Udhayam. A comparative field trial for the 15 banana varieties showed that Saba, FHIA -1 and Karpooravalli could withstand sodic conditions in the field in terms of bunch characteristics, biochemical parameters and plant growth. Grand Naine, Rasthali and CO 1 were vulnerable to sodicity stress. Regardless of cultivar, sodicity stress increased the days needed for shooting and harvest (Nithya Devi *et al*., 2024).

Number of Hands

Fruit set number greatly determines the weight of the banana bunch and its efficient market value.

Table 2. Number of fingers, finger length ,finger breadth , Bunch weight, yield and number of hands in a bunch of Germplasm/varieties.

Sr. No.	Germplasm/ Varieties	Number of Fingers in bunch	Finger Length (cm)	Finger Breadth (cm)	Bunch weight (Kg)	Average yield per ha (kg/ha)	Number of Hands in a bunch
T1	Kaveri Kalki	57	9.8	4.6	8.8	28.52	7
T2	Adukku Monthan	39	11	5.3	8.4	27.21	5
T3	CO_2	44	10.6	4	6.3	20.41	4
T4	Kaveri Saba	50	12	4.8	10.3	33.37	6
T5	Monthan	42	10.4	5	7.2	23.33	6
T6	Udhayam	65	11.8	5.4	11	35.64	8
T7	Poovan	38	11.3	4.7	7.6	24.63	5
T8	Karpooravall	61	10.2	5.2	9.8	31.75	7
T9	KaveriHaritha	36	8.9	3.9	7.5	24.30	4
T10	Ney Poovan	35	9.3	4.3	5.9	19.11	4
T11	Vayal Vazhai	38	8.3	4.9	6.7	21.71	5
SEd =		1.13	0.29	0.29	0.18	0.6124	0.12
CD(P=0.05)		3.22	0.83	0.83	0.51	1.74	0.35
CV% =		3.02	3.19	3.19	2.74	2.85	2.78

The Number of hands in a banana bunch is mainly determined by environmental factors, such as climatic conditions and cultural practices, along with the genetic factors related to the variety or cultivars. The germplasm/varieties like Udhayam, Kaveri Kalki and Karpooravalli showed maximum number of hands. The minimum number of hands was observed in CO2 (T3), Kaveri Haritha (T9) and Ney Poovan (T10) Table 2. In the sodic soil condition, the germplasm/variety with ABB genome *i.e., Musa balbisiana* species performed well and produced more hands than the other species.

Fingers in bunch

Fingers in a bunch vary in a bunch depending on the factors such as the specific cultivar, growing conditions, and other factors. Among the germplasm/varieties observed in the experimental field, the maximum number of fingers was observed in Udhayam (T6) and Karpooravalli (T8) Table 3. The genetic characteristics for these varieties may be the major reason for more fingers in a bunch, when compared to the variety like Ney Poovan, having minimum fingers with different characteristics.

Finger length

Banana's finger length varies within each species, depending on specific cultivar or variety. In sodic soil condition, the *Musa balbisiana* species tend to show large finger length than the *Musa acuminata* cultivars. Similar report was done by (Ravi *et al,* 2014). The varieties such as Udhayam (T6), Adukku Monthan (T2) and Karpooravalli (T8) showed only slight variation between them, in term of length, while minimum finger length was observed in CO2 (T3) and Ney Poovan (T10) when all the 11 germplasm/varieties compared.

Finger breadth

The breadth of banana fingers, when observed is usually high in the *Musa balbisiana* species. The maximum size was observed in Udhayam (T6), Adukku Monthan (T2), Karpooravalli (T8) and Vayal Vazhai (T10), other remaining treatments shows comparatively shorter finger breadth size.

Physiological and Biochemical Analyses:

Table 3. Chlorophyll content analysed for the Germplasm/varieties

Sr.No.	Germplasm/Varieties	Chlorophyll content (mg/g of leaf sample)
T1	Kaveri Kalki	0.2879
T2	Adukku Monthan	0.0171
T3	CO_2	0.0350
T4	Kaveri Saba	0.0146
T5	Monthan	0.0440
T6	Udhayam	0.4281
T7	Poovan	0.2533
T8	Karpooravalli	0.1897
T9	Kaveri Haritha	0.3920
T10	Ney Poovan	0.3643
T11	Vayal Vazhai	0.0834
SEd =		0.0032
CD(P=0.05)		0.0092
CV% =		7.40

Soil pH

The soil sample from the experimental field recorded a pH value of 7.43. Among the two *Musa spp., Musa balbisiana* was found to be more suitable for sodic soil condition. As they are tropical in habitat, have adapted to thrive in alkaline soil with high level of nutrient availability. Rengasamy (2006) reported in Australia, soils with ESP between 6 and 14 are designated as sodic while those having ESP>15 are classified as strongly sodic. Rajkishore Kumar *et al*. (2017) also reported land characterization and soil-site suitability- evaluation of banana growing areas of South Gujarat, India.

Soil EC

The recorded EC for the sample from experimental field is 1.20 dS/m. It showed relatively low concentration of other minerals (calcium, potassium and magnesium) in the soil, which still may cause some detrimental effects on the plants. Improper salt concentration leads to poor soil structure, reduced water infiltration and increased surface runoff.

Exchangeable Sodium Percentage (ESP)

An ESP of 16.65%, which is relatively high was obtained through the experiment. High level of exchangeable sodium may lead to the reduction of other minerals in soil. It is primarily due to the competition between sodium ions and other cations for the uptake by plant roots. Elevated sodium levels can indirectly affect magnesium availability to plants. Its accumulation at the root zone causes increased osmotic stress, which can inhibit magnesium uptake (Choudhary *et al,* 1996).

Chlorophyll content

Sodic soil condition can induce chlorosis condition in plants, where the leaves turn yellow due to a lack of chlorophyll. Chlorophyll is essential for photosynthesis, whose reduction in plant hampers the ability to photosynthesize effectively, leading to reduces growth and productivity. Xiao-tang Yang *et al*. (2009). Banana varieties Udhayam (T6) and Kaveri Haritha (T9) showed high chlorophyll content (*Musa balbisiana spp*.), showing the presence of healthy greenish leaves on the plants, compared to other treatment germplasm/varieties (Table 4).

Available nitrogen in soil

The analysis recorded a low-level availability of nitrogen in sodic soil conditions which may lead to stunted growth as deficiency of nitrogen can lead to slow or stunted growth, along with yellowing of leaves, reduced fruit production and poorly developed roots.

Available potassium in soil

Recorded value for available potassium was low in level and the low potassium level may lead to visible symptoms like leaf discoloration and necrosis, reduced growth, decreased yield and

increased susceptibility to pests and diseases. These effects may lead to development of unfavorable appearance on the fruit and leaves, decreasing its market value (Jeyabhaskaran, 2000).

CONCLUSION

The results of the study conducted that among the 11 treatments screened, the highest bunch weight and highest yield per hectare were recorded for the genotypes Udhayam (T6) followed by Kaveri Saba (T4) and Karpooravalli (T8). Highest number of hands was recorded for the genotypes Udhayam (T6) followed by Kaveri Kalki (T1) and Karpooravalli (T8). Maximum number of fingers in a bunch was recorded by the germplasm Udhayam (T6) and Kaveri Kalki (T1). Regarding the finger length and finger breadth maximum recorded in Udhayam (T6) and Kaveri Saba (T4). The pH for the soil sample taken from the experimental field was found to be 7.43, which is slightly alkaline in nature. The Electrical conductivity (EC) of the soil sample of the experimental field was found to be 1.20 dS/m, which indicated low concentration of other minerals in the soil. The exchangeable sodium percentage (ESP) for the soil sample was found to be 16.65%, which is relatively high in concentration. Among the 11 germplasm/varieties screened, the maximum chlorophyll concentration was recorded in Udhayam (T6), followed by Kaveri Haritha (T8). The available nitrogen in soil was recorded to be 78.4 kg/ha, which was considered to be low based on the rating of soil in available nitrogen range. The available potassium in soil was recorded to be 56.67 kg/ha, which as per the range of potassium presence in soil, found to be low in concentration .The germplasm/varieties having the *Musa balbisiana* genome were found to perform well under the sodic soil conditions, when compared to the *Musa acuminata* species due to their physiological characteristics to survive under adverse climatic conditions.

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Received on 1/8/2024 Accepted on 7/10/2024

J Krishi Vigyan 2024, 12(4) : 845-848
DOI : 10.5958/2349-4433.2024.00145.7
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Evaluation of Thinning Practices for Crop Load Management in High-Density Gala Apple Orchards in Kashmir

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ABSTRACT

The adoption of high-density (HD) apple orchards in Kashmir, particularly for the cultivar Gala, provides a pathway for improving productivity and fruit quality. Effective crop load management, especially during the formative years, is essential to avoid biennial bearing and maintain yield consistency. This study, conducted as an On-Farm Trial (OFT) from 2022 to 2024 in the Anantnag district, assesses the impact of various thinning methods on fruit quality, yield, and economic returns in HD Gala orchards. Six thinning treatments, encompassing both chemical and manual methods, were evaluated against a control. The findings demonstrate that precision crop load management significantly enhanced fruit size, uniformity, and marketable yield, affirming the critical role of thinning in HD systems.

Key Words: Crop load management, Gala apple, High-density orchards, Kashmir, Thinning

INTRODUCTION

Apple (Malus × domestica Borkh.), often referred to as the "King of Temperate Fruits," holds global significance, covering approximately 4.7 million hectares with an annual production of around 79 million metric tons (FAOSTAT, 2019). In India, apple orchards span 309,000 ha., yielding 2.78 million metric tons, with Jammu and Kashmir contributing about 164,742 ha. and 1.88 million metric tons (Anonymous, 2020a; Anonymous, 2020b). The shift towards high-density (HD) orcharding is a key strategy to boost yield and fruit quality in Kashmir, particularly for Gala, a cultivar appreciated for its regular bearing and consumer preference.

During the last decades, the foliar application of mineral elements has become an established procedure in fruit plants to increase the production and improve the quality of produce (Khan *et al,* 2019). Without proper crop load management in the early growth phases, HD orchards risk biennial bearing, adversely impacting yield stability and fruit quality. Excessive crop loads often lead to reduced fruit size and color, limiting economic returns and potentially shortening orchard lifespan. Thinning—both chemical and manual—is a vital technique in crop load management to enhance fruit size, quality, and marketability. This study aims to evaluate the effectiveness of various thinning techniques for optimizing crop load, yield, and fruit quality in HD Gala apple orchards in Kashmir.

MATERIALS AND METHODS

Experimental Design

The study was conducted from 2022 to 2024 across three locations in Anantnag district, Kashmir. The experiment followed a Randomized Complete Block Design (RCBD) with each site comprising high-density Gala apple trees of similar age (3-4 years) under uniform management conditions. Six thinning treatments, plus a control (no thinning), were tested as under.

Treatments

T1: Control (No Thinning) - Farmer's Practice

T2: Chemical Thinning with Benzyladenine (BA) @ 150 ppm when fruit diameter was 10-12 mm.

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T3: Chemical Thinning with Naphthaleneacetic Acid (NAA) @ 15 ppm at 10-12 mm fruit diameter.

T4: Hand Thinning to retain 4 fruits per Trunk Cross-Sectional Area (TCSA).

T5: Hand Thinning to retain 6 fruits per TCSA.

T6: Hand Thinning to retain 8 fruits per TCSA.

T7: Chemical Thinning (BA or NAA) followed by Hand Thinning to 5-6 fruits per TCSA.

Plot Size and Replications

Each treatment was replicated three times at each location, with plots consisting of high-density Gala apple trees spaced at 3 m x 1 m. A randomized layout was used to avoid bias.

The Trunk Cross-Sectional Area (TCSA) was calculated using the formula as given by Westwood (1993).

Trunk cross section area (cm^2) = [Trunk girth of scion (cm)]^2/3.14

Observations recorded

Fruit Size and Quality: Average fruit weight, length, diameter, % A Grade Fruits (based on color uniformity and size) were recorded at harvest. A digital caliper and weighing scale were used for measurements.

Yield per Tree: Total yield was measured as the weight of harvested fruits per tree (kg/tree).

Economic Analysis: Gross returns were based on market prices, with net profitability calculated as: Net Profit =Gross Returns − Cost of cultivation including Thinning Costs

Bloom Return: Number of flower clusters per tree was recorded in the subsequent spring to assess the impact of thinning on future productivity.

Statistical Analysis

The data were analyzed using ANOVA, with differences between treatments assessed using the Least Significant Difference (LSD) test at a 5% significance level.

RESULTS AND DISCUSSION

Effect on Fruit Size

As shown in Table 1, chemical and manual thinning significantly enhanced fruit size (fruit weight, length, and diameter) compared to the control. Treatment T7 (Chemical + hand thinning) achieved the highest average fruit weight (195 g) and diameter (76.05 mm), indicating the efficacy of combined methods in achieving optimal fruit quality. Increase in fruit size and weight by thinning can be attributed due to reduced number of fruits per tree, increased leaf to fruit ratio, increased availability of photosynthates and lesser nutritional competition among the developing fruits and more translocation of assimilates to the remaining developing fruits, resulted in increased fruit size and fruit weight. These results were in agreement with the findings of Khan *et al* (2023a), Link (2000) who also observed that average fruit diameter is negatively correlated with crop load. Maximum fruit weight was observed by thinning treatments over the control. Koike and Ono (1998) also reported that crop load management by thinning is the most important step to harvest large sized fruit. Serra (2016) reported that the highest crop load resulted in a dramatic reduction in fruit size and fruit weight. Henriod *et al* (2008) reported that mean individual fruit size was negatively related to the number of fruit per tree.

Yield, Quality and Economic Returns

Table 2 illustrates the impact of thinning on yield, percentage of A-grade fruits, and economic returns. Although T_1 (control) had the highest yield per tree (14.44 kg), it produced a lower proportion of A-grade fruits. Conversely, T_7 achieved the highest revenue with a benefit-cost ratio (BCR) of 3.81, demonstrating that precision thinning enhances marketable yield and profitability. These results were in alignment with the results of Khan *et al* (2023b) wherein the study underscores the critical importance of thinning Gala Redlum apple trees to ensure a high quality yield is achieved and thereby returns. Moreover, the study further revealed that maintaining an

Table 1. Effect of Crop load management on Fruit weight, length and diameter of Apple cv.Gala

Treatment	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)
T1 (Control)	143	60.05	68.0
T2 (BA @ 150ppm)	185	65.55	73.70
T3 (NAA@ 15 ppm)	178	64.0	69.30
T4 (Hand Thinning 4 fruits/TCSA)	193	68.49	75.07
T5 (Hand Thinning 6 fruits/TCSA)	179	67.0	72.55
T6 (Hand Thinning 8 fruits/TCSA)	155	62.00	70.10
T7 (Chemical + Hand Thinning)	195	69.10	76.05
Mean	175.43	65.17	72.11
C.D ($p \leq 0.05$)	28.54	4.39	3.99

Table 2. Effect of Crop load Management on Yield (Kg/tree), % A Grade Fruits and Economics (B ratio) of Apple cv. Gala

Treatment	Yield (Kg/tree)	A Grade Fruits (%)	Revenue (₹)	Cost (₹)	BC Ratio
T1 (Control)	14.44	53.0	650.52	259.92	2.81
T2 (BA @ 150ppm)	10.61	79.50	716.97	190.98	3.75
T3 (NAA@ 15 ppm)	11.87	77.90	785.97	213.66	3.68
T4 (Hand Thinning 4 fruits/TCSA)	8.49	79.90	576.60	152.82	3.77
T5 (Hand Thinning 6 fruits/TCSA)	11.81	79.95	802.57	212.58	3.78
T6 (Hand Thinning 8 fruits/TCSA)	13.64	62.30	722.31	245.52	2.94
T7 (Chemical + Hand Thinning)	11.93	80.70	818.34	214.74	3.81
Mean	11.83	73.32			
C.D ($p \leq 0.05$)	2.44	14.57			

Table 3. Effect of crop load on return bloom (number of flower clusters per tree) in apple cv. Gala

Treatment	Return Bloom (No. of flower Clusters per tree)
T1 (Control)	17.44
T2 (BA @ 150ppm)	111.60
T3 (NAA@ 15 ppm)	107.80
T4 (Hand Thinning 4 fruits/TCSA)	137.00
T5 (Hand Thinning 6 fruits/TCSA)	109.10
T6 (Hand Thinning 8 fruits/TCSA)	47.64
T7 (Chemical + Hand Thinning)	131.93
Mean	94.36
C.D ($p \leq 0.05$)	58.55

optimal fruit quality and consistent bloom is achievable at a crop load threshold of around 6 fruits per cm^2 of TCSA. The thinning treatments tended to reduce the yield efficiency in comparison to control. But average fruit weight was significantly increased. This can be attributed to the fact that the percentage of fruits retained at the time of maturity was low compared to control and therefore, there was no appreciable increase in fruit yield. These findings were in accordance with those of Marini (2004). Our results were also in agreement with the findings of Fruk *et al* (2017)

who reported that the untreated trees yielded highest total number of fruits with maximum total yield efficiency.

Return Bloom

Table 3 highlights the influence of thinning treatments on the number of flower clusters in the subsequent season. Manual thinning (T4) to 4 fruits per TCSA recorded the highest return bloom (137 clusters), indicating improved future flowering potential, reducing biennial bearing risks. The results highlighted the significant roles of both crop load and trunk cross-sectional area in shaping return bloom in the studied apple cultivar. The intricate relationship between crop load and trunk cross-sectional area emphasizes the need for a holistic understanding of orchard management practices to optimize flowering and, consequently, fruit production. These findings are consistent with those of Khan *et al* (2023b).

CONCLUSION

Precision crop load management in HD Gala apple orchards during the formative years is essential for sustainable productivity. Combined chemical and manual thinning methods significantly improved fruit quality, economic returns, and return bloom, highlighting thinning's role in preventing biennial bearing. Future research should focus on environmentally friendly thinning alternatives and adaptive methods to align with evolving orchard management practices in Kashmir.

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Received on 29/10/2024 Accepted on 20/11/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 849-855

DOI : 10.5958/2349-4433.2024.00145.7

Factors Affecting Participation in Paddy Royalty Scheme among Farmers of Kerala

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ABSTRACT

Paddy Royalty scheme is a financial incentive mechanism formulated on the basis of payments for ecosystem services (PES) concept, wherein the paddy wetland owners were compensated for the ecosystem services that their resource provided. This study attempted to estimate the farmer participation in paddy royalty scheme. The factors that affected farmers' participation was analyzed in a logistic regression framework, using the primary data collected from randomly selected 118 paddy farmers from Kole wetlands of Kerala. Further, it was also tried to identify and rank the constraints that limited the farmer response towards the scheme. The farmers' participation in the year 2023-24 was 57% but only 40% of the farmers were willing to participate in next year. Education, land holding size, farmer association membership and digital literacy were found to be positively influencing the participation whereas age influenced negatively. The most severe constraint identified was insufficiency in royalty amount followed by high transaction costs. Adopting a comprehensive approach that includes better programme design, increased incentives and supportive policies, the government can encourage greater participation to achieve the primary scheme objectives of sustaining paddy cultivation and preserving wetlands, thereby ensuring the food security and ecological sustainability in the state.
Key Words: Eco-compensation, Kole wetlands, Logistic regression, Payments for ecosystem services.

INTRODUCTION

The payments for ecosystem services (PES) concept envisioned an incentive mechanism where natural resource owners were compensated for the ecosystem services that their resource provided. The paddy royalty scheme in Kerala was evidently inspired by the essence of payments for ecosystem services (PES) concept was one such effort wherein the paddy wetland owners were financially incentivised for the ecosystem services that the wetland provided. Wunder (2015) defined PES as the conditional cash transfers provided to natural resource owners intending to encourage the ecologically beneficial activities. PES programmes had also been widely referred as eco-compensation programmes or agri-environmental schemes, representing a strategic approach to environment conservation by offering incentives for activities that sustain or enhance unpaid ecosystem services such as biodiversity conservation, water quality improvement, carbon sequestration, soil preservation, ground water recharge etc. In recent times, PES had emerged as a key instrument for ecosystem conservation, while simultaneously enhancing the livelihoods of farmers who act as environmental service providers (Le *et al*, 2024; Wunder *et al,* 2020).

The Paddy Royalty scheme was introduced in Kerala with an intention to protect the remaining paddy wetlands, addressing the serious challenges of depletion, degradation, and conversion mainly due to housing expansion and real estate development. The Wetland agro-ecosystems refers to agricultural systems that are situated in or near wetland environments. These ecosystems often emphasize sustainable

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agricultural practices to minimize environmental impacts. This may include practices such as integrated nutrient management which is widely recognized as a sustainable strategy that enhances agricultural productivity and soil health over the long term (Thulasi *et al*, 2022), integrated pest management to improve soil and water quality (Sharma *et al*, 2021), conservation tillage to promote biodiversity, soil health and water conservation, organic farming etc. Besides, wetlands provide various non-marketed ecosystem services such as water filtration, flood control, carbon sequestration, nutrient recycling, ground water recharge, biodiversity conservation etc.

The Kole wetlands in Kerala are unique sub-sea level rice production wetland agro-ecosystem spread over Thrissur and Malappuram districts, covering an area of 13632 hectares. They are one of the most productive as well as threatened wetland in Kerala State (Jayson and Sivaperumal, 2005). Kole lands are multifunctional wetland agro- ecosystem with high ecological significance and were declared as Ramsar site in 2002 (Srinivasan, 2011). The total economic value which comprises direct, indirect and non-use values of the Kole wetlands was estimated as Rs. 3905 lakh per year which implies a value of Rs.3.23lakh/ha/year (Tamhankar, 2021). Despite their potential benefits, Kole wetland agro-ecosystems also face challenges such as land conversion, ecosystem degradation, habitat loss, climate change and conflicts over land use. Harithalekshmi and Ajithkumar (2023) has reported that the warming climate is reshaping the hydrological cycle of major agro-ecosystems in Kerala , with profound effects on precipitation patterns and intensities. Therefore, balancing agricultural production with the conservation of wetland ecosystems requires careful planning and management to ensure long-term sustainability.

The Paddy Royalty scheme which nearly resembled a PES programme, was initiated by State government of Kerala in the year 2020-21, for the conservation of paddy wetlands. This scheme offered a royalty amount of Rs. 2,000/ha/year to the landowners of cultivable paddy land. The primary objective of the scheme was to incentivize the retention and cultivation of paddy fields, particularly wetlands, thereby addressing the significant decline in paddy cultivation over recent decades. This initiative not only supports sustainable agriculture but also preserves vital ecosystems and enhances the economic well-being of local farmers.

Despite its intended benefits, the scheme has turned up a low participation rate among wetland farmers. According to the official reports, in the year 2021-22, the total number of royalty applications received for Thrissur and Malappuram districts together were 11509, covering an area of 4676 ha. This implies that even one-third of the wetland farmers have not applied for royalty in the initial year. In the year 2023-24, the royalty amount was increased to Rs. 3000/ha/year. Apart from that, on an average farmer is receiving a total assistance Rs. 32860/ha in form of various subsidies for paddy cultivation. In May 2024, it was found that the cumulative number of royalty applications received since inception for both the districts were 47095. Out of that, 77% of applications got approved , 17% got rejected and 6% were still in processing status (https://dashboard.kerala.gov.in/e-services/service.). The statistics clearly highlights that the royalty scheme failed to enthuse wetland paddy farmers. In this context, the present study attempts to identify the constraints that limit the farmer response towards the scheme and the severity of the constraints is ranked according to farmer perspectives. The actual farmer participation and the willingness to continue the participation was also estimated. Further, the factors influencing the participation were analysed and the preferences from farmer side was documented.

MATERIALS AND METHODS

Study area and sampling

Thrissur Kole wetlands being one among the major paddy producing area recording high rice productivity in the state as well as having high ecological significance was selected as the study area. The Thrissur Kole area is spread over 8 block panchayaths in Thrissur district. The study was solely based on the primary data. The three block

Table 1. Socio-economic characteristics of sample farmers.

Sr. No.	Particular	Sample average (N = 118)
1.	Age (Years)	57
2.	Education (Years)	9
3.	Experience (Years)	24
4.	Average monthly income of farm household (Rs.)	11,642
5.	Farm household size (Number of family members)	4
6.	Kole land area (H actares)	0.62

Table 2. Farmer awareness, participation and willingness to continue participation in paddy royalty scheme.

Sr. No.	Particular	Awareness (%)	Registered in scheme during 2023-24 (%)	Willingness to register in scheme during 2024-25 (%)
1.	Marginal farmers	81.17	49.41	28.23
2.	Small farmers	96.55	75.86	68.96
3.	Large farmers	100.00	100.00	100.00
4.	Total	85.59	57.62	40.67

panchayaths namely Anthikkad, Puzhakkal and Mullassery having the highest number of wetland paddy farmers, were selected at the initial stage. In the next stage, 118 sample farmers were randomly selected from the *krishibhavan* wise farmer list. The primary data on socio-economic status, Kole land area, Paddy Royalty scheme awareness, participation details, willingness to continue the participation, perspectives and preferences, transaction costs of participation, digital literacy etc were collected from farmers through personal interview method using pre-tested structured interview schedule. The digital literacy score was obtained depending upon the parameters such as smart phone ownership, social media participation, knowledge gathering from online sources and application submission by self or by family members or through Akshaya centres. Transaction costs of participation include all extra costs incurred starting from Paddy Royalty scheme application submission, follow up etc, till the receipt of royalty amount. Focus group discussions were also carried out to identify the constraints of participation. The survey was carried out during April to May of the year 2024-25.

Analytical tools

The relative severity of identified constraints was rated using relevancy rating method. The farmers were asked to rate the severity of the constraint on a five-point relevancy continuum i.e. no decision, not severe, less severe, moderately severe and highly severe. The ranks assigned were 0,1,2,3, and 4 respectively. The problem with highest relevancy coefficient is ranked first is of highest severity. The following formula was used to work out the relevancy coefficient (R_i) for the i^{th} constraint (Rose and Prema, 2021).

A binary choice logistic regression model specified in equation (1) was used to analyse the factors that influence the probability of Kole wetland farmers participating in Paddy Royalty scheme. Descriptive statistical methods were also used as per the requirement.

$$L_i = Ln [P_i / (1-P_i)] = \alpha + \Sigma \beta_i X_i + \varepsilon_i \ldots..(1)$$

P_i = Probablity of Paddy Royalty scheme participation (Yes = 1)

$1-P_i$ = Probablity of Paddy Royalty scheme non-participation (No = 0)

α – Intercept, ε_i - Error term, β_i – Regression coefficients, X_i– Independent variables

Independent variables considered were X1 – Age (years), X2 – Education (years), X3 – Gender (Male = 0, Female = 1), X4 – Farm house hold size

Table 3. Estimates of logistic regression.

Sr. No.	Independent variable	Coefficient	Std. Error	P value
1.	Age	-0.0643*	0.0378536	0.090
2.	Gender	0.1538	0.4884538	0.753
3.	Education	0.2397***	0.1018788	0.010
4.	Farm household size	-0.0838	0.2057273	0.684
5.	Average monthly income	-1.03e-06	0.0000361	0.977
6.	land holding size	1.0351***	.2681472	0.000
7.	Farmer association membership	1.9932*	1.229756	0.100
8.	Digital literacy	0.4451**	0.218484	0.042
9.	Constant	-7.144613	3.458575	0.039
10.	Number of observations	118		
11.	Log likelihood	-62.896055		
12.	Prob > chi2	0.0000		

*Notes: ***denotes P < 0.01, **denotes P < 0.05, *denotes P < 0.10*

(Number of family members), X5 – Average monthly income (Rs.), X6 – Kole land area (Ha), X7 – Farmer association membership (Yes = 1, No = 0), X8 – Digital Literacy (Score).

RESULTS AND DISCUSSION

Socio-economic characteristics

The socio-economic characteristics of the sample farmers were given in table 1. The average age was 57 indicating the involvement of older generation in wetland paddy farming and were highly experienced in sub-sea level farming. All sample farmers were literate with an average education of 9 years. Small farm house holds were dominant in the study area with an average Kole land holding size of 0.62 ha. As the average land holding size is small, the farmers were classified based on the total land holding size as marginal (< 1ha), small (1 – 2 ha) and large (> 2ha). Majority of the farmers (72.06%) participated in the survey belong to marginal category.

Awareness and participation status

Awareness about the paddy royalty programme in Kerala, was important for the success of the scheme. The results (Table 2) showed that the farmers were highly aware of the scheme. The major sources of information were social media, peer group discussions like farmer association meetings and also from *krishibhavans*. Majority of the farmers (86%) knows the details of the scheme such as royalty amount, application procedure etc but only 28 per cent has clearly understood the objectives. Therefore, it was essential to impart vital knowledge about the eco-compensation payments for not only supporting the economic well-being of the farmer but also to contribute to the ecological sustainability of the region.

The data on farmer participation in Paddy Royalty scheme presented in Table 2 provided valuable insights into how different categories of farmers perceive the scheme. There was a clear mismatch between the awareness level and actual participation. Only 57 per cent of the farmers actually participated in the Paddy Royalty scheme in 2023-24 and less than half of the farmers were willing to register for the scheme in next year. The results indicated the dissatisfaction at farmer level and points towards the deficiencies in paddy royalty programme design and implementation. The reluctance from farmer side was highest among the marginal farmers followed by small and large farmers.

Factors influencing farmer participation in paddy royalty scheme

The results of logistic regression analysis presented in Table 3, provided insights on various variables significantly affect the likelihood of

Table 4. Severity ranking of participation constraints in paddy royalty scheme

Sr. No.	Identified constraints	Relevancy coefficient	Severity ranking
1	Insufficient royalty amount	0.7458	I
2	High transaction costs	0.7225	II
3	Irregular payment release	0.5996	III
4	Complex application procedure and follow up	0.4492	IV
5	Delay in application processing and approval	0.4279	V

farmers enrolling in the Paddy Royalty scheme. The variables such as education, Kole land holding size, farmer association membership and digital literacy were found to be positively and significantly influence the probability of participation in the scheme. Conversely, the age of the farmer was found to have negative and significant effect on probability of participation. At younger ages, the probability of participation in scheme was high, but the probability decreases as the farmer gets older. Therefore, young farmers had prime involvement in the scheme. Education increases the likelihood to participate in the scheme like any other new programme, as the educated farmers can better process information which in turn creates a more favourable mental attitude towards an innovative action. Thakur and Pandya (2021) also reported that the variable education had positively and significantly affected farming decision making and participation.

The land holding size was the most important factor that influenced participation as the royalty amount was directly proportional to the Kole land area. Higher the acreage, higher will be the royalty amount resulted in higher participation rate. Another probable reason was that the large farmers would have more availability of resources that facilitated the participation. The reason for the significance of farmer association membership variable could be the fact that farmers discuss new information and scheme details in group meetings, peer discussions etc which may motivate farmers to participate. As the participation was restricted through online mode, digital literacy factor becomes crucial. The digital literacy imparts knowledge about the scheme, stimulates farmer enthusiasm and facilitates farmer to submit application and further follow up activities in online mode. Thus, the digital literacy becomes the key element that improves participation.

Participation constraints in paddy royalty scheme

The major constraints identified and the severity ranking is listed in Table 4. According to the farmer response, the most limiting factor was the insufficient royalty amount which failed to incentivize the farmers adequately. The eco-compensation amount was incomparable with the expenses of maintaining the wetland agro-ecosystem. The royalty amount together with all forms of subsidies accounts for only 11 per cent of the per hectare total economic value of ecosystem services provided by Kole wetlands. Therefore, the farmers were incentivised only marginally for conserving and providing the ecosystem services. A revision in quantum of incentives as well as scheme design on a scientific basis was a pressing priority. The second severe constraint was the transaction costs involved. The farmers reported that the extra efforts or costs involved right from submission of application till the receipt of amount was considerably higher when compared to the eligible royalty amount. The irregularity in payments was ranked as the next important constraint. Farmers report that they received royalty amount of 2020-21 and 2021-22 but the payments for 2022-23 and 2023-24 were not released as of April 2024. The complex application procedure and its follow up is another limitation. The combined one-time application for yearly farming activities has to considered instead of submitting various applications for same farming activity. In some cases, unexplained delay was observed in processing and approval/rejection of applications.

Farmer perspectives and preferences about paddy royalty scheme

The majority of farmers (94.81%) opined that a better paddy royalty programme design required exclusively for Kole lands. The farmer

preferred cash incentive at higher rates in proportional to the yearly maintenance cost of wetland ecosystem. More than half of the farmers also supported for a combination of cash and in-kind incentives through Paddy Royalty scheme. Most of the farmers (90.43%) preferred regular quarterly or half yearly payments prior to the cropping season. The proportion of farmers supported one-time or lump sum payment once in three years was 12.30 per cent and 8.79 per cent of farmer demanded additional land tax exemption incentives.

CONCLUSION

PES programmes offer a promising approach to conserve ecosystems by aligning economic incentives with environmental objectives. However, careful design, implementation, and monitoring were essential to maximize its effectiveness and to address potential challenges. A clear mismatch between the awareness level and actual farmer participation was obvious in the study. Only 57 per cent of the farmers actually participated in the Paddy Royalty scheme in 2023-24, while less than half of the farmers were willing to register in 2024-25. The royalty amount together with all forms of subsidies accounts for only 11 per cent of the per hectare total economic value of ecosystem services provided by the Kole wetlands. Therefore, farmers were incentivised only marginally for conserving wetlands and providing the ecosystem services. The continued diminishing response to the paddy royalty scheme in Kerala highlights the need to address the problems of insufficiency as well irregularity in royalty payments along with enhanced efforts to improve the digital literacy among farmers and to simplify the application process for reducing the transaction costs. Adopting a comprehensive approach that includes better program design, increased incentives, and supportive policies, may foster greater participation and will help to achieve the primary objectives of scheme such as sustaining paddy cultivation and preserving wetlands, which in turn ensures food security and ecological sustainability.

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Received on 20/6/2024 Accepted on 12/10/2024

J Krishi Vigyan 2024, 12(4) : 856-860
DOI : 10.5958/2349-4433.2024.00147.X
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Feeding Management Practices Followed by Dairy Farmers of Kandi Area of Punjab

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ABSTRACT

A field survey was undertaken to record the prevailing feeding management methods employed by dairy farmers in the Kandi region of Hoshiarpur district in Punjab. The study encompassed on 80 farmers from various villages. Structured interviews, utilizing a pre-tested questionnaire, were conducted to gather information about the existing feeding practices. The data were recorded through direct interaction with the farmers and first hand observations. The study revealed there was a limited supply of both green and dry fodder available in the area. As a result, farmers relied on acquiring both dry and green fodder through purchases, considering the limited availability of land at their disposal. Concentrate feed was primarily given to lactating animals but in restricted amounts. Concentrate was often prepared at home consisting of majorly wheat grains as primary energy source and mustard and cotton seed cake as protein, fat and fibre sources. Knowledge about fodder preservation methods like silage and hay-making was lacking. Similarly, the recognition and implementation of providing concentrate mixtures during late lactation/transition period were also missing. The importance of feeding mineral mixture and vitamins were also limited. Consequently, the dairy farmers in the region were deficient in scientific knowledge concerning dairy management, leading to compromised production and reproductive performance outcomes. Therefore, there is a need to conduct various trainings to educate the dairy farmers of the area for obtaining better performances and returns.

Key Words: Green fodder, Kandi area, Mineral mixture, Silage.

INTRODUCTION

Feeding management is crucial for maximizing the potential of dairy animals, accounting for around 70% of the total costs associated with milk production (Singh *et al,* 2023). Underfeeding prevents animals from reaching their genetic potential, leading to stunted growth, delayed maturity, and reduced productivity. Effective feeding practices are therefore vital for animal health, productivity, and overall farm profitability. The *Kandi* area faces significant challenges, such as small and marginal landholdings, uneven terrain, and limited water availability, which impede fodder production and agricultural productivity. These constraints limit economic opportunities for farmers (NAIP, 2014). Understanding the feeding management practices followed by farmers is essential to identify strengths and weaknesses and formulate suitable intervention policies (Prajapati *et al,* 2021). This approach aims to improve animal welfare, optimize production efficiency, and promote sustainable agricultural development. Therefore, the present investigation was undertaken to study the knowledge level of farmers regarding various feeding management practices in the Kandi area of Hoshiarpur district, Punjab. The aim is to identify opportunities to improve feeding strategies, enhance animal welfare, and ensure the long-term sustainability of dairy farming in the Kandi area.

MATERIALS AND METHODS

A field survey was conducted on farmers from the blocks of Hajipur, Talwara, and Bhunga in District Hoshiarpur. These farmers had mostly attended various trainings and awareness camps conducted by the Regional Research and Training

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Centre, Talwara. The study encompassed 80 farmers from several villages (Nangal Behalan, Sathwan, Jakhrawal, Bela Sariana, Thane, and Waziran) within the Kandi area of Hoshiarpur. Dairy farmers were selected randomly, and information regarding various feeding practices was collected using structured interviews and a pre-tested questionnaire. The data was gathered through direct interaction with the farmers and firsthand observations. The interviews covered a wide range of feeding management aspects, including utilization of crop byproducts, silage, hay, and available cultivated fodder. The discussions also addressed feeding strategies at different stages of dairying, including calf and heifer care, late pregnancy, and early lactation. Other topics included the administration of colostrum, mineral supplementation, and the enhancement of diets with essential vitamins. The data was then transferred to a data sheet and analysed using frequencies and percentages.

RESULTS AND DISCUSSION

In the *Kandi* area, farmers practiced stall feeding for their livestock despite having adjacent forest areas available for grazing. Most of these animals (76%) were fed individually, while the remaining were fed in groups of two to three animals using a central feeding manger. It was similar to findings of Sourav *et al* (2023), who observed that stall feeding as common practice of feeding among the farmers. The animals' diet primarily consisted of green fodder, dry fodder (mainly wheat straw), and home-prepared concentrate, which was limited to lactating animals with an average milk yield of 2-12 kg in a restricted amount only. During the *Rabi* season, the green fodder included green oat, berseem, and rye grass. In the *Kharif* season, green bajra, Nutri feed bajra, and maize were the main types of green fodder available. Most farmers cultivated green fodder on small plots of land near their homes and used self-prepared chopped wheat straw (2 to 3 cm in length) as the primary source of dry fodder. However, a significant number of farmers reported a limited supply of both green and dry fodder Consequently, they often had to purchase fodder due to the limited availability of land (Singh *et al,* 2024). Similar findings were reported by Rathore (2023) who observed small land holdings, low production and limited fodder supply in Kandi area dairy farmers. Only a few farmers used paddy straw as dry fodder.

Fodder conservation methods such as silage and hay making were almost non-existent in the area, possibly due to the limited availability of fodder and a lack of knowledge about these technologies.Sharma (2015) who observed limited knowledge of fodder preservation among small farmers in Kapurthala district of Punjab. Very few farmers purchased silage bales during the off-season. The home-prepared concentrate for lactating animals typically consisted of wheat as the primary energy source and mustard and cottonseed cake for protein, fat, and fiber. Wheat grains were preferred over maize grains due to their availability at home and a common belief that maize grains could cause mastitis due to toxins.

The concentrate offered was mainly in the form of mash whereas few farmers also fed the pelleted concentrate mixture of various commercial preparations. Further, it was also observed that homemade concentrate was soaked for 2 to 3 hours before being offered to the animals. Sabapara *et al* (2015) observed the practice of soaking concentrate ingredients in water before feeding to animals. The farmers practiced feeding concentrate two times a day just prior to milking or during the milking. Limited concentrate use is likely due to high ingredient costs, low animal production, and limited knowledge of feed formulation. Sharma (2015) also identified poor knowledge of feed nutritive value and high raw ingredient costs as major barriers to adopting cattle feed formulation technology and concentrate feeding on dairy farms.

The practice of feeding TMR (Total mixed ration) was not found prevalent in the area, but few farmers (8 %) did practices feeding concentrate, chopped green and wheat straw together as hand mixed total ration. The practice of providing specific concentrate mixtures during different stages, such as late lactation, transition period, and growth period, was also missing. Although farmers lacked knowledge regarding importance of feeding during transition period, few farmers recently have started using various available

Table 1. Feeding management practices followed by farmers of Kandi area of Punjab

Sr.No.	Characteristic	Frequency	Percentage
1.	Type of Fodder cultivated		
a.	During Rabi Season		
	Leguminous (Berseem/Rye Grass)	05	6.3
	Non leguminous (oat)	18	22.5
	Non availability	16	20.0
	Both	31	38.8
b.	During *Kharif*		0
	Bajra/Maize/ Nutri feed Bajra/Sorghum	59	73.8
	Non availability	21	26.2
2	Whether fodder was cultivated/purchased		
	Cultivated	64	80.0
	Purchased	38	47.5
	Both	22	27.5
3	Preparation and purchase of silage and Hay	05	6.3
4	Feeding Tree leaves as fodder	08	10.0
5	Dry fodder used in Ration	80	100.0
c.	Wheat straw as Dry fodder	76	95.0
d.	Paddy Straw	6	7.5
6	Whether concentrate given to lactating animals	76	95.0
7	Whether concentrate given to Dry animals	6	7.5
8	Whether concentrate given to growing animals	14	17.5
9	Whether any specialized feed given to transition animals	28	35.0
10	Whether concentrate was prepared at Home	54	67.5
11	Whether commercial preparation was used	28	35.0
12	Preparation of Total mixed ration	6	7.5
13	Whether animals were fed as per requirement	19	23.8
14	Whether colostrum was feeding within two hours to calves	24	30.0
15	Whether calf starter was given to calves	08	10.0
16	Use and awareness regarding mineral mixture and vitamin supplementation	59	73.8
17	Use and awareness regarding By pass supplementation	1	1.3
18	Feeding salt to the animals	60	75
19	Source of water		
	Ground water	28	35
	Other than ground water	52	65
20	No. of times water offered		
	ad libitum (24 h)	18	22.5
	Once a day	28	35.0
	Twice a day	32	40.0
	More than once	2	2.5

commercial preparation of Transition feed to animals particularly twenty days prior to calving. It is worth to mention that few farmers feed wheat grain and cotton seed cake in gruel form prepared by heating these ingredients in low flame just prior to transition period. No specific attention was given to calf feeding, as it was believed by many farmers that colostrum should not be fed to calves until the placenta had been expelled. However, placenta expulsion is aided by early suckling, and essential antibodies are received by the calf within the first two hours of birth. These findings align with those of Singh *et al* (2023) and Singh *et al* (2019), who also noted that farmers wait for placenta expulsion before feeding colostrum to calves. Additionally, the importance of feeding mineral mixtures and vitamins was not well recognized. However, a considerable farmer has started using mineral mixture as top dressed and observed significant improvement in productive and reproductive performance of animals. However, still a large number of farmers were reluctant to use mineral mixture in the diet of animals. The use of supplements like bypass fat was almost non-existent.

Water intake is a crucial yet often overlooked nutrient (Sharma *et al,* 2016). The source of the water can greatly affect its quality, particularly the total dissolved content level, which in turn influences animal performance (Sharma *et al,* 2017). The primary source of water for drinking and other daily farm operations was either groundwater through hand pumps or tube wells, pucca reservoirs at some places and tap water, consistent with the findings of Sourav *et al* (2023), who identified groundwater as a major source of drinking water in animals. Most farmers lacked a twenty-four-hour water supply, with observations indicating that water was provided by farmers once, twice, and daily at rates of 35%, 40%, and 2.5%, respectively.

CONCLUSION

It was concluded that farmers lacked the scientific knowledge regarding feeding of dairy animals leading to compromised production and reproductive performance outcomes. Therefore, there is need for creating awareness and enhancing knowledge level of farmers regarding scientific feeding management through various trainings.

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Received on 10/7/2024 Accepted on 5/10/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 861-864

DOI : 10.5958/2349-4433.2024.00148.6

Impact of Imidacloprid 17.8 SL on Coccinellids in Cotton

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ABSTRACT

Field trials were conducted to study the toxicity of chloronicotinyl compound, imidacloprid against the predator, coccinellids in cotton cultivars, Ranjit and MCU 12. All the imidacloprid treatments, irrespective of doses recorded a sudden decrease in the coccinellids population after application, in cotton ecosystem, but found to increase in numbers subsequently. The neonicotinoid check, thiamethoxam was also found to be similar to imidacloprid in its toxicity to coccinellids. Thus, the results revealed that neonicotinoids were relatively safer to coccinellids when compared to conventional insecticide methyl demonstration.

Key Words: Coccinellids, Cotton, Imidacloprid, Toxicity.

INTRODUCTION

Leafhoppers, *Amrasca biguttula biguttula* (Ishida), thrips, *Thrips tabaci* Lindeman, whiteflies, *Bemisia tabaci* (Gennadius), and aphids, *Aphis gossypii* Glover, are the major sucking pests that attack cotton ecosystem. The problem of these pests has been observed from the seedling stage, resulting in a significant decrease in the yield of up to 22.85 per cent in cotton seeds (Satpute *et al*, 1990). Coccinellids are found to be the most well-known group of beneficial insects and they usually consume aphids, other soft-bodied insects, also feed on mites, and small nematocerous Dipteran flies (Hodek, 1970). Over the past 20 years, predators have declined around 68.4 per cent and the eradication of numerous parasitoids was observed in the cotton ecosystem (Dhawan and Simwat, 1996). As the farmers spray broad range of spectrum insecticides that have a relatively long-term residual effect. According to Acharya *et al* (2002), in India at least two to three sprays are used to combat sucking pests in cotton.

This practice may cause reduction in the count of natural enemies from the field and lead to complex insect pest damage and they tend to flare up of one or more pest species in the cotton ecosystem. In such scenario, there is an immediate need for newer systemic and selective insecticide, which has the least effect on the beneficial insects. Imidacloprid is to be very effective in testing the insect pests of cotton, especially sucking pests, but its effect on the beneficial need to be studied. So the impact of imidacloprid on the coccinellid population was studied in the major cotton growing regions of Coimbatore district of Tamil Nadu.

MATERIALS AND METHODS

Field trials were conducted for two seasons to study the impact of imidacloprid 17.8 SL on coccinellids in cotton. The trial for first season was conducted in cotton cultivar (Ranjit) at Kanjapalli, Annur, and the second season trial in MCU 12 cotton at Kavilipalayam, Puliampatti. The crop was sown in three replications for each trial in a randomized block design (RBD) with plot size of 6 x 5 m and 7 x 5 m for I and II trial. All agronomic practices were followed properly as recommended by Tamil Nadu Agricultural University. To evaluate the impact of imidacloprid 17.8 SL on coccinellids, the number of coccinellids (grubs, pupae, and adults) were recorded before insecticide treatment, and after application of insecticide treatment on 1, 3, 7, 10, and 14 DAT (Day After Treatment) from ten randomly selected plants for each trail.

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Table 1. Effect of imidacloprid 17.8 SL on coccinellids in cotton ecosystem.
(Mean of three replications)

Treatment	Number/ 3 leaves/ plant													
	Days after first application							Days after second application						
	PTC	1	3	7	10	14	Mean	PTC	1	3	7	10	14	Mean
Imidacloprid 15 g a.i. ha^{-1}	6.33	5.67^{ab} (2.47)	6.00^{b} (2.53)	7.00^{ab} (2.73)	7.67^{b} (2.85)	8.67^{ab} (3.02)	7.00	9.33	8.33^{b} (2.96)	9.00^{b} (3.07)	9.67^{b} (3.18)	10.33^{b} (3.29)	11.00^{ab} (3.38)	9.67
Imidacloprid 25 g a.i. ha^{-1}	6.67	5.00^{b} (2.28)	5.67^{b} (2.43)	6.33^{b} (2.57)	7.00^{b} (2.70)	8.00^{bc} (2.88)	6.40	9.00	6.67^{bcd} (2.63)	7.00^{bc} (2.70)	7.67^{bc} (2.82)	8.33^{bc} (2.94)	9.00^{bcd} (3.05)	7.73
Imidacloprid 50 g a.i. ha^{-1}	7.00	4.67^{b} (2.25)	5.00^{b} (2.32)	5.67^{b} (2.47)	6.33^{b} (2.60)	7.67^{bc} (2.85)	5.87	8.67	5.33^{cd} (2.40)	5.67^{c} (2.47)	6.67^{c} (2.66)	7.33^{c} (2.79)	8.33^{cd} (2.96)	6.67
Imidacloprid 25 g a.i. ha^{-1} (Tatamida®)	7.00	5.00^{b} (2.34)	5.33^{b} (2.41)	6.00^{b} (2.55)	7.33^{b} (2.80)	8.00^{bc} (2.91)	6.40	9.00	7.00^{bc} (2.74)	7.33^{bc} (2.80)	8.00^{bc} (2.91)	8.33^{bc} (2.97)	9.33^{bcd} (3.13)	8.00
Thiamethoxam 25 g a.i. ha^{-1}	7.33	5.67^{ab} (2.47)	6.33^{ab} (2.60)	7.00^{ab} (2.73)	7.33^{b} (2.79)	8.33^{b} (2.96)	6.93	9.33	8.00^{b} (2.91)	8.67^{b} (3.02)	9.33^{b} (3.13)	10.00^{b} (3.23)	10.67^{bc} (3.34)	9.33
Methyl demeton 125 g a.i. ha^{-1}	7.67	4.00^{b} (2.10)	4.67^{b} (2.26)	5.00^{b} (2.33)	5.67^{b} (2.47)	6.00^{c} (2.54)	5.07	8.00	4.67^{d} (2.26)	5.33^{c} (2.40)	6.00^{c} (2.54)	7.00^{c} (2.73)	7.67^{b} (2.85)	6.13
Untreated check	7.33	8.00^{a} (2.91)	8.67^{a} (3.02)	9.33^{ab} (3.13)	10.67^{a} (3.34)	11.00^{a} (3.39)	9.53	12.33	12.67^{a} (3.62)	12.67^{a} (3.62)	13.00^{a} (3.67)	13.67^{a} (3.76)	13.33^{a} (3.77)	13.07

PTC - Pre treatment count
Figures in parentheses are $\sqrt{x+0.5}$ transformed values
In a column, means followed by a common letter(s) are not significantly different by DMRT (p=0.05)

RESULTS AND DISCUSSION

In the first field trial, the population of coccinellids in cotton was found uniformly distributed (6.33 to 7.67/ ten plants) before spraying insecticides. As compared with all the insecticide treatments, the mean population of coccinellid predators was significantly higher in the lowest dose (15 g a.i. ha^{-1}) of imidacloprid (7.00/ ten plants) followed by thiamethoxam at 25 g a.i. ha^{-1} (6.93 coccinellids/ ten plants), imidacloprid (Tatamida®) at 25 g a.i. ha^{-1} (6.40/ ten plants) and imidacloprid at 25 g a.i. ha^{-1} (6.40/ ten plants), respectively (Table 1). The least population of coccinellid was recorded in the standard check, methyl demeton at 125 g a.i. ha^{-1} (5.07/ ten plants) followed by the high dose of imidacloprid at 50 g a.i. ha^{-1} (5.87/ ten plants). The treatment with imidacloprid at 50 g a.i. ha^{-1} has recorded a reduction of 2.33 coccinellids/ ten plants on the first day after spray, when compared to PTC. Thus it is evident from the table that all the insecticidal treatments applied for the control of sucking pests had significantly reduced the coccinellids grub as well as the adult population of coccinellid predators over control.

The coccinellid population before second round of spray varied from 8.00 to 12.33/ ten plants (Table 1). Imidacloprid at 15 g a.i. ha^{-1} has recorded a mean coccinellid population of 9.67/ ten plants followed by thiamethoxam at 25 g a.i. ha^{-1} (9.33/ ten plants), imidacloprid (Tatamida®) at 25 g a.i. ha^{-1} (8.00/ ten plants) and imidacloprid at 25 g a.i. ha^{-1} (7.73/ ten plants). As compared with untreated check, all the insecticidal treatments showed a decrease in the population of coccinellids but it was known that after initial decline there is a slow progressive increase in the number of coccinellids.

In the second field trial, the population of coccinellids ranged from 7.67 to 8.33/ ten plants before imposing the treatments (Table 2). Imidacloprid at 15 g a.i. ha^{-1} recorded the higher mean coccinellid population of 8.07/ ten plants next to untreated check (9.80/ ten plants). The standard check, methyl demeton 25 EC at 125 g

Table 2. Effect of imidacloprid 17.8 SL on coccinellids in cotton ecosystem.
(Mean of three replications)

Treatment	Number/ 3 leaves/ plant													
	Days after first application							Days after second application						
	PTC	1	3	7	10	14	Mean	PTC	1	3	7	10	14	Mean
Imidacloprid 15 g a.i. ha^{-1}	7.67	6.67^{b} (2.67)	7.33^{b} (2.79)	8.00^{b} (2.91)	8.67^{b} (3.03)	9.67^{b} (3.19)	8.07	10.33	9.00^{b} (3.08)	9.33^{b} (3.13)	10.00^{b} (3.24)	10.67^{b} (3.34)	11.67^{b} (3.49)	10.13
Imidacloprid 25 g a.i. ha^{-1}	7.67	5.67^{bc} (2.48)	6.00^{cd} (2.54)	6.67^{c} (2.68)	7.67^{cd} (2.86)	8.33^{cd} (2.97)	6.87	9.00	7.00^{c} (2.73)	7.33^{c} (2.79)	8.33^{c} (2.97)	9.00^{cd} (3.08)	10.00^{c} (3.24)	8.33
Imidacloprid 50 g a.i. ha^{-1}	8.33	5.00^{cd} (2.34)	5.33^{de} (2.41)	5.67^{d} (2.48)	6.67^{ef} (2.67)	8.00^{d} (2.91)	6.13	9.00	6.67^{c} (2.67)	7.00^{c} (2.74)	8.00^{c} (2.91)	8.67^{d} (3.03)	9.33^{c} (3.13)	7.93
Imidacloprid 25 g a.i. ha^{-1} (Tatamida®)	8.00	5.67^{bc} (2.48)	6.00^{cd} (2.55)	7.00^{bc} (2.74)	7.33^{de} (2.80)	8.33^{cd} (2.97)	6.87	9.33	7.33^{c} (2.80)	7.67^{c} (2.86)	8.33^{c} (2.97)	9.33^{cd} (3.13)	10.00^{c} (3.24)	8.53
Thiamethoxam 25 g a.i. ha^{-1}	8.33	6.33^{b} (2.61)	7.00^{bc} (2.74)	7.67^{bc} (2.85)	3.33^{bc} (2.97)	9.00^{bc} (3.08)	6.67	10.00	7.67^{c} (2.85)	8.00^{c} (2.91)	8.67^{c} (3.03)	9.67^{c} (3.19)	11.00^{b} (3.39)	9.00
Methyl demeton 125 g a.i. ha^{-1}	7.67	4.33^{d} (2.19)	4.67^{e} (2.27)	5.33^{d} (2.41)	6.00^{f} (2.55)	7.00^{e} (2.74)	5.47	8.00	5.33^{d} (2.41)	5.67^{d} (2.48)	6.67^{d} (2.68)	7.33^{e} (2.80)	8.33^{d} (2.97)	6.67
Untreated check	8.00	8.33^{a} (2.97)	9.00^{a} (3.08)	9.33^{a} (3.13)	10.33^{a} (3.29)	12.00^{a} (3.53)	9.80	13.00	14.00^{a} (3.81)	14.67^{a} (3.89)	15.00^{a} (3.94)	16.00^{a} (4.06)	16.33^{a} (4.10)	15.20

PTC - Pre treatment count
Figures in parentheses are $\sqrt{x+0.5}$ transformed values
In a column, means followed by a common letter(s) are not significantly different by DMRT (p=0.05)

a.i. ha^{-1} recorded a relatively less population of coccinellids (5.47/ ten plants). After second round of pesticide application, imidacloprid at 15 g a.i. ha^{-1} has recorded 10.13 per ten plants, while imidacloprid at 50 g a.i. ha^{-1} has recorded 7.93 coccinellids/ ten plants. The least population of coccinellids was reported by the standard check, methyl demeton at 125 g a.i. ha^{-1} (6.67/ ten plants). All the insecticidal treatments were found to have adverse effect on coccinellids population when compared with the untreated check throughout the observation period. But it was quite worth to note that after a sudden decline in the population immediately after spraying there was a gradual increase in the population of coccinellids.

Beneficial predators and parasites are typically abundant in cotton ecosystems and often offer partial to adequate pest control. Choosing insecticides for pest control should be done carefully to conserve the natural enemies and reduce the negative impacts they cause. The suggested dosage of imidacloprid 17.8 SL (25 g a.i. ha-1) significantly reduced the harmful effect on natural enemies, particularly coccinellids.

Srinivasababu and Sharma (2003) found that imidacloprid at 12.5 g a.i. ha^{-1} was the safest chemical against coccinellids compared to conventional insecticides like dimethoate and chlorpyriphos. Whereas, Skouras et al (2017) reported that the mortality rates of coccinellid predator, *C. septempunctata* can be increased through residual toxicity and by feeding on imidacloprid treated aphids which deviated from the present findings. The toxicity of standard check, methyl demeton was already reported by Manisekaran *et al* (1991) that the application of methyl demeton considerably reduced the population of coccinellids.

CONCLUSION

In the present study, imidacloprid was found to be safer to natural enemies when compared with conventional insecticides.

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Received on 10/8/2024 Accepted on 11/10/2024

J Krishi Vigyan 2024, 12(4) : 865-871
DOI : 10.5958/2349-4433.2024.00149.2
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Impact of Sensory Attributes in Protein Enriched Ready to Serve Papaya - Beverage during Storage

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ABSTRACT

This study investigated the development and assessment of a protein-fortified ready-to-serve (RTS) beverage from papaya juice, enriched with milk and soy protein isolates. Different proportions of milk protein isolate (MPI) and soy protein isolate (SPI) were used to enhance the protein content. Among the formulations tested, the RTS beverage with 5% milk protein isolate and 10% soy protein isolate resulted in the highest sensory acceptability. Throughout a 60d storage period in PET bottles at room temperature, no microbial spoilage was observed, indicating good shelf stability. Sensory quality parameters, such as appearance, colour, flavour, taste and overall acceptability remained basically unaffected by the protein levels even as slight increases in titratable acidity and total soluble solids (TSS) were observed, alongside a reduction in pH, ascorbic acid, and protein content. Final protein levels in the RTS beverage were 4.7 g/100 ml for the 5% MPI formulation and 9.8 g/100 ml for the 10% SPI formulation. These results support the feasibility of commercially producing protein-fortified papaya RTS beverages are offering an innovative and nutrient-enriched option for consumers.

Key Words: Milk protein isolates, Papaya, Protein enrichment, RTS, Sensory attributes Soybean protein isolates.

INTRODUCTION

Fruit juices occupy an unique position among those product classified as beverages. Pure fruit juices, being a source of energy, phytonutrients, vitamins, and minerals are not only indispensable for maintaining health but also considered as the beverages of refreshment, which quench thirst and encourage liquid intake. They are becoming popular due to their pleasing flavour and nutritional characteristics. They contribute significantly to the vitamins especially vitamins A and C and minerals including potassium, magnesium, and calcium of the diet. They additionally contain antioxidants and phytochemicals, which have been shown to help safeguard human cells from oxidative damage. However, fruit juices are commonly low in protein. This intrinsic lack of protein in juices can be adjusted by adding a protein-rich substance that has no effect on the colour or flavour (Agarwal and Kumar, 2017).

The fortification must be such that it is highly consumed and preferred by the consumers and there is a great demand in the market. Since the demand for fruit juices in the market is increasing every year, this trend may be exploited by developing protein-enriched fruit juice beverages, as consumers are becoming increasingly conscious of how diet is linked to a healthy lifestyle. Multiple fruit juices or pulps can be mixed in different ratios to produce nectars, ready-to-serve drinks, and more. Combining juices can boost the aroma, taste, and health benefits of the beverage. Moreover, mixing can lead to the creation of new products, like a natural health drink that could also function as an appetizer.

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Table 1. Standardization of milk and soy protein isolate enriched Papaya RTS.

Treatment combinations
T_0 - Papaya fruit juice 100%
T_1 M - Papaya fruit juice (95%) + Milk protein isolate (5%)
T_2 M - Papaya fruit juice (90%) + Milk protein isolate (10%)
T_3 M - Papaya fruit juice (85%) + Milk protein isolate (15%)
T_4 S - Papaya fruit juice (95%) + Soy protein isolate (5%)
T_5 S - Papaya fruit juice (90%) + Soy protein isolate (10%)
T_6 S - Papaya fruit juice (85%)+ Soy protein isolate (15%)

Figure 1. Protein isolate enriched Papaya RTS in PET bottles

Papaya (*Carica papaya* L.) is well known for its exceptional nutritional and medicinal properties throughout the world. Since ancient times, every part of the papaya plant, including its leaves, seeds, ripe and unripe fruits, and their juice is used as a traditional medicine (Sindumathi *et al*, 2017). Nowadays, Papaya is considered as a nutraceutical fruit due to its multi-faceted medicinal properties. Phytochemically, the whole plant contains enzymes (Papain), carotenoids, alkaloids, monoterpenoids, flavonoids, minerals, and vitamins. However, the protein content of papaya is only 0.3%. (Akathsingh *et al,* 2010). Hence, the present experiment was aimed to develop and standardise protein enriched Papaya RTS using milk and soy protein isolates. The sensory attributes and nutrient content of highly accepted protein-enriched Papaya RTS was analyzed during the storage period.

MATERIALS AND METHODS

Standardization of protein enriched Papaya RTS

This study was carried in Laboratory of Food Science and Nutrition Department, Community Science College and Research Institute, Madurai. The fresh, uniform size matured papaya was procured from the wholesale fruit market and used for experimentation. The chosen fruits were thoroughly washed with tap water to remove any dust particles from their surfaces before being used for experimentation. Papaya juice was extracted using a mixer blender and juice was filtered. Filtered juice was used to standardize Papaya ready to serve beverage. Commercially available food-grade milk protein isolate and soy protein isolate were purchased from the local market and used to enrich the Papaya juice at definite proportions (Figure 1). The details of the treatments are as presented in table 1.

Organoleptic evaluation of protein enriched Papaya RTS

Data related to the effect of recipe and treatment combination and sensory attributes such as appearance, colour, flavour, taste, and overall acceptability of RTS were organoleptically evaluated by a panel of untrained judges following 9-point hedonic scale (Balaswamy, 2011).

Shelf-life studies and nutritional quality assessment of protein enriched Papaya RTS

The sensory characteristics of protein

Table 2. Sensory characteristics of developed protein enriched Papaya RTS.

Treatment	Appearance	Colour	Flavour	Taste	Overall acceptability
T_0	9.0	9.0	7.9	7.9	8.5
T_1 M	8.7	8.7	8.7	8.7	8.7
T_2 M	8.7	8.6	8.6	8.6	8.6
T_3 M	8.5	8.5	8.6	8.6	8.5
T_4 S	8.3	8.4	8.4	8.4	8.4
T_5 S	8.2	8.3	8.5	8.5	8.3
T_6 S	7.9	7.6	8.3	8.3	8.1
CD (0.05)	0.19	0.16	0.17	0.17	0.28
SEd	0.09	0.08	0.08	0.08	0.13

Table 3. Effect of treatments on appearance attribute of protein enriched Papaya RTS during storage.

Treatment	Storage periods (days)		
	Initial	30	60
T_0	9.0	8.9	8.9
T_1M	8.7	8.6	8.5
T_2M	8.7	8.5	8.5
T_3M	8.5	8.4	8.3
T_4S	8.3	8.1	8.0
T_5S	8.2	8.0	8.0
T_6S	7.9	7.5	7.4
CD (0.05)	0.19	0.07	0.19
SEd	0.09	0.15	0.09

enriched Papaya RTS beverage were evaluated during a storage period of 60 days and nutritional quality parameters were assessed initially. Crude protein content was determined by the Lowry's method and vitamin C was assessed by titration method.

Statistical Analysis

The data obtained from the different treatments were subjected to completely randomized design statistical analysis in OP stat software version to find out the impact of different treatments. (Sheoran *et al,* 1998)

RESULTS AND DISCUSSION

Effect of treatments on sensory attribute changes of protein enriched Papaya RTS

Data to study about the sensory scores of protein enriched Papaya RTS among the different treatment combinations is presented in table 2.

The RTS prepared from various combinations of milk and soy protein isolate was organoleptically evaluated to obtain the most acceptable treatment. It was found that 5% of milk protein isolate T_1 M and 10% soy protein isolate T_5S incorporated RTS was highly accepted (Table 2). After being protein-enriched and pasteurized, the 200 ml bottles of Papaya RTS were sealed and kept at room temperature (35±5°C) until further examination and comparison with a control sample. Similar study was done by Bhardwaj and Pandey (2011) and Dande (2017) and the results of the present findings were in concordant with it.

Appearance attribute of protein enriched Papaya RTS beverage

The details regarding the changes in the appearance of Papaya RTS beverage as affected by treatment combination during storage were evaluated by visual examination at initial day intervals up to 60d (Table 3). The T_0 had a clear appearance and the T_6S treatment combination had a viscous appearance. The T_4S and T_5S combinations had a light turbid appearance on the initial day. After 30d T_4S, T_5S, and T_6S treatment combinations had protein settlement at the bottom and top. The same thing in appearance was observed after 60d of storage. The T_1M and T_2M treatment combination obtained a maximum appearance score of 8.5 during storage and T_6S obtained a minimum appearance score of 7.4 on 60th day of storage.

Table 4. Effect of treatments on colour changes of protein enriched Papaya RTS during storage.

Treatment	Storage periods (days)		
	Initial	30	60
T_0	9.0	9.0	8.9
T_1M	8.7	8.6	8.5
T_2M	8.6	8.5	8.4
T_3M	8.5	8.4	8.2
T_4S	8.4	8.0	8.0
T_5S	8.3	8.2	8.1
T_6S	7.6	7.4	7.2
CD (0.05)	0.17	0.18	0.16
SEd	0.08	0.08	0.07

Table 5. Effect of treatments on flavour changes of protein enriched Papaya RTS during storage.

Treatment	Storage periods (days)		
	Initial	30	60
T_0	7.9	7.7	7.6
T_1M	8.7	8.6	8.6
T_2M	8.6	8.5	8.5
T_3M	8.6	8.4	8.3
T_4S	8.4	8.2	8.1
T_5S	8.5	8.4	8.3
T_6S	8.3	8.1	8.0
CD (0.05)	0.17	0.399	0.394
SEd	0.08	0.184	0.182

The T_1M and T_2M treatments had a good appearance because they contained less amount of protein isolate. However, the appearance of T_6S obtained a very low score due to the incorporation of a high amount of protein isolate. Similar study was done by Hemalatha *et al* (2018) and Kumar (2018). Research findings of Saied and El Zubeir (2024) have elaborated the usage of whey proteins in enriched development of Roselle, Doum and Baobab juices. It was found in their studies that there was enhancement of product colour for Roselle blends, taste enhancement and protein content increase in the case of Doum and Baobab juices through whey incorporation.

Colour attribute of protein enriched Papaya RTS

The details regarding the changes in the colour of RTS beverage as affected by treatment combination during storage were evaluated organoleptically at first-day intervals up to 60d. It was evident from the data that fresh RTS beverages had light orange colour and the T_1M, T_2M, and T_3M treatment combination had light orange to dark orange colour. T_4S, T_5S, T_6S treatment combination had a light orange to light white colour. However, with the advancement of the storage period, colour changes were observed in all the treatment. T_0 obtained the maximum colour score of 9.0 and the T_6S treatment combination obtained the minimum colour of 7.6.After 30d, a maximum colour score of 8.6 was obtained in the T_1M treatment combination and a minimum colour score of 7.4 was obtained for the T_6S treatment combination. After 60d, maximum colour score of 8.5 was obtained in the T_1M treatment combination and a minimum colour score of 7.2 was obtained for the T_6S treatment combination. However, among all the treatments, the T_6S treatment shows a minimum colour score from 7.6 to 7.2 during the storage period.

The colour and amount of the protein isolate incorporation into RTS are responsible for the final colour characteristics of all the treatment combinations.

Flavour attribute of protein enriched Papaya RTS

The flavour value of RTS beverages was significantly affected by the treatment combination and storage period from the initial to

Table 6. Effect of treatments on taste changes of protein enriched Papaya RTS during storage.

Treatment	Storage periods (days)		
	Initial	30	60
T_0	8.6	8.5	8.4
T_1M	9.0	8.9	8.7
T_2M	8.8	8.7	8.6
T_3M	8.7	8.6	8.5
T_4S	8.8	8.7	8.6
T_5S	8.7	8.6	8.5
T_6S	8.6	8.5	8.4
CD (0.05)	0.16	0.13	0.17
SEd	0.07	0.06	0.08

Table 7. Effect of treatments on overall acceptability changes of protein enriched Papaya RTS during storage.

Treatment	Storage periods (days)		
	Initial	30 days	60 days
T_0	8.5	8.4	8.3
T_1M	8.7	8.6	8.5
T_2M	8.6	8.5	8.4
T_3M	8.5	8.4	8. 3
T_4S	8.4	8.3	8.2
T_5S	8.3	8.2	8.1
T_6S	8.1	8.0	7.9
CD (0.05)	0.28	0.15	3.19
SEd	0.13	0.07	1.49

6d of storage. The flavour value was reduced with the advancement of storage period in all treatments. The control obtained the minimum flavour score of 7.9 and the T_1M treatment combination obtained the maximum flavour score of 8.7.After 30 d, a maximum flavour score of 8.6 was obtained in the T_1M treatment combination and a minimum flavour score of 7.7 was obtained for control. After 60 days maximum flavour score of 8.6 was obtained in the T_1M treatment combination and a minimum flavour score of 7.6 was obtained for T_0. Similar study was done by Priyanthi (2008).

Taste attribute of protein enriched Papaya RTS

The taste value of RTS beverages was significantly affected by the treatment combination and storage period from the initial day to 60d. The taste value was reduced with the advancement of the storage period in all treatments. The T_6S obtained the minimum taste score of 8.6 and the T_1M treatment combination obtained the maximum taste score of 9.0. After 30d, a maximum score of 8.9 was obtained in the T_1M treatment combination and a minimum taste score of 8.5 was obtained for T_6S. After 60d maximum taste score of 8.7 was obtained in the T_1M treatment combination and a minimum taste score was obtained for T_6S and T_0.

Overall acceptability attribute of protein enriched Papaya RTS

The overall acceptability of the protein enriched RTS beverage was significantly affected by the treatment combination and storage period from the initial day to 60d. The overall acceptability value was reduced with the advancement of storage period in all treatments. The T_6S obtained the minimum overall acceptability score of 8.1 and the T_1M treatment combination obtained the maximum overall acceptability score of 8.7.After 30d, a maximum overall acceptability score of 8.6 was obtained in the T_1M treatment combination, and a minimum overall acceptability score of 8.0 was obtained for T_6S. After 60d maximum overall acceptability score of 8.5 was obtained in the T_1M treatment combination and a minimum score of 7.9 was obtained for T_6S. As per sensory evaluation,

Table 8. Nutritional quality of protein enriched papaya RTS

Treatment	TSS (°Brix)	pH	Acidity	Protein(g)	[illegible]	Ascorbic acid (mg)
T_0	15.0	5.4	0.39	0.2	632	0.75
T_1M	14.4	5.1	0.35	4.7	654	0.73
T_2M	14.7	5.0	0.37	9.7	654	0.73
T_3M	14.9	5.0	0.37	14.5	651	0.72
T_4S	14.5	4.9	0.39	4.8	653	0.72
T_5S	14.7	4.9	0.41	9.8	653	0.71
T_6S	14.9	4.9	0.40	14.6	654	0.71
CD (0.05)	NS	0.243	0.018	0.374	NS	0.037
SEd	0.327	0.112	0.008	0.173	14.505	0.017

treatment combination T_1M and T_5S had the maximum overall acceptability in the milk and soy protein isolate enriched Papaya RTS.

Nutritional quality of developed protein enriched Papaya RTS

Data about the presents of nutrients in protein enriched Papaya RTS beverage such as TSS, acidity, pH, protein, β - carotene, and ascorbic acid were recorded. Panghal *et al* (2017) experimented protein enrichment of papaya RTS with whey to increase the protein content and other nutritional parameters. It was registered that 25% of whey wastes was acceptable with good sensory scores in the development of papaya RTS based beverages.

The data on the total soluble solids content of protein enriched Papaya RTS beverage was recorded in the range from 14.4°Brix (T_1M) to 15.0°Brix ($T_{0)}$ and it was significant for different treatment combination. Same type of RTS was developed by Sasi Kumar *et al* (2012) and the results were in accordance with our present findings. In view of the preservation, date palm sap based RTS was developed by Shanta *et al* (2021), which illustrated that heat treated Date palm RTS prepared using 30% Date palm juice was highly accepted which registered TSS of 18º Brix. The increase in TSS might be due to hydrolysis of insoluble polysaccharides into simple and soluble sugars

The T_6M obtained the minimum pH content of 4.9 and the T_0 obtained the maximum pH of 5.4. Fruit juices have a low pH because they are comparatively rich in organic acids (Tasnim *et al,* 2010). The T_1M obtained the minimum acidity content of 0.35 and the T_5S treatment combination obtained the maximum acidity of 0.41. There were significant differences in the acidity of the variants of RTS containing milk protein or soy protein isolates.

Protein increased in all treatments. The T_6S obtained the maximum content of 14.6 and the T_0 obtained the minimum of 0.2. The storage period does not influence protein content. However, the treatment combination influences the protein content. In the present investigation, a significant increase in protein vs control was observed in different variants of protein enriched Papaya RTS. The different treatment combinations do not influence the β-carotene. There was no significant effect on β-carotene observed in different treatment combinations and same result was obtained in ascorbic acid content of control and protein enriched Papaya RTS.

CONCLUSION

Based on the findings of this study, it can be concluded that the Papaya RTS enriched with 5% milk protein isolate and 10% soy protein isolate received the highest level of acceptance among all treatments. Further, the nutrient analysis revealed that the developed Papaya RTS enriched with milk and soy protein was superior in terms of nutritional quality than the Papaya RTS alone. The developed protein enriched Papaya RTS is mostly liked and preferred by the consumers of all age groups.

ACKNOWLEDGEMENT

Authors are grateful to Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India for all the financial support and rendering the technical facility to undergo this University Research project.

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Received on 9/8/2024 Accepted on 23/10/2024

J Krishi Vigyan 2024, 12(4) : 872-877
DOI : 10.5958/2349-4433.2024.00150.3
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Management of Collar Rot in Groundnut in Coastal Sandy Soils of Andhra Pradesh

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ABSTRACT

This study investigated the efficacy of Integrated Disease Management (IDM) compared to Farmer's Practices (FP) for controlling collar rot disease in groundnut cultivated on coastal sandy soils in the Sri Potti Sriramulu Nellore district of Andhra Pradesh, India. A survey in the *rabi* season (2019-2020) revealed significant variation in disease incidence across locations, with factors like previous crop and seed treatment influencing severity. Seed treatment with carbendazim or mancozeb significantly reduced disease compared to untreated plots. Locations with watermelon as the previous crop and those lacking organic amendments like FYM exhibited higher disease incidence. A field experiment evaluated IDM practices consisting of seed and seedling protection with fungicide (Tebuconazole @ 1g/Kg), soil application of biocontrol agent (FYM enriched with *Trcihoderma asperellum*) and need based *in situ* fungicidal application (hexaconazole @ 2ml/L) and farmer's practices treatments on disease incidence at 10, 20, and 30 days after sowing (DAS). IDM consistently resulted lower disease incidence at all stages compared to FP. At 10 DAS, IDM showed a 2.46% disease incidence compared to 10.04% for FP ($p < 0.05$). This trend continued at 20 DAS (5.87% vs 17.64%, $p < 0.05$) and 30 DAS (6.64% vs 24.35%, $p < 0.05$). These findings suggested that IDM practices effectively suppress collar rot development, possibly through a combination of cultural, chemical, and biological control measures.

Key Words: *Aspergillus niger*, Coastal sandy soils, Collar rot, Groundnut, Management.

INTRODUCTION

The groundnut (*Arachis hypogaea* L.) production in India faces a decline due to various biotic and abiotic stresses. Among biotic stresses, fungal, bacterial, and viral diseases significantly impact yield. Soil borne fungal diseases are particularly noteworthy, posing a major threat with the potential for substantial yield losses. Collar rot disease caused by the omnipresent and highly destructive fungus *Aspergillus niger* van Teighem (Vimal Kumar and Saifulla, 2017), this soilborne and seedborne disease is prevalent in almost all groundnut-growing regions globally. Studies have reported alarmingly high disease incidence of 28-50% in Maharashtra (Dighule *et al*, 2018).

Groundnut, is also a significant commercial crop in Andhra Pradesh, thrives across diverse soil types, primarily in red soils. However, some locations in the state's coastal regions, particularly in SPS Nellore, Prakasam, Guntur, and Krishna districts, have seen groundnut cultivation expand into coastal sandy soils (Mohan *et al,* 2018). These coastal sandy soils, prevalent along the coastline, are characterized by several challenges for sustainable agriculture. They are known for their light texture, low nutrient content, limited water holding capacity, and reduced biological activity. Furthermore, they often exhibit low cation exchange capacity (CEC), deficiencies in essential micronutrients like zinc and boron, and generally low fertility, making them unsuitable for most crops. Despite these unfavorable conditions, farmers in these regions have developed unique local practices to cultivate groundnut and sustain their livelihoods. In the Vidavaluru and TP Gudur

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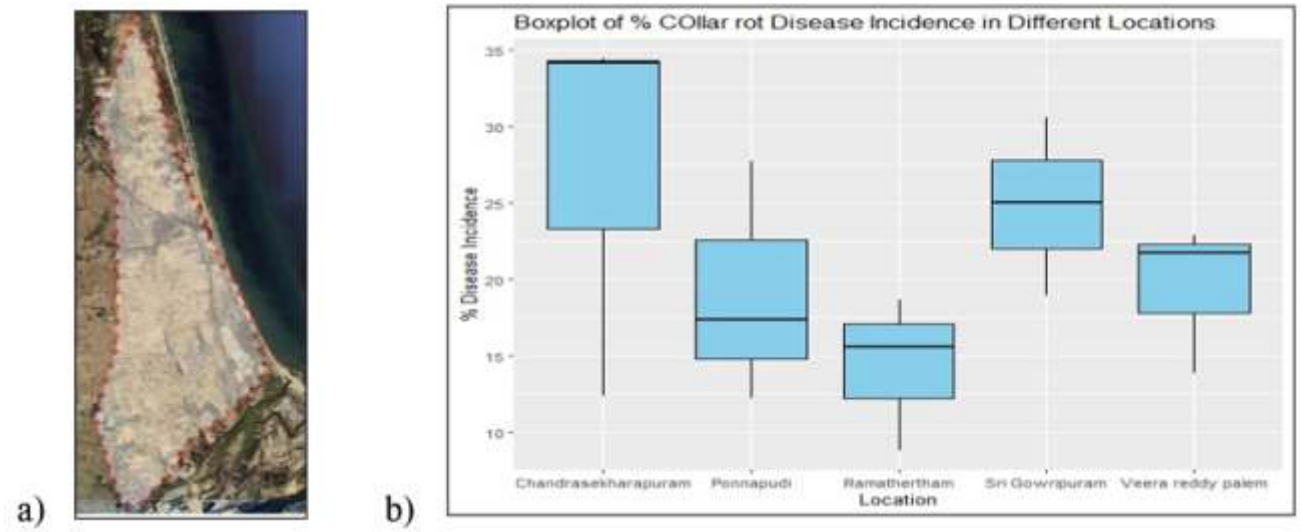

Fig 1: a) Geographical area showing groundnut cultivation in Coastalareas of SPSR Nellore district, AP
b) Boxplot showing collar rot disease incidence surveyed areas

Fig 2: Collar rot symptoms observed in the field

mandals of SPSR Nellore district, a specific case study exists. This area, encompassing ten settlements spread across three revenue villages, has witnessed intensive monoculture of groundnut covering roughly 1618.74 hectares for the past three decades. Notably, groundnut cultivation serves as the sole source of income for all farmers in this region. During past years (2015-17), there was an incremental increase in disease occurrence of collar rot in this region. Therefore, experiment in this area in collaboration between KVK researchers and farmers were taken up to develop location-specific interventions and technologies that can benefit not only this specific ecosystem but also similar coastal sandy soils where groundnut cultivation is prevalent.

MATERIALS AND METHODS

A survey was conducted in 15 random locations of Vidavalur and TP Gudur mandals of SPSR Nellore district of Andhra Pradesh during *rabi* 2019-20 (Fig 1). During the survey the essentially percent disease incidence was calculated along with other parameters presented in Table 1. Micronutrient status of surveyed locations was collected from Soil Health Cards

(SHCs) provided to respective farmers by State Department of Agriculture, Andhra Pradesh. The per cent disease incidence in these areas was calculated using the following formula (5 random locations in each field in one sq metre area)

A management trial with two treatments were analysed in 10 locations in farmer's fields (0.25 ha each) on susceptible groundnut variety TAG-24. The management module (IDM) consisted of seed treatment with tebuconazole 5.36 % w/w FS @ 1 g /kg of seed, *Trcihoderma asperellum* (Regional Agricultural research Station (ANGRAU), Tirupati) application @ 2kg with 90 kg FYM and 8 kg Neem cake before sowing and need based soil drenching with hexaconozole 5% SC @ 2 ml/L was evaluated against the farmers' practice. Farmers' practice consisted of either no fungicidal treatment or treatment with mancozeb 75% WP @ 2.5g/kg seed was considered as another treatment. The observations on disease incidence were recorded 10, 20 and 30 days after sowing, while pod yield recorded at 10 days after harvest.

RESULTS AND DISCUSSION

The survey data on collar rot disease incidence in groundnut during the *rabi* season of 2019-20 revealed significant variation in disease incidence percentages. During early stages of crop growth, the main symptoms of infected seeds were black masses of spores covering the seeds with soft, watery internal tissues (seedling blight) or brown, circular spots appearing on the young seedling's cotyledons (crown rot). Discolored spots on the stem at the collar region were observed in subsequent stages. The affected area on the stem becomes soft and rotten leading to wilting and death of the plants (Fig 2). Chandrasekharapuram recorded the highest disease incidence at 34.20%, and Ramathertham exhibited relatively lower disease incidences of 8.81% and 15.61%. The results revealed seed treatment with fungicide carbendazim and mancozeb resulted in a disease lower disease incidence of 15.61% and 18.98% respectively, which was significantly lower compared to the untreated plots (Table 1, Fig1b) overall with an exception at one location (Ramatheerthm, 8.81%). The variety TAG-24 was consistently used across all locations, and despite similar varietal choices, disease incidence varied. This indicates that other factors, such as soil health and management practices, might have contributed to disease development. The deficit micro-nutrient status was reported in all locations obtained from soil health cards, suggesting higher collar rot disease incidence. FarmYard Manure (FYM) application in some locations associated with relatively less disease incidence indicating possible disease suppression by beneficial microbial activity. Thus, the survey data suggested that collar rot disease incidence is influenced by a combination of factors, including seed treatment, previous crop, micro-nutrient status, and organic amendments emphasizing the importance of diversified and sustainable agricultural practices.

This study also investigated the efficacy of Integrated Disease Management (IDM) compared to Farmer's Practice (FP) in controlling collar rot disease in groundnut at different growth stages. The mean percentage of collar rot disease incidence in IDM and FP treatments at different stages of groundnut growth is presented in the Table 2 (Fig 2). Notably, IDM consistently recorded lower disease incidence compared to FP at all stages. IDM showed 2.46% disease incidence, significantly lower than FP with 10.04% indicating a highly significant difference after 10 DAS. The same trend was observed after 10 days from initial observation (20 DAS) wherein IDM exhibited 5.87% disease incidence, while FP records a significantly higher collar rot incidence (17.64%) implying the substantial disparity (Pvalue <0.05). IDM maintained its effectiveness with 6.64% disease incidence, as compared to FP's 24.35% even after 30DAS (Pvalue<0.05). The findings affirm the superiority of IDM over FP in managing collar rot disease in groundnut. The consistent reduction in disease incidence across all observations demonstrated the efficacy of integrated disease management practices. The IDM treatments constituting a combination of cultural, chemical, and biological control measures, have demonstrated their ability to suppress the development of collar rot. Seed

Table 1: Survey data on collar rot disease incidence in Groundnut during*abi* 2019-20								
Sr.No.	Place	% Disease incidence	Days after sowing	Seed treatment	Previous crop	Variety	Micro-Nutrient status	Organic manure applied/Not
1	Ramathertham	8.81	10	No	Water melon	TAG-24	Deficit	FYM
2	Ramathertham	18.63	10	Yes (Carbendazim)	Water melon	TAG-24	Deficit	FYM
3	Ramathertham	15.61	15	Yes (Carbendazim)	Groundnut	TAG-24	Deficit	FYM
4	Veera reddy palem	22.90	15	No	Groundnut	TAG-24	Deficit	Not applied
5	Veera reddy palem	13.90	15	No	Groundnut	TAG-24	Deficit	FYM
6	Veera reddy palem	21.75	12	No	Groundnut	TAG-24	Deficit	Not applied
7	Sri Gowripuram	30.58	15	No	Groundnut	TAG-24	Deficit	Not applied
8	Sri Gowripuram	18.98	20	Yes (Mancozeb)	Groundnut	TAG-24	Deficit	FYM
9	Sri Gowripuram	25.02	20	No	Groundnut	TAG-24	Deficit	Not applied
10	Chandrasekharapuram	34.20	15	No	Groundnut	TAG-24	Deficit	Not applied
11	Chandrasekharapuram	12.39	10	No	Watermelon	TAG-24	Deficit	Not applied
12	Chandrasekharapuram	34.49	15	No	Groundnut	TAG-24	Deficit	Not applied
13	Ponnapudi	17.40	13	No	Watermelon	TAG-24	Deficit	FYM
14	Ponnapudi	27.75	10	No	Groundnut	TAG-24	Deficit	Not applied
15	Ponnapudi	12.22	8	No	Groundnut	TAG-24	Deficit	Not applied
Mean		20.97						
St. deviation		8.08						

Table 2. Collar rot incidence at different stages groundnut in IDM and Farmer's Practice

Sr.No.	Collar rot per cent disease incidence					
	10 DAS*		20 DAS		30 DAS	
	IDM	FP	IDM	FP	IDM	FP
1	1.93	10.32	6.24	14.79	6.30	24.63
2	2.68	8.77	6.47	12.63	6.54	18.22
3	2.11	14.23	7.89	25.13	8.20	25.70
4	2.82	7.00	5.10	10.65	6.11	17.89
5	2.91	12.57	4.73	22.01	5.11	29.27
6	1.57	9.10	3.92	13.44	4.01	22.00
7	2.29	5.88	5.63	19.76	8.21	24.15
8	2.84	13.45	7.25	24.71	8.64	30.17
9	2.33	7.32	6.01	24.05	7.00	29.11
10	3.10	11.79	5.45	9.23	6.30	22.33
Mean	2.46	10.04	5.87	17.64	6.64	24.35
St.error	0.70	1.70	1.08	2.48	1.20	2.09
P-value	<0.05		<0.05		<0.05	
t Stat	8.17		5.9		12.17	

*DAS-Days after Sowing

treatment and soil health management play crucial role for management of collar rot in intial stages of crop growth which was addressed through above treatments

In contrast, the higher disease incidence in FP suggested that traditional or conventional farming practices may be less effective in mitigating collar rot. Farmers who are relying solely on routine practices may benefit by adopting integrated disease management strategies to enhance crop health and yield. Fungus *Aspergillus niger* can devastate crops, especially during the vulnerable seedling stage. Studies have shown that seed treatment with fungicides can significantly reduce these losses. Kumari *et al* (2016) identified Companion (a combination of carbendazim and mancozeb) as the most effective fungicide, followed by carbendazim and vitavax. Nathawat *et al* (2014) identified tebuconazole and propiconazole as

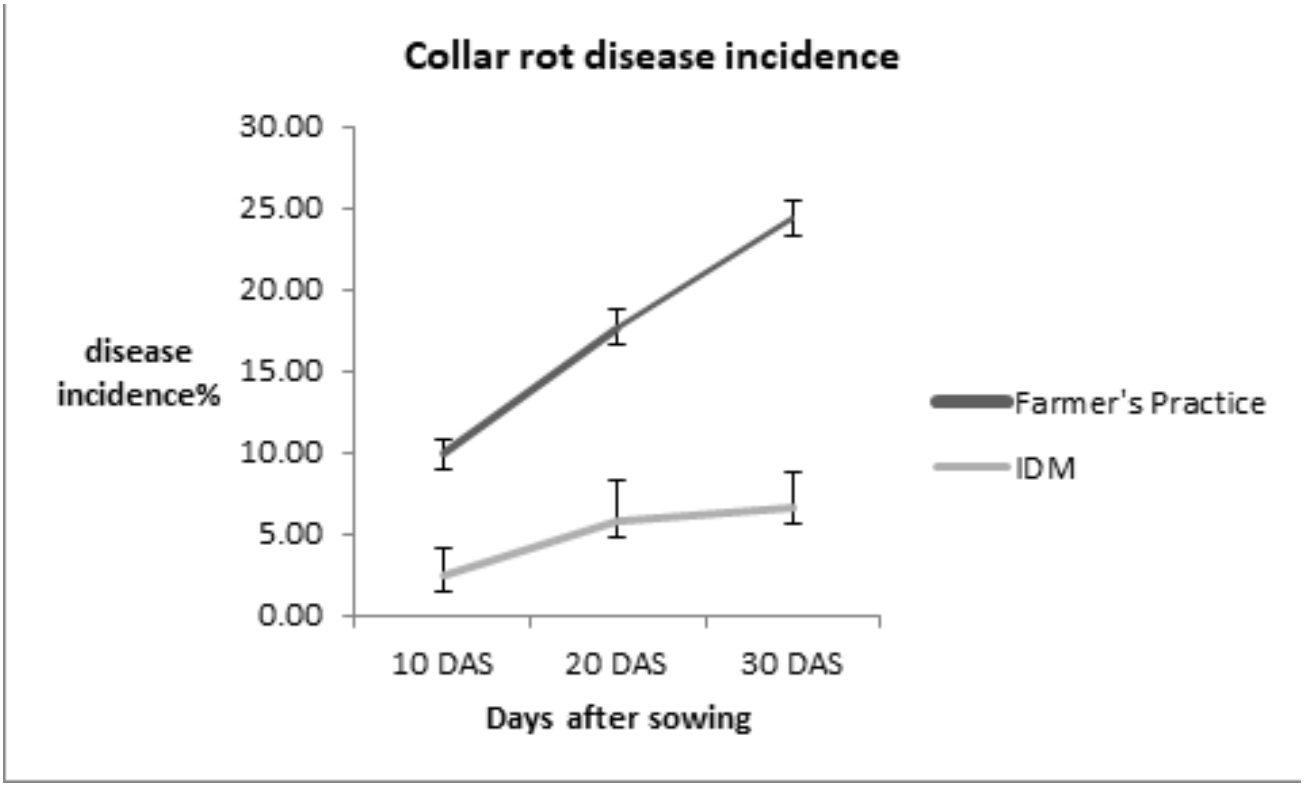

Fig 2: Graphical representation of collar rot incidence over 30days of sowing in two treatments

highly effective fungicides. Jadon *et al* (2015) evaluated ten fungicides against major soilborne diseases of groundnut. Their research found tebuconazole 2 DS @1.5 g/kg seed, mancozeb 75% WP @3 g/kg seed, and carbendazim 12% + mancozeb 63% WP @3 g/kg seed to be very effective in managing soilborne diseases, including collar rot. This finding corroborated with Kapadiya and Moradiya's (2017) work, where it was observed that seed treatment and two foliar sprays of tebuconazole were highly effective in controlling collar rot disease.

Charitha *et al* (2009) observed that *Trichoderma* species and *Pseudomonas fluorescens* displayed antifungal properties against *A. niger* in pot culture experiments. Furthermore, their study demonstrated that combining *T. viride* seed treatment with the fungicide Captan significantly reduced collar rot disease incidence in peanuts. Latha (2013) demonstrated the collar rot incidence was least (20.4%) in bioformulation mixture of Pf1 (*P fluorescens*)+ Tv1 (*T. viride*) + neem cake + FYM as against 60.0% in untreated control. The maximum pod yield was recorded in Pf1+Tv1+ Neem cake + FYM (1321kg ha) which was significantly high over the untreated control (933 kg ha). This suggests that IDM practices are more effective in enhancing crop productivity. IDM's higher BC Ratio also suggests that it provided a better return on investment compared to FP (Table 3).

CONCLUSION

This research investigated factors such as micronutrient deficiencies, non-fungicidal seed treatment, monoculture are contributing collar rot disease incidence in groundnut, a major problem for groundnut cultivation in sandy soils of SPSR Nellore district. The study also revealed the importance of IDM through seed treatment with fungicide and soil enrichment with bio control agents and organic matter in reducing collar rot disease incidence in early stages of groundnut cultivation. Other potential cultural practices such as crop rotation, incorporation of green manure crops, organic amendments *etc* needs to be explored further to improve soil health against collar rot for sustainable yields.

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Received on 9/10/2024 Accepted on 10/11/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 878-887

DOI : 10.5958/2349-4433.2024.00151.X

Mapping the Growth Trajectory of Indian Dairy Exports and Imports

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ABSTRACT

Indian dairy industry is one of the largest and fast growing industries which contribute significantly to the national economy. The global dairy market has undergone significant structural changes in recent times, particularly concerning milk production. But even though India is the world's largest milk producer, it only managed to capture one per cent of global dairy trade. Under this backdrop, the study was undertaken with the objectives to determine the growth of export/import of dairy products from 2001-2022 and calculate competitiveness of India's dairy products in the world market. The study is based on secondary data. The structural change in import and export of Indian dairy products was examined by Chow test and for direction of trade Gauss Markov Chain analysis was applied. The results of study showed that there was structural change in import/export of Indian dairy products in year 2013. After that data have witnessed a remarkable growth in export of dairy products and decline in import as a consequence of Intensive Dairy Development Programme initiated by Government of India. The result of direction of trade showed Bangladesh, Egypt and other countries are the loyal importers and USA, New Zealand and other countries are the loyal exporters of Indian dairy products throughout the study period. Study recommends that to enhance the production and global trade of dairy products, additional efforts should be directed towards the implementation of dairy development programs.

KEY WORDS: Chow test, Dairy products, Export, Gauss Markov analysis, Import.

INTRODUCTION

The global dairy market has experienced substantial structural transformations, over the past two decades with milk production witnessing an annual average compound growth rate of nearly 2 per cent. The majority of global milk production, exceeding fifty per cent, is generated in developing nations. (Ohlan R, 2012). Dairy product demand has increased along with production in many developing nations and oil-exporting nations due to their rapid economic growth. Furthermore, the rise in population, growing urbanization, and the adoption of western dietary preferences has also contributed to an increased demand. In addition, as dairying provides the majority of the rural poor with their primary source of food and income, it is crucial for food security in many developing nations, including India (FAO, 2011).

Milk production is an integral component of Indian agriculture supporting the livelihood of more than two-thirds of the rural population (Ohlan R, 2012). The dairy industry in India is the largest smallholder milk production system in the world (Chandel *et al,* 2020). The level of milk production per household is notably limited, with 63 per cent of households producing 2.75 liters of milk per day or less. (Birthal, 2008). The industry has created new income avenues for rural households and serves as a crucial tool in combating poverty (Verma *et al,* 2007).

Trade of dairy products in India has experienced remarkable growth as India's Export of Dairy products was 67,572.99 MT to the world for worth Rs. 2,269.85 Crores during the year 2022-23. The Government of India's 1991 economic reforms led to a rise in the trading of

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dairy products. Following delicensing and deregulation, the Uruguay Round Agreement (URA) of the General Agreement on Tariffs and Trade (GATT) was signed by India, ushering in a new era for the dairy industry. The conventional dairy sector, once heavily regulated by government interventions, is now transitioning to a scenario characterized by widely acknowledged trade barriers, restrictions on export subsidies, and established minimum market access provisions. These developments are poised to drive the industry into new phases of growth. This is due to the gradual easing of international trade restrictions and regulations following the GATT negotiations, which led to the establishment of the World Trade Organization (WTO). India also became the net exporter of dairy products after 2000 (Kumar *et al*, 2011; Parida *et al*, 2019). The Middle East, South Asia, South East Asia, and USA are the major markets for India's dairy products (Parida *et al*, 2019). Furthermore, the environment in which the Indian dairy business operates may very well be rebuilt as a result of the combined consequences of the WTO commitments and macroeconomic reforms. The dairy industry is showing initial indications of shifts in trade patterns, marked by a redistribution of market share among key players in the global dairy market. However, the immediate effects of the Agreement on Agriculture, which advocates for liberalization in global trade, remain uncertain. In this context, the present study was conducted to examine the major markets, trade direction, and structural changes of Indian dairy products.

MATERIALS AND METHODS

The entire study and discussion has been made based on secondary data. The different journals and related websites especially APEDA website have been consulted in this regard. The information regarding the production and trade of dairy products in terms of value from 2001 to 2022 is sourced from the FAOSTAT database.

Analytical Tools

Chow test: In 1960, econometrician Gregory Chow formulated the Chow test to ascertain whether the actual coefficients in two linear regressions based on distinct datasets are equal (Karacor *et al,* 2013). In time series analysis, one of the most widely used applications of econometrics is to examine the presence of a structural break at a moment that can be considered known a priori (for example, a significant historical event like a war). In present study this test proposed to study the structure change over the period of time with respect to dairy export and import. Here the annual values of export/import were used to check the structural transformation for period 2001 to 2022 by using Chow test. For the calculation the study period were divided into two time period i.e., 2001 to 2013 and 2014-2022.

Gauss Markov Chain Analysis: To provide a comprehensive depiction of the trade direction, specifically the import/export practices of Indian dairy products, the Gauss Markov Chain model with first order has been employed, as described by Dent (1967) and Bansal and Singh (2020). Other features of its uses include those by Zimmermann and Heckelei (2012), Gohain *et al,* (2022), Chavan *et al,* (2023). Prediction of value is made by using Transitional Probability Matrix (Siddeshwar *et al,* 2017).

RESULTS AND DISCUSSION

India's dairy exports showed a very erratic pattern, mostly because of changes in domestic demand, international market pricing, and dairy production. Historically, India used to be a net importer of dairy products until the initiation of Operation Flood. The trend of imports persisted until 1993 when exports eventually surpassed imports. However, between 1993 and 1999 imports and exports continued to gain ground, and by 2000, India was turning a profit on its dairy products exports (Joshi, 2014). Its exports continued to increase almost consistently from US$ 39713 thousand in 2001 to US $575360 thousand in 2022.

Figure 1 revealed that balance of trade of dairy exports have increased from US $34852 thousand in 2001 to US $540751 in 2013. In 2009, trade volumes experienced a deceleration to $88,950 thousand, attributed to the global economic crisis in 2008. Subsequently, as income levels increased in metropolitan areas, there is a

Figure 1 Trade performance of Indian dairy products (2001-2022)

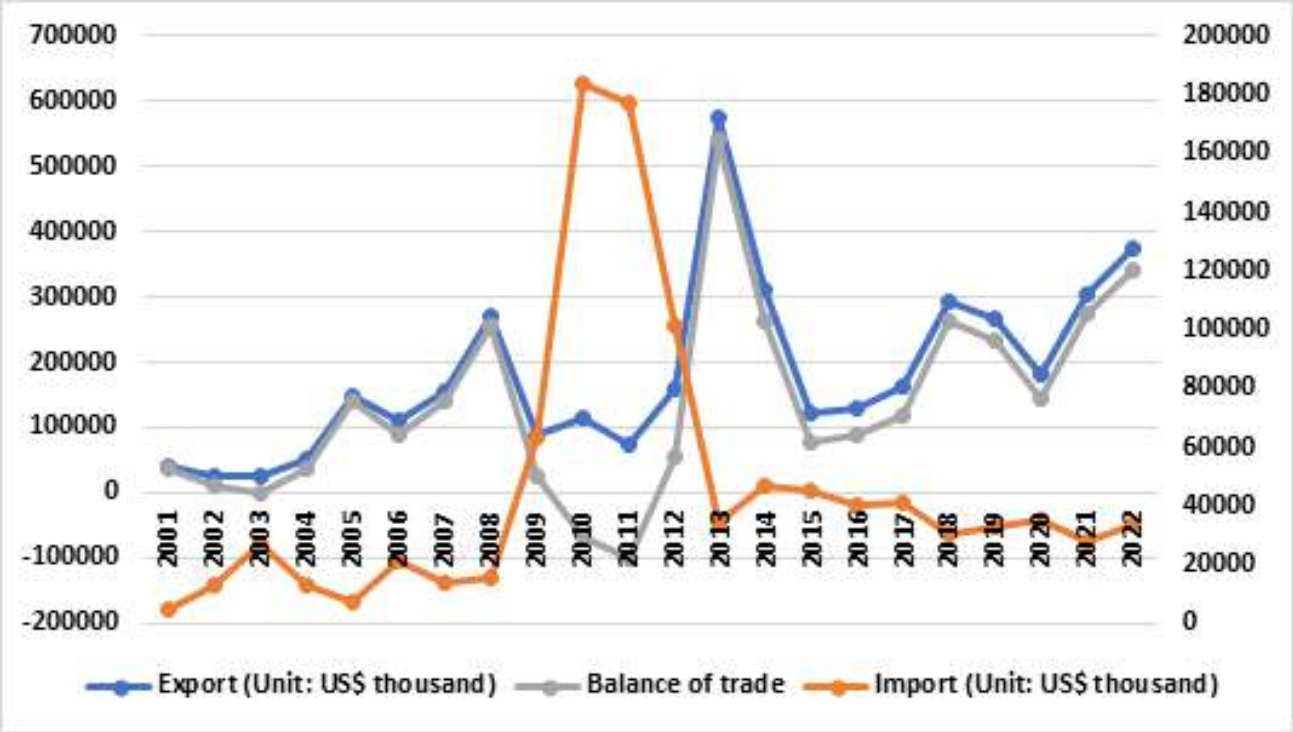

Table 1. Results of First Stage.

Particular	Export			Import		
Variables	Coefficient	t-statistics	P value	Coefficient	t-statistics	P value
Intercept	38451.88	0.795302	0.435775	35067.43	1.616819	0.121582
Time	12362.04	3.358143	0.003129	943.7888	0.571514	0.574019
R-squared	0.360555	SSR	2.4E+11	0.016069	SSR	4.83E+10

Table 2. Results of Second Stage.

Particular	Export			Import		
Variables	Coefficient	t-statistics	P value	Coefficient	t-statistics	P value
Intercept	-24710.7	-0.35102	0.732203	-18609.3	-0.61623	0.550284
Time	23700.59	2.672255	0.021706	10094.93	2.653278	0.022455
R-squared	0.393637	SSR	1.5748E+11	0.39024	SSR	2.9E+10

heightened demand for processed dairy products. Moreover, the liberalization of dairy trade policies has led to a significant upswing in export volumes (Ahmed *et al*, 2023).

Conversely, India has witnessed a rapid surge in dairy imports, escalating from US$ 4,861 thousand in 2001 to US$ 177,392 thousand in 2011, driven by the country's swiftly growing domestic demand. As a result, in the period of 2010–2011, India transitioned into a net importer of milk products (Figure 1). However, while its imports decreased, India's dairy exports increased significantly over the ensuing years. India once again emerged as a net exporter of dairy goods in 2022, with its dairy exports reaching US$374518 thousand as opposed to US$33636 thousand in imports. This could be attributed to the implementation of India's National Dairy Plan (NDP) by the Government of India. The NDP aims to improve an extensive dairy development

Table 3: Results of Third Stage.

Particular	Export			Import		
Variables	**Coefficient**	**t-statistics**	**P value**	**Coefficient**	**t-statistics**	**P value**
Intercept	154579.7	2.5254	0.039498	47424.56	16.93874	6.12E-07
Time	16595.68	1.525717	0.170912	-2072.8	-4.16616	0.004209
R-squared	0.249556	SSR	49692556725	0.712607	SSR	1.04E+08

initiative, create infrastructure for producing high-quality and sanitary milk products, and implement a program for fostering dairy entrepreneurship (Ohlan, 2016).

Structural Change in the growth of dairy export and import products

An economic model has been developed, and its variables include:

$$Y= b_0+b_1X+e$$

Y: Dairy export/import (US$ thousand) and X: Time (years)

First stage: The regression model for the export and import of Indian dairy products was formulated for the period 2001-2022.

Second stage: The development of the regression model for the export and import of Indian dairy products was undertaken for the period 2001-2013.

Third stage: The development of the regression model for the export and import of Indian dairy products was undertaken for the period 2013-2022.

Fourth stage: hypothesis

H_0: There is structural change in dairy export/import during study period

H_1: There is no structural change in dairy export/import during study period

Fifth stage: (a) Calculation of F test statistics of export of Indian dairy products

$$F=\frac{(2.4E+11-(1.5748E+11+49692556725))/2}{(1.5748E+11+49692556725)22-2(2)} \quad F=1.425$$

(b) Calculation of F test statistics of export of Indian dairy products

$$F=\frac{(48296356635-(28980439209+103966019.8))/2}{(28980439209+103966019.8)22-2(2)} \quad F=5.945$$

Sixth stage: (a) Decision of export of Indian dairy products

$F_{calculated}=1.425$, $F_{table}=0.051$, $F_{calculated} > F_{table}$

(b) Decision of export of Indian dairy products

$F_{calculated}=5.945$, $F_{table}=0.051$, $F_{calculated} > F_{table}$

Since the computed F-test value exceeded the critical F-test value, it indicates the rejection of the null hypothesis for both the export and import of dairy products. The outcome of the Chow test confirmed the existence of a structural change in dairy export/import patterns over time. Specifically, the structural change in 2013 exerted a positive impact on dairy export/import.

Loyalty within India's dairy export markets

The Markov chain model has been employed to quantify the structural changes in the trajectory of India's dairy exports. The figures representing retention per centages can be observed in the primary diagonal of the transitional probability matrix. How much of an import partner's market share from the previous year, it has kept this year, is known as its retention per centage. The diagonal elements in the Transitional Probability Matrix offer insights into the probability of trade ownership. On the contrary, components from the rest of the world delineate the potential risks of losses in trading due to competition from other countries. The elements presented in a column signify the likelihood of successful trade from competing nations.

As indicated (Table 4), other countries, as a collective entity, demonstrated stability as prominent importers of Indian dairy products, evidenced by a higher retention probability of

Table 4. Transitional probability matrix of Indian Dairy Products Exports (Unit: US$ thousand).

Country	Bangladesh	USA	Saudi Arabia	UAE	Egypt	Others
Bangladesh	**0.5147**	0.0000	0.0000	0.0000	0.0000	0.4853
USA	0.6294	**0.1149**	0.2557	0.0000	0.0000	0.0000
Saudi Arabia	0.8745	0.0000	**0.1255**	0.0000	0.0000	0.0000
UAE	0.0000	0.1673	0.0000	**0.1168**	0.1962	0.5198
Egypt	0.1357	0.0000	0.1185	0.0000	**0.3128**	0.4330
Others	0.0204	0.0004	0.0454	0.3003	0.0000	**0.6336**

Source: Author's computation based on data available from APEDA

0.6336 from the period 2009-10 to 2022-23. It indicated the probability that other countries combined retains its export share of 63.36 per cent. Similarly, it maintained its export share to Bangladesh at a rate of 51.47 per cent, while Egypt retained 31.28 per cent of its export share. USA, UAE and Saudi Arab had more or less same probability of retention i.e., 12 per cent with similarly defined. According to the ICFA (2020) report, the most important products that India exports are skim milk powder, casein, and ghee, followed by butter and whole milk powder. The majority of these exports are made to countries in the region that lack access to milk, such as Bangladesh, Pakistan, Afghanistan, Nepal, Bhutan, and the United Arab Emirates. Small amounts of casein are also exported by India to the US, Europe, and other nations.

The data clearly showed that Bangladesh, with a probability retention rate of 51.47 per cent, surpassed the United States, Saudi Arabia, Egypt, and the least amount of other nations in terms of share. Conversely, it only lost 48.53 per cent to other countries. In case of USA, with 11.49 per cent probability retention gained from UAE but lost to Bangladesh (62.94%), Saudi Arab (25.57 %). While Egypt stands as the third most loyal and stable market among the major importers of Indian dairy products, as indicated by a higher retention probability of 31.28 per cent, it experienced a loss of approximately 13.57 per cent to Egypt, 11.85 per cent to Saudi Arabia, and 43.30 per cent to other countries. But it gained only from UAE i.e. 19.62 per cent. In case of other counties, it gained share from UAE and Egypt but lost to Bangladesh, USA, Saudi Arab and UAE with small probability retention. It is astounding to see that all of the per centages added together from row to row equal 100%. This makes sense because whatever that is lost must also be retained. Conversely, the total of the per centages along a column need not equal 100. The reason for this is that those numbers represent per centages of market shares from many countries rather than the market share of a single nation from the prior year.

Projection of Dairy Products in India to major importing countries

A Transitional Probability Matrix was employed to compute the export share of Indian dairy products to various countries. Projections for the future market shares of Indian dairy products to the major importing countries were extended up to 2027-28. A detailed examination of the actual and projected per centages of dairy products exported from India to various nations during the course of the study period shows that the projected export shares, which came from the Markov Chain method, were inconsistence with the predicted share of exports.

As evident from Annexure 1 that the actual export to Bangladesh has increased from 13685 thousand US$ to 83209 thousand US$ between 2009-10 to 2022-23. Nevertheless, within the same period, the anticipated export share of Bangladesh witnessed an increase from 14.81 per cent to 25 per cent. The projected share of Indian dairy products to importing countries up to 2027-28 indicated a declining trend. But in case of USA, the actual value of export of dairy product had shown increasing trend from 2.16 per cent in 2009-10 to 6.75 per cent in 2022-23. But it expected value shown fluctuation over the years. The projected share of Indian dairy product was

Table 6: Projected exports of Indian dairy products to major importing countries: 2023-24 to 2027-28.

Country	Bangladesh	USA	Saudi Arabia	UAE	Egypt	Others
2023	77769 (20.77)	11127 (2.97)	14992 (4.00)	60759 (16.22)	15152 (4.05)	194719 (51.99)
2024	66166 (17.67)	11512 (3.07)	15364 (4.10)	65564 (17.51)	16659 (4.45)	199254 (53.20)
2025	61059 (16.30)	12361 (3.30)	15894 (4.24)	67486 (18.02)	18072 (4.83)	199645 (53.31)
2026	59629 (15.92)	12781 (3.41)	16363 (4.37)	67828 (18.11)	18892 (5.04)	199026 (53.14)
2027	59665 (15.93)	12886 (3.44)	16598 (4.43)	67682 (18.07)	19215 (5.13)	198472 (52.99)

Source: Author's computation based on data available from APEDA

more or less same during the projected period. Moreover, the result of Saudi Arab had shown an increasing trend till 2022-23. After that, the predicted future market share had suggested decreasing trend up to 2027-28 shown in Table 6. The actual share of UAE and Egypt has shown a decreasing trend from 19.22 to 13.84 per cent in UAE and 7.00 to 1.55 in Egypt during the study period. While the estimated predicted future value from 2023-24 to 2027-28 suggested an increasing trend from 16.22 to 18.07 per cent in UAE and 4.05 to 5.13 per cent in Egypt. Considering the rest of other countries both the actual and expected export value declined during the study period. While the estimation of future export market value of Indian dairy product from 2023-24 to 2027-28 has suggested an increasing trend.

Thus, Bangladesh, Egypt and other countries are the loyal importers of Indian dairy products throughout the study. But the future market share of dairy products showed encouragement of export of dairy products in UAE, USA, Saudi Arab. According to the research conducted by Ahmed et al. (2023), with improved domestic production and marketing efficiency, increased competitiveness, and enhanced access to the growing global market, India has the potential to boost its export of dairy products. Nevertheless, there is still considerable room for further advancements in market conditions.

Loyalty among India's dairy import markets

Policy modeling for the progression of a nation's exports should align with the swift shifts in global commodity markets. Consequently, it is important to properly document any changes that can aid in export promotion strategies. Even though it can be exceedingly challenging to pinpoint the nature and direction of changes, Markov chain analysis has employed a novel strategy that uses probability terms to provide a thorough unwinding of the charges.

The major countries for the study were New Zealand, France, Denmark, Italy, USA and remaining exporting countries were grouped as others. An examination of Table 7 indicates that during the study period, the USA remained the most robust market among the major importers of Indian dairy products, boasting a higher probability of retention at 0.69. This signifies a 69 per cent probability that the USA maintained its import share over the study period. The higher probability retention was estimated in New Zealand (64.54%), followed by Other countries (60.53%) and France (57.37%), respectively. Although Italy and Denmark had probability retention i.e. 47 per cent. It is evident from the results that New Zealand with 64.54 per cent probability retention gained share from Italy (29.95 %) and USA (31%). In contrast, it lost to other countries (27.59 %) and least proportion to Denmark, Italy and USA. In case of France, with 57.37 per cent probability retention gained 22.69 from Italy and 35.24 from other countries but lost

Table 7. Transitional probability matrix of Indian Dairy Products imports (Unit: US$ thousand).

Country	New Zealand	France	Denmark	Italy	USA	Others
New Zealand	**0.6454**	0.0000	0.0234	0.0228	0.0325	0.2759
France	0.0000	**0.5737**	0.0649	0.0780	0.0000	0.2834
Denmark	0.0000	0.0000	**0.4733**	0.0617	0.0000	0.4650
Italy	0.2995	0.2269	0.0000	**0.4736**	0.0000	0.0000
USA	0.3100	0.0000	0.0000	0.0000	**0.6900**	0.0000
Others	0.0000	0.3524	0.0277	0.0145	0.0000	**0.6053**

Source: Author's computation based on data available from APEDA

Table 9. Projected exports of Indian dairy product to major exporting countries: 2023-24 to 2027-28.

Country	New Zealand	France	Denmark	Italy	USA	Others
2023	1843 (5.48)	13139 (39.06)	2310 (6.87)	2712 (8.06)	128 (0.38)	13505 (40.15)
2024	2041 (6.07)	12912 (38.39)	2364 (7.03)	2690 (8.00)	148 (0.44)	13481 (40.08)
2025	2169 (6.45)	12769 (37.96)	2379 (7.07)	2669 (7.94)	169 (0.50)	13482 (40.08)
2026	2252 (6.69)	12682 (37.70)	2380 (7.07)	2652 (7.88)	187 (0.56)	13484 (40.09)
2027	2306 (6.85)	12629 (37.55)	2376 (7.06)	2639 (7.85)	202 (0.60)	13484 (40.09)

Source: Author's computation based on data available from APEDA

to Denmark (6.49%), Italy (7.80 %) and (28.34 %) from rest of other countries. Despite being recognized as the most loyal and stable market among the major exporters of Indian dairy products, with a higher retention probability of 69 per cent, the USA holds this distinction, it lost approximately 31 per cent to New Zealand and gained just 3.25 per cent from USA. In case of other counties, it gained more share from Denmark (46.50 %) followed by France (28.34%) and New Zealand (27.59%), respectively. But lost to France, Denmark and Italy.

As evident from Annexure 2 that the actual import to New Zealand has decreased from 37231 thousand US$ to 987 thousand US$ between 2009-10 to 2022-23. However, during the same period, the expected import share of Bangladesh had shown an decreased from 39.46 per cent to 4.54 per cent. The projected share of Indian dairy product to exporting countries up to 2027-28 had suggested increasing trend shown in Table 9. But in case of France,the actual value and expected of import of dairy product had shown increasing trend from 2.42 per cent to 39.80 per cent and 12.14 to 39.90 per cent, respectively from the period 2009-10 to2022-23. The projected share of Indian dairy product has suggested declining trend. Moreover, the result of Denmark had shown an increasing trend till 2022-23 for actual and expected value. But, the predicted future market share had suggested more or less same trend upto 2027-28. In case of Italy the actual and expected share had shown tremendous growth but its predicted value for the period of 2023-24 to 2027-28 a declining trend. In case of USA, the actual and expected import share had shown fluctuation over the study period. Considering the rest of other countries both the actual and expected export value increased during the study period. While the estimation of future export market value of Indian dairy product from 2023-24 to 2027-28 has suggested more or less same trend i.e., 40 percent.

Annexure 1. Actual and Expected share of Indian dairy products exports (Unit: US$ thousand)

Particular	Bangladesh		USA		Saudi Arabia		UAE		Egypt		Others		Total
	A	E	A	E	A	E	A	E	A	E	A	E	
2009	13685 (15.39)	13172 (14.81)	1925 (2.16)	3097 (3.48)	3574 (4.02)	3788 (4.26)	17093 (19.22)	15943 (17.92)	6224 (7.00)	5300 (5.96)	46449 (52.22)	47650 (53.37)	88950 (100.0)
2010	16884 (14.64)	15812 (13.71)	1673 (1.45)	3780 (3.28)	4376 (3.79)	4708 (4.08)	21309 (18.48)	21770 (18.88)	6877 (5.96)	6331 (5.49)	64214 (55.68)	62932 (54.57)	115333 (100.0)
2011	4533 (6.01)	8556 (11.34)	2493 (3.30)	3197 (4.24)	2717 (3.60)	3994 (5.29)	17318 (22.95)	13189 (17.48)	11198 (14.8)	6900 (9.15)	37187 (49.29)	39611 (52.50)	75446 (100.0)
2012	20712 (13.17)	26684 (16.96)	4091 (2.60)	4555 (2.90)	11208 (7.12)	7918 (5.03)	24244 (15.41)	27632 (17.56)	14469 (9.20)	9282 (5.90)	82596 (52.50)	81249 (51.65)	157320 (100.0)
2013	97589 (16.96)	104237 (18.12)	5007 (0.87)	8922 (1.55)	39009 (6.78)	29284 (5.09)	49232 (8.56)	98015 (17.04)	77247 (13.4)	33822 (5.88)	307276 (53.41)	301079 (52.33)	575360 (100.0)
2014	76576 (24.58)	48853 (15.68)	2755 (0.88)	6702 (2.15)	3514 (1.13)	10286 (3.30)	37772 (12.12)	59814 (19.20)	6430 (2.06)	9421 (3.02)	184511 (59.22)	176482 (56.64)	311558 (100.0)
2015	19205 (15.82)	16386 (13.49)	2605 (2.15)	5157 (4.25)	4004 (3.30)	4198 (3.46)	28900 (23.80)	23408 (19.28)	0 (0.0)	5669 (4.67)	66716 (54.94)	66612 (54.86)	121430 (100.0)
2016	17405 (13.34)	15872 (12.16)	2807 (2.15)	5064 (3.88)	4065 (3.11)	4772 (3.66)	28179 (21.59)	26729 (20.48)	0 (0.0)	5528 (4.24)	78058 (59.81)	72549 (55.59)	130514 (100.0)
2017	11056 (6.85)	17869 (11.07)	6268 (3.88)	6266 (3.88)	4744 (2.94)	8241 (5.11)	32962 (20.43)	30785 (19.08)	16620 (10.3)	11665 (7.23)	89705 (55.59)	86529 (53.63)	161355 (100.0)
2018	32314 (11.07)	43507 (14.91)	14386 (4.93)	8999 (3.08)	10023 (3.43)	16897 (5.79)	43604 (14.94)	49172 (16.85)	44677 (15.3)	22529 (7.72)	146800 (50.31)	150700 (51.64)	291804 (100.0)
2019	10831 (4.08)	33746 (12.72)	13557 (5.11)	7803 (2.94)	15361 (5.79)	15450 (5.83)	36976 (13.94)	54760 (20.65)	20480 (7.72)	13660 (5.15)	167990 (63.35)	139776 (52.71)	265195 (100.0)
2020	11953 (6.66)	33218 (18.50)	23715 (13.2)	8959 (4.99)	11272 (6.28)	12029 (6.70)	37079 (20.65)	32152 (17.91)	2891 (1.61)	8178 (4.55)	92658 (51.60)	85031 (47.35)	179568 (100.0)
2021	71500 (23.67)	67115 (22.22)	15072 (4.99)	11068 (3.66)	20233 (6.70)	12921 (4.28)	55522 (18.38)	47704 (15.79)	2477 (0.82)	11666 (3.86)	137277 (45.44)	151608 (50.19)	302081 (100.0)
2022	83209 (22.22)	93617 (25.00)	25266 (6.75)	11633 (3.11)	34952 (9.33)	19412 (5.18)	51818 (13.84)	58141 (15.52)	5796 (1.55)	11978 (3.20)	173477 (46.32)	179737 (47.99)	374518 (100.0)

CONCLUSION

In the study an attempt has been made to calculate the growth, structural change and direction of trade of export and import of dairy product from India. Throughout the study period, there was a notable decline in the import of dairy products, coupled with a substantial increase in exports. In 2022, India transitioned into a net exporter of dairy products, with dairy exports totaling US$374,518 thousand, while imports stood at US$33,636 thousand. Moreover the result of Chow test showed that there was structural change in import and export of Indian dairy products in year 2013. It might due to the introduction of India's National Dairy Plan (NDP) by Government of India. Hence, the research suggests that to boost the production and international trade of dairy products, it is advisable to focus additional efforts on the execution of dairy development programs.The result of direction of trade showed Bangladesh, Egypt and other countries are the loyal importers and USA, New Zealand and other countries are the loyal exporters of Indian dairy products throughout the study.

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Annexure 2. Actual and Expected share of Indian dairy products imports (Unit: US$ thousand)

Particular	New Zealand		France		Denmark		Italy		USA		Others		Total
	A	E	A	E	A	E	A	E	A	E	A	E	
2009	37231 (58.73)	25014 (39.46)	1532 (2.42)	7700 (12.14)	2598 (4.10)	2722 (4.29)	807 (1.27)	1782 (2.81)	2397 (3.78)	2865 (4.52)	18833 (29.71)	23315 (36.78)	63398 (100.0)
2010	120485 (65.56)	79009 (42.99)	3567 (1.94)	20854 (11.35)	3517 (1.91)	6158 (3.35)	1927 (1.05)	4906 (2.67)	2158 (1.17)	5408 (2.94)	52123 (28.36)	67441 (36.70)	183777 (100.0)
2011	53147 (29.96)	37338 (21.05)	18960 (10.69)	44293 (24.97)	3572 (2.01)	6708 (3.78)	4743 (2.67)	6486 (3.66)	5212 (2.94)	5325 (3.00)	91758 (51.73)	77242 (43.54)	177392 (100.0)
2012	35345 (34.91)	24410 (24.11)	31135 (30.75)	27468 (27.13)	3828 (3.78)	5372 (5.31)	2433 (2.40)	4995 (4.93)	2804 (2.77)	3085 (3.05)	25693 (25.38)	35908 (35.47)	101238 (100.0)
2013	6081 (17.57)	6235 (18.02)	6731 (19.45)	8414 (24.31)	2782 (8.04)	2214 (6.40)	2224 (6.43)	2055 (5.94)	5305 (15.3)	3859 (11.1)	11486 (33.19)	11832 (34.19)	34609 (100.0)
2014	7459 (15.83)	7280 (15.45)	10580 (22.45)	13199 (28.01)	2600 (5.52)	2603 (5.52)	2798 (5.94)	2748 (5.83)	5252 (11.1)	3867 (8.21)	18428 (39.11)	17420 (36.97)	47117 (100.0)
2015	11099 (24.63)	7831 (17.38)	13020 (28.90)	13071 (29.01)	4227 (9.38)	3507 (7.78)	2198 (4.88)	2780 (6.17)	30 (0.07)	382 (0.85)	14480 (32.14)	17483 (38.80)	45054 (100.0)
2016	7029 (17.38)	5252 (12.99)	13011 (32.18)	12905 (31.92)	4057 (10.0)	3316 (8.20)	2307 (5.71)	2720 (6.73)	78 (0.19)	282 (0.70)	13953 (34.51)	15959 (39.47)	40435 (100.0)
2017	2953 (7.15)	2741 (6.64)	8787 (21.28)	13912 (33.69)	3385 (8.20)	2890 (7.00)	2780 (6.73)	2617 (6.34)	7 (0.02)	101 (0.24)	23381 (56.62)	19032 (46.09)	41293 (100.0)
2018	121 (0.40)	1146 (3.81)	10132 (33.69)	11572 (38.48)	2107 (7.01)	2050 (6.82)	3398 (11.30)	2738 (9.10)	163 (0.54)	116 (0.39)	14156 (47.07)	12453 (41.41)	30077 (100.0)
2019	1248 (3.81)	1797 (5.48)	12617 (38.48)	12754 (38.90)	2037 (6.21)	2189 (6.68)	3223 (9.83)	2862 (8.73)	85 (0.26)	99 (0.30)	13577 (41.41)	13085 (39.91)	32787 (100.0)
2020	3402 (9.63)	2645 (7.48)	16308 (46.14)	14410 (40.77)	746 (2.11)	1863 (5.27)	1480 (4.19)	2291 (6.48)	20 (0.06)	124 (0.35)	13388 (37.88)	14011 (39.64)	35344 (100.0)
2021	807 (2.90)	898 (3.23)	11335 (40.77)	11345 (40.81)	1465 (5.27)	1807 (6.50)	1248 (4.49)	1772 (6.37)	10 (0.04)	33 (0.12)	12937 (46.53)	11947 (42.97)	27802 (100.0)
2022	987 (2.93)	1528 (4.54)	13386 (39.80)	13421 (39.90)	1838 (5.46)	2163 (6.43)	2855 (8.49)	2742 (8.15)	117 (0.35)	113 (0.34)	14453 (42.97)	13669 (40.64)	33636 (100.0)

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Received on 26/10/2024 Accepted on 18/11/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 888-895

DOI : 10.5958/2349-4433.2024.00152.6

Microbial Population and Soil Enzymatic Activities under Long Term Rice-Fallow and Uncultivated Soils of Nalbari District, Assam, India.

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ABSTRACT

Microorganisms in soils and their enzymatic activities play a critical role in maintaining soil fertility and sustaining crop productivity by nutrient transformation and organic matter decomposition. The present investigation was carried out to assess the effect of long term continuous cultivation of rice on microbial population and soil enzymatic activities that was compared with adjacent uncultivated soils. For this Geo-referenced (N:26^{0}31.882'to26^{0}18.224'and E:091^{0}30.536'to091^{0}15.750') soil samples (0-15cm depth) were collected after harvest of rice from rice-fallow system and adjacent uncultivated sites.A total of 120 numbers of soil samples were collected and microbial counts of general bacteria, fungi, *Azotobacter, Azospirillum,* Phosphate solubilizing bacteria (PSB) and soil enzymatic activities viz. Dehydrogenase (DHA), Fluroscence diacetate hydrolases (FDA), Phosphomonoesterase (PME) and Arylsulphatase (ARYL) were determined following standard procedures.The results revealed that population of bacteria (6.49 $\log_{10}$cfu g^{-1}), *Azotobacter* (3.77$\log_{10}$cfu g^{-1}), *Azospirillum* (3.75$\log_{10}$cfu g^{-1}), Phosphate solubilizing bacteria (3.71$\log_{10}$cfu g^{-1}), registered higher in rice-fallow cultivated soils compared to adjacent uncultivated soils (bacteria-6.36 $\log_{10}$cfu g^{-1}, *Azotobacter*-3.62 $\log_{10}$cfu g^{-1},*Azospirillum*-3.54 $\log_{10}$cfu g^{-1}, PSB- 3.69 $\log_{10}$cfu g^{-1}and differed significantly ($p<0.05$),whereas the population of fungi was found more in uncultivated (5.38$\log_{10}$cfu g^{-1}) soils compared to rice cultivated soils (5.30 $\log_{10}$cfu g^{-1}).The soil enzymatic activities viz. DHA , FDA, PME and ARYL were recorded significantly ($p<0.05$) higher in rice - fallow soils (DHA-79.01µg TPF g^{-1} 24 h^{-1}, FDA-12.16µg fluorescein g^{-1} h^{-1}, PME-114.06µg *p*-nitro phenol g^{-1} h^{-1}, ARYL-21.43 µg *p* -nitrophenol g^{-1} h^{-1}) as compared to uncultivated soils (DHA-66.26µg TPF g^{-1} 24 h^{-1}, FDA-9.49 µg fluorescein g^{-1} h^{-1}, PME-92.14µg *p*-nitro phenol g^{-1} h^{-1}, ARYL-15.72µg *p*-nitrophenol g^{-1} h^{-1}). The results indicated that continuous cultivation of rice crop followed by a fallow period enhanced the biological properties of soils including microbial population count and enzymatic activities in soils.

Key Words: Microorganisms, Population, Rice- fallow, Soil enzymes, Uncultivated

INTRODUCTION

Beneficial soil microbes are essential and integral component of soil, directly related to soil fertility and plant growth. Soil microorganisms play pivotal role by performing various functions in soils that includes mineralization of organic matter, nitrogen fixation, phosphorous availability, disease control, degradation of pesticides. Microorganisms play a crucial part in soil nutrient cycling by decomposing the organic material into plant-available elements, maintenance of soil structure, degradation of agrochemicals and pollutants, and plant pest control and maintain the soil health (Kuht *et al*, 2022: Stockdale and Brookes, 2006), hence it has often been indicated as an important component of soil fertility (Nogueira *et al*, 2006).

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Soil enzyme is a kind of biologically active protein and enzymes having catalytic ability released by soil microorganisms, and closely related to the organic matter content in soil and play a key role in decomposing organic matter, nutrients availability to plants hence important in Agriculture (Rao *et al,* 2017). Although enzymes are primarily of microbial origin, it can also be originated from plants and animals in soil. Enzymes catalyses all biochemical reactions and are integral part of nutrient cycling in soil (Nivitha and Vimalan, 2022) and these are sensitive indicators of soil ecological stress or other environmental changes (Marinari *et al*, 2006).Soil enzymatic activities are the potential indicator of soil quality that responds to management and environmental induced changes (Mohammadi, 2011). Both activities of soil enzyme and diversity of microbial community depend on land use patterns. Therefore, investigating soil physical, chemical, and biological properties under diverse land use patterns is vital to conserve and rejuvenate the soil's ability to provide ecological services (Van Leeuwen *et al*, 2017).

Nalbari district is one of the agriculturally important district of Assam lies between 26^0 N Latitude and 91^0 E Longitude with mean elevation 89 m above msl and about 80% of the population directly or indirectly dependent on agriculture and allied activities. Though the district comprises 2.6% of state's geographical area, it contributes 5.46% and 4.96% of the state's net and gross cropped area, respectively. Rice is the major crop covering an area of 65 thousand hectare and rice based cropping systems are predominantly practiced by the farmers in the district and majority of the area comes under rice -fallow system. The present study was undertaken with an objective to assess the impact of long term continuous cultivation of rice crop under rice –fallow system on soil microbial population and enzymatic activities in soils comparing with adjacent uncultivated soils.

MATERIALS AND METHODS

Geo-referenced (N: $26^0$31.882 ' to $26^0$18.224' and E: $091^0$30.536' to $091^0$15.750') soil samples (0-15cm) from rice -fallow cultivated soils were collected after harvest of rice crop during the year 2015-16. For comparison, the soil samples from adjacent uncultivated sites were also collected. The representativeness and uniformity of the fields were taken into consideration while collecting the soil samples. The sampling is focused on the plough layer because; this is where most soil quality changes are expected to occur due to long -term land use and soil management practices. All total 120 soil samples, 60 from cultivated rice-fallow and 60 from adjacent uncultivated soils, were collected covering 23 villages of the district. At the time of collection of soil samples, the crop history including management practices was recorded from respective farmer. The soil samples were mixed uniformly, kept in zipped poly pouches with proper labelling and store at 4^0C for analysis of biological parameters.

Enumeration of microbial population

The classical serial dilution technique was used for enumeration of bacteria, fungi, *Azotobacter*, *Azospirillum* and phosphate solubilizing bacteria (PSB) from the soil by spread plate technique on appropriate media. Nutrient agar (NA) and Martin Rose Bengal (MRB) media were used for enumeration of bacteria and fungi respectively. The soil sample of 1 g was suspended in 9 ml water blank followed by serial dilution up to 10^{-5}. Aliquot of 10 µl from 10^{-3}, 10^{-4} and 10^{-5} dilution were spread over solidified media in triplicates and plates were incubated at 30 ± 1^0C for bacteria and fungi population.

For enumeration of *Azotobacter*, *Azospirillum* and PSB the media used were that of Burk's, nitrogen free bromothymol blue (NFb) and Pikovskaya's media respectively. 100 µl aliquot of 10^{-4} and 10^{-5} dilutions were spread over the solidified media in triplicates and plates were incubated at 30 ± 1^0C for *Azotobacter* and PSB while NFb plates were incubated at 35 ± 1^0C for 3-5 days. The microbial numbers were estimated as colony forming unit per gram(cfu g^{-1}) soil on dry weight basis and transformed to $\log_{10}$cfu g^{-1}.

Dehydrogenase activity (DHA)

Dehydrogenase activity (DHA) was determined by the reduction of triphenyl tetrazolium chloride (TTC) to triphenyl formazan

(TPF) as described by Casida*et al* (1964) with modifications. Moist soil (10 g) was treated with 10 ml of 3% TTC, and then incubated at 32^{0}C for 7 days in screw cap test tube (30 ml). After incubation period, the soil was extracted by addition of 10 ml of extractant (methanol) following incubation in dark and agitated for 1 h. The mixture was then filtered using Whatman No.42 filter paper. After the filtration, 1 ml of filtrate was transferred to 1.5 ml micro centrifuge tube and centrifuged at 5000 rpm for 5 min. Absorbance of the supernatant was measured in Nanodrop 1000 spectrophotometer at OD_{485nm}. To account for any abiotic TTC reductions, sterile controls consisted of autoclaved soil (121^{0}C, 20 min. for three consecutive days) to which 10 mL of TTC was added. Spectrophotometer blanks consisted of 10 g soil and TTC replaced with 10 mL Millipore water. Except for the addition of Millipore water in blank and autoclaving in control, they were treated like samples for the rest of the procedure. A calibration curve was constructed by determining OD_{485nm} values for the working standard of TPF (20, 40, 80, 120, 200, 300 and 500 µ ml^{-1}). The OD_{485nm} values was compared to that of TPF standards. DH activities was expressed on dry weight as µg TPF g^{-1}24 h^{-1} on dry weight basis as

$$\text{DH activity } (\mu g \text{ TPF } g^{-1} 24\ h^{-1}) = \frac{[(TPFs) - (TPFc)] \times 20}{edw}$$

Where, TPFs = TPF conc. (µg ml^{-1}) in the sample; TPFc = TPF conc. (µg ml^{-1}) in the sterile control; edw is the equivalent dry weight of 1 gm soil; 20 is the volume of solution added in the assay (TTC + Extractant). All samples were replicated three times.

Phosphomonoesterase activity (PME)

Phosphomonoesterase (PME) activity involves the use of an artificial substrate, *p*-nitrophenyl phosphate (*p*-NPP). The product of PME activity, *p*-nitrophenyl, is a yellow chromophore under alkaline conditions and can be detected colorimetrically. The method of Tabatabai and Bremner (1969) was followed to estimate the PME activity. Moist soil (5 g) was taken in 30 ml screw cap test tubes and 10 ml modified universal buffer (pH 6.5), 0.25 ml toluene and 1 ml of *p*-NPP (115 mM) solution were added to it. After properly mixing and vortexing for 30 seconds, the samples were incubated at 37^{0}C for 1 hour. At the end of the incubation, 1 ml $CaCl_2$ (0.5M) and 4 ml of NaOH (0.5M) were added and mixed again for 5 min. in a vortex mixture, and allowed to settle for 5 min. 1 ml of the mixture was taken in a 1.5 ml of microcentrifuge tube, and the soils were removed by centrifugation at 5000 rpm for 5 min. The absorbance of the supernatant was determined at OD_{400nm} using Nanodrop 1000 spectrophotometer. The control was prepared in a similar manner except for the fact that 1 ml of *p*-NPP (115 mM) solution was added only after the addition of $CaCl_2$ (1 ml) and NaOH (4 mL) but immediately before centrifugation. Spectrophotometer blank consisted of similar to that of sample but *p*-NPP replaced with 1 ml Millipore water. *p*-nitrophenyl content of sample was calculated by referring to the calibration curve obtained with standards containing 0, 50, 100, 150, 200 and 250 µg of *p*-nitrophenyl. PME activity was expressed as µg *p*-nitrophenyl g^{-1} h^{-1} on dry weight basis. All samples were replicated three times.

Fluorescein di acetate hydrolysis (FDA)

Fluorescein di acetate (FDA), hydrolysis activity was carried out following the method described by Adam and Duncan (2001). Moist soil (1 gm) weighed in 30 ml sterile screw cap test tube and added 7.5 ml potassium phosphate buffer (pH 7.6, 60 mM) and allowed to equilibrate at 25^{0}C on an Environmental shaker. The reaction was started by addition of 0.1 mL FDA solution (1000 µg ml^{-1}) and incubated at 25^{0}C for 1 hour. Spectrophotometer blanks consisted of the soil and buffer mixture with the FDA solution replaced by 0.1 ml acetone and incubated like the sample.After completion of 1 hour incubation, the reaction was stopped immediately by adding 7.5 ml of chloroform: methanol (2:1) and mixing the content thoroughly in vortex for 30 seconds and allowed to settle for 30 min. After settling down 1.0 ml of upper phase was transferred to 1.5 ml microcentrifuge tube and centrifuged (5000 rpm

for 5 min.) to remove suspended particles and absorbance of the supernatant was measured at OD_{490nm} using Nanodrop 1000 spectrophotometer. The calibration curve was prepared with standards 0, 2, 4, 6, 8, 10 µg fluorescein mL^{-1}. The mass of fluorescein produced in each assay was determined from the corresponding optical density (OD_{490nm}) value divided by the equivalent dry weight of soil (determined by loss of weight of field- moist sub –samples after heating at 105^0C until constant weight). FDA hydrolysis activity was expressed as µg fluorescein g^{-1} h^{-1}. All samples were replicated three times.

Arylsulphatase activity (ARYL)

The assay for Arylsulphatase (ARYL) activity was carried out by using *p*-nitrophenyl sulphate (*p* -NPS) as substrate (Tabatabai and Bremner, 1970). Soil (2.0 g) was placed in 15 ml screw cap test tube and amended with 4.0 ml of acetate buffer (0.5M, pH 5.8), 1.0 ml of 20mM *p* –NPS and 0.5 ml toluene. The sample was vortexed and incubated at 20^0C for 5 h. On completion of incubation, 2.0 ml of 1.0 M NaOH and 1.0 ml of $CaCl_2$ was added. The sample was mixed and the amount of *p*-nitrophenyl, the hydrolysis product produced in the supernatant was measured at OD_{400nm} (Nanodrop 1000 Spectrophotometer). The ARYL activity was calculated from *p*-nitrophenol standard curve and expressed on dry weight basis (µg *p*-nitrophenol g^{-1} h^{-1}). All samples were replicated three times.

RESULTS AND DISCUSSION

Population of Bacteria

The mean bacterial population in cultivated sites of rice-fallow system was found to be of 6.49(±0.13) log_{10}cfu g^{-1} compared to the 6.36(±0.22) log_{10}cfu g^{-1} in uncultivated sites (Table1, Fig 1). Both rice-fallow and uncultivated soils contained higher population of bacteria (>5log_{10}cfu g^{-1}) and exhibited significant difference between cultivated and uncultivated soils (Table 1). Higher bacterial population in rice-fallow soils might be attributed to root exudation in rice cultivation, since 40-90% of the 30-60% root allocated substrates in rice translocate into the soil (Lynch and Whipps, 1990). Srivastava *et al* (2004) reported a higher bacterial population (5.46 log_{10}cfu g^{-1}) in sub-humid moist bioclimate followed by semi-arid (5.34 log_{10}cfu g^{-1}) soil in different Indo-Gangetic Plains under rice based crop sequence. A previous report indicates that the relative abundance of soil bacteria increases under high soil moisture conditions and is confirmed by the presence of high microbial density in the sub-humid (moist) IGP, whereas fungi dominate in dry soil (Collins *et al*, 2008).

Population of Fungi

The mean population counts of fungi in the soils of cultivated sites of rice-fallow, sequences found to be of 5.30(±0.14) log_{10}cfu g^{-1} compared to the 5.38(±0.12) log_{10}cfu g^{-1} in uncultivated site (Table 1, Fig1) and exhibited significant difference between rice-fallow and uncultivated soils (Table 1). Comparatively the lower population sizes in cultivated soils might be due to the tillage practices which could damage the fungal hyphae as well as metabolic and physiological requirement of fungi, since fungi prefers low water content for growth (Griffin, 1969; Lopes *et al*, 2011).

Population of *Azotobacter*

The population count of *Azotobacter* in the soils of rice-fallow system were found to be of 3.77(±0.22), log_{10}cfu g^{-1} compared to the 3.62(±0.17), log_{10}cfu g^{-1} in uncultivated sites (Table 1, Fig1). In rice-fallow and uncultivated sites, the *Azotobacter* population was found low (<4 log_{10}cfu g^{-1}) but, exhibited significant difference between rice-fallow and uncultivated soils (Table 1). Palleroni (1984), reported that the free- living non-symbiotic nitrogen-fixing bacteria and those belonging to genus *Azotobacter* sp. which is heterotrophic, aerobic microorganism being broadly dispersed in different environments, such as soil, water and sediments. The existence of *Azotobacter* in the soils of the present investigation is also attributed to the findings of Garg *et al*. (2001), who indicated that the strains of *Azotobacter* could be usefully employed in aquaculture systems.

Population of *Azospirillum*

With reference to the *Azospirillum* population, the mean population counts in the

Table1. Descriptive statistics of population of microorganisms (log_{10}cfu g^{-1}) in Rice –fallow and Uncultivated soils

	Descriptive values	Bacteria	Fungi	*Azotobacter*	*Azospirillum*	PSB
Rice-Fallow	Minimum	6.17	4.95	3.30	3.12	3.30
	Maximum	6.79	5.78	4.17	4.25	4.05
	Mean (±SD)	6.49 (0.13)	5.30 (0.14)	3.77(0.22)	3.75(0.22)	3.71(0.18)
Uncultivated	Minimum	5.45	5.07	3.30	3.30	3.30
	Maximum	6.70	5.70	3.92	3.86	3.93
	Mean (±SD)	6.36(0.22)	5.38 (0.12)	3.62 (0.17)	3.57(0.15)	3.57(0.15)
Paired t -test		4.94*	4.40*	4.00*	6.31*	4.39*

*Significant at p=0.05 level

Table 2. Descriptive statistics of enzymatic activities in Rice –fallow and Uncultivated soils

	Descriptive values	DHA	FDA	PME	ARYL
Rice - Fallow	Minimum	17.85	3.16	36.54	17.46
	Maximum	257.35	19.85	180.96	24.49
	Mean (±SD)	79.01 (±38.51)	12.16 (±4.37)	114.06 (±34.74)	21.43 (±1.89)
Uncultivated	Minimum	11.52	5.24	46.76	1.22
	Maximum	121.72	19.23	132.76	21.45
	Mean (±SD)	66.26 (±27.84)	9.49 (±2.49)	92.14 (±22.78)	15.72 (±3.03)
Paired t -test		4.79*	6.26*	9.53*	15.46*

*Significant at p=0.05 level

cultivated soils of rice-fallow were found to be of 3.75(±0.22), log_{10}cfu g^{-1} compared to the 3.54(±0.13), log_{10}cfu g^{-1} in uncultivated sites (Table 1, Fig1). Both in rice-fallow and uncultivated sites, the *Azospirillum* population was found low (<4 log_{10}cfu g^{-1}) and differed significantly. As *Azospirillum* is being microaerophilic in nature (Tengsingh Baliah and Rajalakshmi, 2015) can be able to colonize the rhizosphere of rice for fixing N_2 in waterlogged situation (Roper and Ladha, 1995). Similar reports of occurrence of *Azospirillum* in rice cultivation were also available from findings of extensive research works (Choudhury and Kennedy, 2004).

Population of phosphate solubilizing bacteria (PSB)

Likewise, in case of phosphate solubilizing bacteria (PSB) the mean population count in the cultivated soils of rice-fallow, were found to be of 3.71(±0.18), log_{10}cfu g^{-1} compared to the 3.57(±0.15), log_{10}cfu g^{-1} in uncultivated sites (Table 1, Fig1). In both cultivated and uncultivated sites the PSB population was found low (<4 log_{10}cfu g^{-1}) and differed significantly. The occurrence of PSB in the range of 3.33-8.33 log_{10}cfu g^{-1} in rice soils were reported from rice rhizosphere of Assam (Nath *et al*., 2010).

Dehydrogenase activity

The mean value of dehydrogenase (DHA) enzyme activity in the cultivated soils of rice-fallow was recorded as 79.01(±38.51), µg TPF g^{-1} 24 h^{-1} as compared to the mean value of 66.26(±27.84), µg TPF g^{-1} 24 h^{-1}in uncultivated sites (Table 2,Fig 2). In cultivated sites 76.67% soils belonged to low level (<100 µg TPF g^{-1} 24 h^{-1}) and rest 23.33% soils in medium category (100-400 µg TPF g^{-1} 24 h^{-1})of DHA activity whereas in uncultivated sites 90% soils showed low level (<100 µg TPF g^{-1} 24 h^{-1}) and only 10% showed medium level(100-400 µg TPF g^{-1} 24 h^{-1}) of DHA

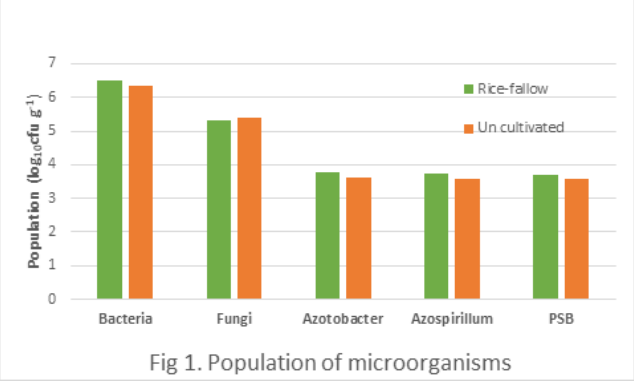

Fig 1. Population of microorganisms

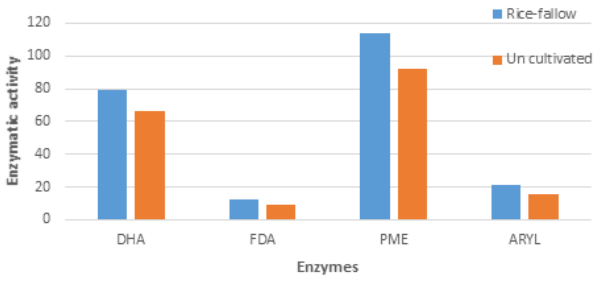

Fig2. Soil Enzymatic activities

activity. (Table 2). Natural decomposition of crop stubbles might stimulate DHA because the organic material on decomposition may provide intra and extracellular enzymes and may also stimulate microbial activity in the soil (Bhattacharyya *et al*., 2005).

Phosphomonoesterase activity

The mean value of phosphomonoesterase (PME) activity in cultivated soils of rice-fallow sequences were recorded as 114.06(±34.74), µg *p*-nitro phenol g^{-1} h^{-1}as compared to the mean value of 92.14(±22.78) µg *p*-nitro phenol g^{-1} h^{-1} in uncultivated sites (Table 2, Fig 2) . In rice-fallow 43.33% soils belonged to low level (<100 µg *p*-nitro phenol g^{-1} h^{-1}) and 56.67% soils belonged to medium level(100-200 *p*-nitro phenol g^{-1} h^{-1}) of PME activity whereas in uncultivated sites 68.33% soils showed low level (<100 µg *p*-nitro phenol g^{-1} h-1) and 31.67% soils showed medium level (100-200 µg *p*-nitro phenol g^{-1} h^{-1}).(Table 2). The mean value differed significantly between the rice-fallow and uncultivated sites. The persistence of elevated and active PME in cultivated soils might be due to their adsorption and protection against proteolysis, once released as extracellular enzymes or following cell death or during humification of organic residues (Nannipieri *et al*, 1996). Comparatively, higher activity of the enzyme PME in cultivated soils might also be due to the higher levels of microbial status maintained in the cultivated sites.

Fluorescein diacetate activity

The fluorescein diacetate (FDA)activity in the cultivated soils in rice-fallow, were estimated and the mean values were recorded as 12.16(±4.37) µg fluorescein g^{-1} h^{-1}as compared to the mean value of 9.43(±2.49) µg fluorescein g^{-1} h^{-1} in uncultivated sites (Table 2, Fig 2). In rice-fallow 68.33% soils belonged to medium level (10-31 µg fluorescein g^{-1} h^{-1})and 31.67% soils belonged to low level(<10 µg fluorescein g^{-1} h^{-1}) of FDA activity whereas in uncultivated sites 63.33% soils showed medium level (10-30 µg fluorescein g^{-1} h^{-1}) and 36.67% soils showed low level(<10 µg fluorescein g^{-1} h^{-1}) of FDA activity (Table 2). The mean value differed significantly between the rice-fallow and uncultivated sites. (Table 2). Nayak *et al* (2007) also illustrated the hydrolase activity of FDA in tropical rice soils. A similar result on FDA activity to the tune of 10.52 µg fluorescein g^{-1} h^{-1} was reported from the paddy soils of Assam (Nath *et al*, 2012).

Arylsulphatase activity

In cultivated soils under rice-fallow sequences the mean values of Arylsulphatase (ARYL) activity was 21.43(±1.89) µg *p* -nitrophenol g^{-1} h^{-1} while in the uncultivated sites, the mean values was 15.72(±3.03), µg *p* -nitrophenol g^{-1} h^{-1} (Table 2, Fig 2). Both in rice-fallow and uncultivated sites 100% soils belonged to low level (<30µg *p* -nitrophenol g^{-1} h^{-1})(Table 2). The mean value differed significantly between the cultivated and uncultivated sites. (Table 2). The enzyme ARYL catalyzes the hydrolysis of aromatic sulphate esters and releasing sulphate for plants uptake. Significantly higher ARYL in the rice-fallow soils might be due to the accretion of rhizodeposits, decomposed roots and leftover rice stubbles after harvest of rice (Lopes *et al*, 2011). In addition, ARYL being extracellular soil enzyme make complexes with humid colloids and get

stabilized on clay surfaces and organic matter, thereby increasing its content in cultivated soils (Bandick and Dick, 1999)

CONCLUSION

The present investigation indicated that due to the continuous cultivation of rice crops, there was an increase in population of bacteria, *Azotobacter, Azospirillum* and PSB in soils as compared to the adjacent uncultivated soils. Similarly, the enzymatic activities in soil also showed a higher value than the uncultivated soils. Continuous cultivation of rice crops in the long term increases microbial population and enzymatic activities as compared to the uncultivated soils. Therefore, the cultivation of crops with proper soil management practices like balanced use of chemical fertilizers based on soil test values, use of organic manures, and inclusion of legume crops in crop sequence etc. has to be adopted for sustaining soil health and crop productivity.

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Received on 19/7/2024 Accepted on 5/10/2024

J Krishi Vigyan 2024, 12(4) : 896-901
DOI : 10.5958/2349-4433.2024.00153.2
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Performance of Cluster Front Line Demonstration on Toria (*Brassica campestris*) in Anjaw District of Arunachal Pradesh

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ABSTRACT

The Cluster Front Line Demonstrations on toria were carried out during two consecutive *rabi* season 2021-22 and 2022-23 using the toria variety TS 67 covering an area of 18 ha. Identifications of the critical inputs and technical backstopping were identified though focus group discussions and face to face interactions with the farmers. The results of the study showed significant increase in the average yield of demonstration plots (28.23%) as compared to farmer's plots. However, lower yield observed in the farmer's practices was due to the considerable gap in the extent of adoption of recommended technology. The average technology gap, extension gap and technology index of toria crop was estimated to be 3.97 q/ha, 1.76 q/ha and 33.12 percent respectively. An average additional income of Rs. 9702 and effective gain of Rs. 8357 were obtained under demonstration plot could be on account of the use of improved technology, non-monetary factors, timely operation of the technology and monitoring. The overall higher yield and returns in demonstrations indicated that the productivity at farmer's field could be enhanced through the adoption of improved technologies.

Key Words: Demonstration, Impact, Toria, Net returns, Technological Index.

INTRODUCTION

Oilseeds are one of the important crops and a major source of income among the states of the North East Region of India. Toria *(Brassica campestris)* is a *rabi* season oilseed crop belonging to the family Cruciferae and genus Brassica. It is the second leading oilseed crop next to soybean and widely grown in North Eastern Region of the country.

The region shares a total of 1.69 percent in area and 1.05 percent in production of oilseeds at the national level. Among the states of the north east region, Assam has the highest area with 309.65 thousand ha and production of 199.93 thousand tons during the year 2022-23 (Directorate of Economics & Statistics, Govt. of India). Arunachal Pradesh is also one of the major oilseeds growing states in the region. The state share around 7.29 per cent in area and 9.90 percent in the production to the total NER area and production. The major oilseeds crops grown in the state are rapeseeds and toria, groundnut, sesame and soybean. The cultivation of these oilseeds crops is most done either in the *Jhum*, low-lying areas under rice fallow or in rice terrace cultivation. In Anjaw district, rainy season starts during the month of March-April and continue upto September-October and so the residual moisture remains abundantly till November to December which provides an ideal condition for cultivation of toria in the rice fallow and *Jhum* land. Bezbaruah and Deka (2019) reported that the farmers who generally keep fallow their field after rice can adopt the cropping system of medium duration rice followed by toria to maximize the production from the same land. Chaturvedi *et al* (2024) reported that due to ignorance and lack of interest, farmers were not employing seed treatment techniques for serious diseases like downy mildew and dumping off.

During the year 2016-17, the area under rapeseeds and toria in the district was 162 ha and during 2022-23 the area under the district expanded upto 182 ha indicating an increase in the growth rate in area of 0.83 percent whereas during 2016-17 the production of toria was 200 t and in 2022-23 the production declines to 187 t indicating

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Table 1. Comparison between technology interventions and farmers practice under CFLD programme.

Sr. No.	Particular	Technology Intervention	Farmer's practice	Adoption gap
1.	Variety	TS-67	Continuous use of old variety TS-36	Full
2.	Seed rate	10 kg/ha	13-15 kg/ha	Partial
3.	Sowing time	First week of October	Mid to last week of October	Partial
4.	Sowing method/spacing	30 cm row	Broadcasting	Full
5.	Seed treatment	Bavistin (@ 5g/ kg seeds)	No seeds treatment	Full
6.	Thinning	First at 25-30 DAS and second at 60 DAS	No thinning	Full
7.	Fertilizer doses	120:40:40- NPK (Kg/ha)	Non-judicious use of fertilizer	Full
8.	Irrigation	Irrigation at critical stage of growth	Rainfed	Partial
9.	Weed management	Pendamethalin @1.0 kg a.i ha^{-1}	No hand weeding or use of herbicide	Full
10.	Plant protection	Dimethoate 30 EC @ 0.5 l /ha against Aphid Mancozeb @ 0.2 % for Alternaria blight	Some of the farmers use Mancozeb @ 0.2 % for Alternaria blight	Partial

a negative growth rate of 0.81 percent (Economics, Statistics and Evaluation Division, Govt. of India, 2023). Prior to intervention of CFLD programme on rapeseeds and toria under KVK Anjaw, some of the farmers grew this oilseed crops in small areas of the district and were not aware about the newly developed high yielding varieties for its cultivation in larger scale and using the old varieties such as TS-36. The objective of CFLDs programme was to popularize the improved technology and the potential of newly developed varieties (TS-67) was for enhancing the production and productivity at the farmers field.

MATERIALS AND METHODS

The study was carried out among 32 farmers under CFLDs on toria variety TS-67 during the year 2021-22 and 2022-23 in 3 Community Development blocks of the district namely Hayuliang, Metengliang, Walong and Kibithoo covering 16 villages covering a cultivating mean area 18 ha. During the period 2016-17 introduction of toria variety (TS-36) was done and till now the farmers have been cultivating the same variety. Therefore, with a view to popularize and create awareness among the farmers, KVK Anjaw introduced toria variety TS-67. Prior to the demonstration of toria, brief information regarding the farming systems of the villages were collected through field visits and interactions with the farmers, Gaon Bura and PRI members. Generally, sowing of toria is done during the month of October and harvesting in the month of March-April. For carrying out the

Table 2. Extent of technology adoption of rapeseed under CFLD.

Sr. No.	Technology adopted	Before CFLD	After CFLD	Change in number of adopted farmers	Percent (%)
1.	Selections of varieties	6 (18.75)	16 (50.00)	10	166.66
2.	Time of sowing	9 (28.12)	27 (84.37)	18	200.00
3.	Seed rate	11(34.37)	28(87.50)	17	154.54
4.	Seed treatment	0 (0.00)	18 (56.25)	18	18.00
5.	Method of sowing	8 (25.00)	24 (75.00)	16	200.00
6.	Fertilizer application	5 (15.62)	17 (53.12)	12	240.00
7.	Irrigation management	3 (9.37)	14 (43.75)	11	366.66
8.	Weed management	8 (25.00)	25 (78.12)	17	212.50
9.	Pest and Disease management	7 (21.87)	25 (78.12)	18	257.14

**Figures in parenthesis are percentage*

demonstration, farmers were selected and critical inputs were used at the farmer's field. Timely monitoring of the demonstrated field was also done by KVK scientists. As a part of horizontal expansion and to realize the benefits of the technology, demonstrations, field days, hands on training and group discussions were conducted as and when required so as to create capacity building among the farmers. The data output on yield of the crops were collected both for demonstration and farmer's plot. Further, data were compiled and finally yield gap between the demonstrated technology and farmer's practices were estimated. Economic analysis such as gross return, net return and benefit cost ratio was calculated on the basis of the market prices of inputs used. The technology gap, extension gap and technology index were calculated using the formulas defined by Samui *et al* (2000) which are given below.

Technology Gap = Potential Yield (P_y) - Demonstrated Yield (D_y)

Extension Gap = Demonstration Yield (D_y) - Farmer's Practices Yield (F_y)

$$\text{Technology Index (\%)} = \frac{Py - Dy}{Dy} X\ 100$$

Benefit Cost Ratio = Gross Return/Gross Cost

RESULTS AND DISCUSSION

Technological gap analysis

It was observed that there was a full gap in case of the use of use of HYV, sowing method, seed treatment, thinning, fertilizer doses, and weed management, whereas, a partial gap was observed in case of seed rate, sowing time, irrigation and plant protection which generally might be the reason of low productivity of farmer's practices. During the course of interaction with the farmers, it was also realized that they have been continuing the old variety over long period either may be due to the unavailability of HYVs seeds or lack of awareness of the recommended technologies. Generally, farmer's practices broadcasting method of sowing seeds instead of using the recommended method of practices due to which they used higher seed rate. Also, it was also noticed that farmers do not used seed treatment for management of seed borne diseases and application of micro-nutrients due to the lack of awareness and locally unavailability or at nearby market. Further, farmers in the entire district follows rainfed system of agriculture and moreover, during the month of December-January due to the lack of moisture during the growing stage yield of toria crops reduced due to lack of irrigation during the crucial stage.

Table 3. Impact of CFLD on yield and gap analysis of toria crop in Anjaw district.

Year	Area (ha)	No. of demonstration	PY (q/ha)	Av. Yield (q/ha)		% increase in yield	TG gap (q/ha)	EG (q/ha)	TI %
				DP	FP				
2021 - 22	12	10	12	8.12	6.42	26.47	3.88	1.70	32.33
2022 - 23	24	22	12	7.93	6.10	30.00	4.07	1.83	33.91
Mean	18	16	12	8.02	6.26	28.23	3.97	1.76	33.12

PY- Potential Yield, DP- Demonstrated Plot, FP- Farmers' practice, TG- Technology gap
EG-Extension gap, TI- Technology index

Impact of technology demonstration

It was revealed that the numbers of farmers using the improved varieties increased from 18.75 to 50 percent through demonstrations (Table 2). Similarly, in case of sowing time the numbers of adopters significantly increase from 28.12 to 84.37 percent. After the adoption of CFLD, the numbers of farmers also significantly increased from 34.37 to 87.50 percent which indicates the positive impact in maintaining the seed rate among the selected farmers. Prior to the intervention of CFLD most of the farmers adopted broadcasting methods of sowing however after the adoption of CFLD programme the numbers of farmers following line sowing method of sowing increased from 25 to 75 percent. Regarding the seed treatment, none of the farmers practiced seed treatment method but after the intervention of CFLD the numbers of farmers increased to 56.25 percent. The numbers of farmers following recommended dose of fertilizer and their application method increased from 15.62 to 53.12 percent. It can be mentioned that farmers of the district are fully dependent on rainfall and none of the farmers practiced irrigation system in toria crops however, after intervention of CFLD programme some of the farmers have adopted irrigation system through canals, rivers and perennial stream as such the management of irrigation system the numbers of farmers increased to 43.75 percent from 9.37 percent. In case of weed management of toria crop, the numbers of farmers increased from 25 to 78.12 percent. As far as pest and diseases management of toria crop is concern, the numbers of farmers increased from 21.87 to 78.12 percent. It was also observed that the technology intervention on toria crop has made awareness among the non-practicing farmers in the district regarding the scientific package and practices of toria. Further, it was also realized that the overall impact on the adoption level in the production of toria increased by 201.72 percent under CFLD.

Yield Analysis

Perusal of the data (table 2) revealed that the yield of toria fluctuated successively over the two years period in the demonstration plots which could be increased by 26.47 to 30 percent through technology intervention over farmers practice. The maximum average yield of 8.12 q/ha was observed during 2021-22 and minimum yield of 7.93 q/ha was recorded during 2022-23 under the CFLD programme. Also, the average seed yield of toria under demonstration was 8.02 q/ha as compared to 6.26 q/ha in farmers practices which indicates that use of improved varieties of toria TS-67 along with improved technology contributed 28.23 percent higher production than farmer's variety. It was evident that the performance of toria TS-67 was better than the farmer's variety TS-36. Less productivity in farmer's practices may be due to the use of old varieties for longer period, variation in sowing time, low level of agronomic management in addition to timely non-availability of resources. These findings were in agreement with Prasad *et al* (2020). Manan and Sharma (2017) concluded that in order to meet the ever growing demand of oil in the country, the gap is to be bridged through management techniques. Optimum crop geometry, balanced NPK fertilizers, intercultural operations and inclusion of farmyard manure are

Table 4. Economic impact of CFLD on toria crop at farmer's field.

Year	Gross Expenditure (Rs./ Ha)		Add. Cost (Rs./ha)	Selling price (Rs. / Qtl.)	Gross income (Rs./ Ha)		Net return (Rs./ Ha)		Add. Income (Rs./ Ha)	Effective gain (Rs./ha)	B:C ratio (Demo)	B:C ratio (FP)
	Demo.	FP			Demo.	FP	Demo.	FP				
2021-22	23150	22010	1140	6000	48720	38520	25570	16510	9060	7920	2.10	1.75
2022-23	24300	22750	1550	6500	51545	39650	27245	16900	10345	8795	2.12	1.74
Mean	23725	22380	1345	6250	50132	39085	26407	16705	9702	8357	2.11	1.74

the building blocks for achieving the utmost yield targets of rapeseed-mustard.

Technology Gap

The technology gap indicates the gap in the demonstration yield over the potential yield. The trend of technology gap ranged between 3.88 to 4.07 q/ha which reflects the farmer's cooperation in carrying out the demonstration with encouraging results in subsequent years indicated in the table 3. The mean technology gap turned out to be 3.97 which suggest that there is still a gap in technology demonstration which prevents the participating farmers from benefitting from variety potential output. The persisting technology gap might be attributed due to the dissimilarity in fertility status of soil enriching soil nutrient especially with organic manure and weather parameters. In addition to this depending upon the identification and use of farming situations, specific interventions may have greater implications in enhancing the yield of toria . The results have also indicated that CFLD programme on toria crops have significant impact on the demonstrated village as the farmers have motivated and horizontally spread through the improved agricultural practices.

Extension gap

The extension gap refers to the differences between the yield of demonstrated plot and the farmer's practices. The mean extension gap was observed to be 1.76 q/ha. The extension gap showed an increasing trend ranging from 1.70 to 1.83 during the consecutive year study (Table 3). This scenario directed the importance to enhance farmer's knowledge through adoption of improved technologies to reverse the trend. Also the existing gap could be minimize through adoption of various extension activities such as imparting training programme, awareness programme, field demonstration, updating of knowledge through print and electronic media etc. so as to motivate the farmers to adopt improved agricultural practices. These findings were in agreement with Sharma *et al* (2019); Sangwan *et al* (2021).

Technological Index

The technology Index indicates the feasibility of the adopted technology at the farmer's field level. Lower technology index indicates the efficiency of the technological performance and vice versa. The technology Index during the two years showed less variation ranging from 32.33 to 33.91 percent as indicated in table 3. The average technology index was recorded at 33.12 percent and these variations might be on account of persisting weather conditions, differences in the soil fertility status, unavailability of irrigation facilities, diseases outbreak, infestation of pest and diseases and improper management of agricultural practices.

Economic performance

The results (Table 4) revealed that monetary return were directly influenced by the market price of toria seeds and the cost of production during the two years consecutive study periods. Inputs such as seeds fertilizer, bio-pesticides and insecticides were considered as technological interventions and on average an additional average cost of Rs. 1345 were incurred under the demonstration of toria. The results of the economic analysis of toria under Cluster Front Line Demonstration indicates an average gross return of Rs. 50132 per ha and net return of Rs. 26407 with benefit cost ratio of 2.11 as compared to farmers practices of 1.74. The average additional net return of Rs. 9702 per ha and effective gain of Rs. 8357 per ha obtained under the demonstration might be the results of the improved technology, non-monetary factors, timely operation of agricultural practices and

monitoring. The overall results indicated the positive impact of Cluster Front Line Demonstration over the existing farmer's practices.

CONCLUSION

It was evident that the Cluster Front Line Demonstration has given a positive impact in increasing the yield of toria by 28.23 percent provided the improved varieties of toria coupled with improved technologies in the demonstrations and thus increased the production. The demonstrations of the technology under CFLD were found to be more liable as compared to the farmer's practices. The persisting gap in technology and extension could be minimized through inducing of technical knowledge and capacity building programme. Economic analysis showed that the net return of Rs. 26407 with benefit cost ratio of 2.11 could be derived from the introduction of CFLD which was found to be more as compared to farmer's practices. Majority of the farmers have replaced the old varieties with improved varieties due to the efforts made by KVK Anjaw in boosting up the production and productivity as well as horizontal expansion of the technology in the district.

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Received on 4/10/2024 Accepted on 22/11/2024

J Krishi Vigyan 2024, 12(4) : 902-908
DOI : 10.5958/2349-4433.2024.00154.9
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Popularization of Improved Production Technologies in Mango through Farmer Field School Approach

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ABSTRACT

Mango repeatedly acclaimed as the king of fruits, is the most important commercially grown fruit of India due to its wide range of adoptability, high nutritive value and excellent flavour. However its productivity had shown declining trend over the years which need to be addressed. Hence, the farmer field school (FFS) was conducted for twenty five mango growing farmers. Significant increase in knowledge gain was observed among farmers after completion of FFS. Further it enhanced the adoption per cent of production practices in mango which ranged from 36 to 100 per cent. Cent per cent of farmers adopted technologies like mulching, fruit harvesting using tools and artificial ripening of fruits using ethylene gas. Small per centage (36 %) of farmers adopted the technologies related to spongy tissue management, post-harvest treatment with hot water, increasing shelf life of the fruits with plant wax, processing and values addition. A change in level of adoption was also recorded for eco-friendly management of fruit flies.

Key Words: Awareness, Farm Field School, Mango cultivation, Productivity

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important fruit crops of tropical and subtropical regions. India is the leader in mango production (20772 thousand MT) during 2021-22, which accounts for more than 40 per cent of global mango production (Balaganesh, 2023). The area occupied by Mango in India is 22.58 lakh hectare, where the annual production and productivity is 218.22 lakh MT and 9.7 MT/ ha respectively as against a higher productivity of 30 MT/ ha in Israel. Andhra Pradesh leads in area of mango cultivation occupying 3.63 lakh hectare followed by Uttar Pradesh occupying 2.65 lakh hectare whereas Uttar Pradesh leads in production of 45.51 lakh MT followed by Andhra Pradesh producing 43.73 lakh MT and Rajasthan leads in productivity of 17.58 MT/ ha followed by Punjab of 16.9 MT/ ha (Anonymous, 2018).

The main reason for low productivity of mango in India can be attributed due to poor orchard management, dense canopies with wider spacing, poor sunlight interception and ventilation encouraging more pest and disease incidence (Kumar *et al*, 2017). The increased productivity can be achieved through hi-tech cultural practices such as nutrient management, mulching, canopy management, using of growth regulators, floral manipulation in mango by application of exogenous plant hormones, induction of off – season flowering, top working of old and senile orchards for rejuvenation by reducing long gestation period, reduced pest and diseases incidence and post-harvest management.

The affordability of small and marginal farmers towards application of recommended fertilizer doses is increasingly becoming difficult, owing to ever increasing cost of inorganic fertilizers. Therefore, alternate mode/ source of essential plant nutrients should be thought of. In this context, farm yard manure (FYM) and in-situ green manuring as low cost input sources may be considered for improving crop productivity and soil health to the majority of the farming community (Kailash kumar *et al,*2017). Weeds are

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Table 1. Knowledge gain on mango production technologies. n=25

Sr. No.	Production practice	Before FFS	After FFS	X^2Value
A	Summer ploughing in area between the basins			
1	Not aware	14	04	0.6*
2	Fully known	11	21	
B	Green manuring			
3	Not aware	20	02	0.8**
4	Fully known	05	23	
C	Intercropping			
5	Not aware	08	0	1.0**
6	Fully known	17	25	
D	Identification of nutritional deficiencies			
7	Not aware	25	16	0.2*
8	Fully known	0	09	
E	Manuring and fertilizer application based on soil test			
9	Not aware	14	01	0.9**
10	Fully known	11	24	
F	Micro nutrient management			
11	Not aware	16	04	0.6*
12	Fully known	09	21	
G	Canopy management			
13	Not aware	22	0	1.0**
14	Fully known	03	25	
H	Regulation of bearing			
15	Not aware	19	08	0.4*
16	Fully known	06	17	
I	Regulation of fruit drop			
17	Not aware	17	10	0.3*
18	Fully known	08	15	
J	Rejuvenation of old and senile trees			
19	Not aware	12	03	0.6*
20	Fully known	13	22	
K	Importance of mulching			
21	Not aware	04	0	1.0**
22	Fully known	21	25	
L	Eco friendly management of fruit flies through pheromone traps			
23	Not aware	24	06	0.6*
24	Fully known	01	19	
M	Management of spongy tissue			
25	Not aware	25	11	0.4*
26	Fully known	0	14	
N	Tools for harvesting of mango			
27	Not aware	06	0	1.0**
28	Fully known	19	25	
O	Artificial ripening of fruits by ethylene gas			
29	Not aware	20	0	1.0*
30	Fully known	05	25	

Sr. No.	Production practice	Before FFS	After FFS	X^2Value
P	Post -Harvest treatment with hot water			
31	Not aware	23	16	NS
32	Fully known	2	09	
Q	Increasing shelf life of the fruits with plant wax			
33	Not aware	24	14	NS
34	Fully known	01	11	
R	Digital marketing of fruits			
35	Not aware	18	07	0.4*
36	Fully known	07	18	
S	Different packaging Materials			
37	Not aware	08	0	1.0**
38	Fully known	17	25	
T	Processing and value addition			
39	Not aware	19	01	0.9**
40	Fully known	06	24	

X^2 Chi square

** Significant at 0.05 level of probability*

*** Significant at 0.01 level of probability*

NS Non significant

widespread in many mango orchards. If not managed properly, however, they can have a serious economic impact with crop losses and increased production costs. Canopy management is one of the most important factors to sustain the yield and quality of fruits in mango. In many fruit crops, increase in production with enhanced fruit quality is achieved by managing canopies. Capturing and conversion of sunlight into the fruit biomass (dry matter content) is an important process in fruit production.

Micronutrients deficiency in Indian soils are higher in case of Zinc (Zn) and Boron (B). It is estimated the average deficiency of Zn is to be around 50 now and by 2025 projected to increase 63 % (Singh, 2001). It reflects on health at risk across the globe (Alloway, 2008). Deficiency of Zn ranged between 5.9 to 75.0 per cent in soil and 33.3 to 100 per cent in mango leaf tissue analysis in Uttar Pradesh (Kumar *et al*, 2015). Application of 100g borax per plant with spraying of 0.5% boric acid during the month of September- October solution at peanut and marble size of fruits useful for optimum improvement in fruit quality.

Exogenous application of NAA at 50 ppm at pea and marble stage of fruit growth was beneficial in improving the fruit retention and yield of mango cv. Amrapali while, $ZnSO_4$ at 0.75 per cent resulted in production of superior fruits (Vejendla *et al,* 2008). At harvest, fruit number was higher under NAA (20ppm) treatment in Alphonso at Bangalore (Upreti *et al*. 2014). There are number of insect pests damaging mango tree but the main challenge faced by mango producers is fruit infestation caused by the invasive oriental fruit fly, *Bactrocera dorsalis* (Meyer *et al,* 2016). Mango suffers from several diseases at all stages of its life. All the parts of the plant, namely, trunk, branch, twig, leaf, petiole, flower and fruit are attacked by a number of pathogens including fungi, bacteria and algae. They cause several kinds of rot, dieback, anthracnose, malformation, scab, necrosis, blotch, spots, mildew, etc. (Haggag Wafaa, 2014).

The Farmer Field School (FFS) is a tool to build capacities of farmer groups through participatory approach for promoting sustainable agricultural development, managing crop ecosystem, to make them better decision maker in sustainable use of resources at the cropping, farming and watershed levels. It also helps in stimulating local innovation. FFS is based on the farmer's need and training is imparted outside the

classrooms and on the farms. The schools usually comprise season long practical training with a set pattern of activities like regular field monitoring and Agro- Ecosystem Analysis (AESA). FFS provides an opportunity for the farmers to master its basic skills to enable them to make informed field management decisions (Kawale, 2011). Keeping these points in view this study was conducted with FFS approach to popularize production technologies in mango and to assess the impact of FFS programme on awareness and adoption of production technologies among participant farmers.

MATERIALS AND METHOD

This FFS was conducted at Hude village of Hanagal taluk, Haveri district, Karnataka. Hanagal taluk has got highest area under mango crop (3844 ha) contributing 68.64 and 71.36 per cent to total district mango area and production respectively. Before initiation of FFS, a survey was taken up among mango growers of Hude and adjacent villages to assess the knowledge level about production technologies in mango crop. After the survey it was found that nearly 65 per cent of farmers were unaware about production technologies. Based on above fact, at monthly interval the FFS was carried out by including 25 mango growing farmers at Hude village.

Collection of Data

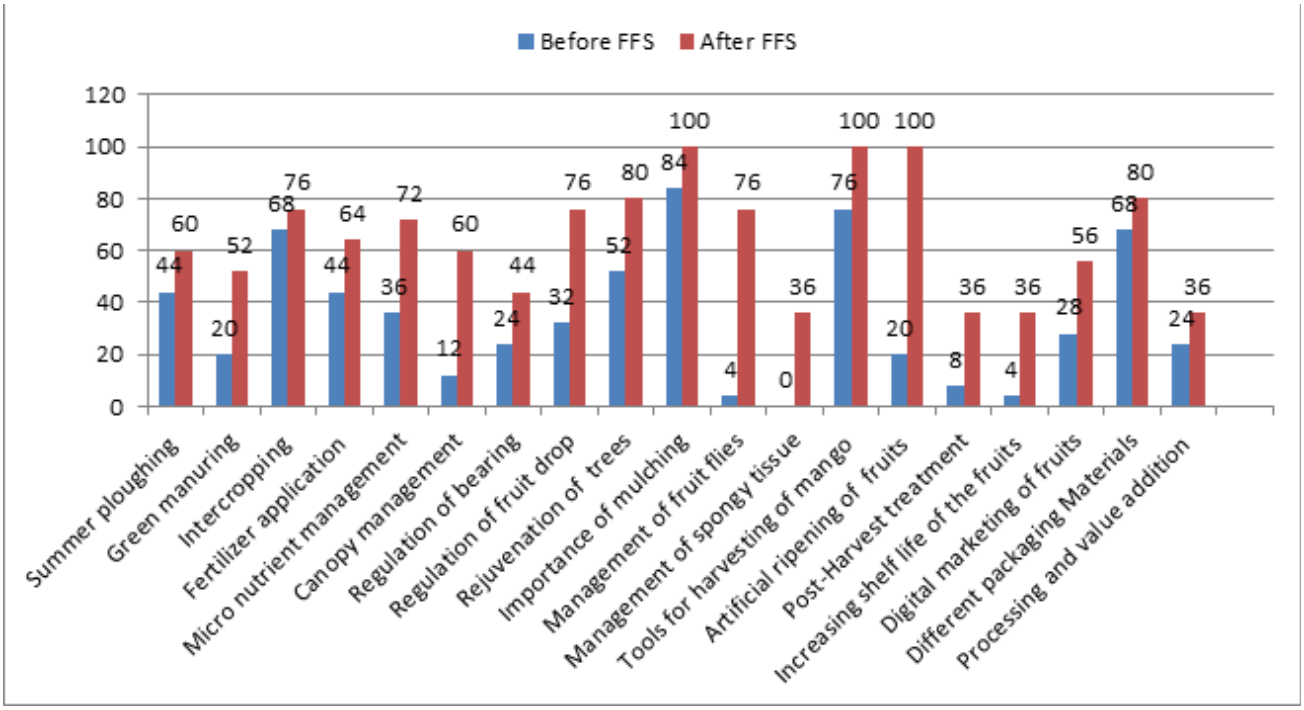
To assess the knowledge gain and adoption of production technologies in mango crop, pre-evaluation and post-evaluation was conducted before initiation of FFS and one year after completion of FFS respectively. Both the pre and post evaluation questionnaires comprised the same questions on cultural practices, soil sampling method and soil test based nutrient management, weed management, intercropping with mango, micronutrient management using mango special, use of pheromone trap, crop stage wise pest and disease management, post-harvest technologies, marketing and value addition aspects. At the time of pre-evaluation, farmers basic information like age, crops cultivated, land holding, education and their contact details etc. were also collected. Differences in knowledge of farmers in technological solutions regarding low productivity and poor fruit quality were analysed using Chi-square (x^2) test, while differences in adoption were interpreted using descriptive statistics.

RESULTS AND DISCUSSION

The Farmer Field School (FFS) is a form of adult education, which evolved from the concept that farmers learn optimally from field observation and experimentation. It provided an opportunity for the farmers to learn together, field oriented participatory and learning by doing. Knowledge gain on mango production technologies presented in Table 1. The results revealed that FFS was an efficient way to improve farmers knowledge. This method of education had significantly influenced the awareness on summer ploughing in area between the basins, green manuring, identification of nutritional deficiencies, intercropping, manuring and fertilizer application based on soil test, micro nutrient and canopy management, regulation of bearing and fruit drop, rejuvenation of old and senile trees, importance of mulching, eco-friendly management of fruit flies through pheromone traps, management of spongy tissue, tools for harvesting of mango, artificial ripening of fruits by ethylene gas, digital marketing of fruits, different packaging materials, processing and value addition. These results are in line with the findings of Rola *et al* (2002) who reported that the FFS farmers gained more knowledge in pest and nutrient management and actively exercised interpersonal networks to share knowledge among themselves, but very little with other farmers. The results showed that there was an improvement in knowledge gain for subjects like post-harvest treatment with hot water and enhancement of shelf life of the fruits with plant wax but it is found to be non-significant.

Some previous studies focused on the economic aspect of the FFS program found that the FFS participants have significantly more knowledge about IPM practices; they have the potential to improve production and productivity (Godtland *et al,* 2003 and Davis *et al,* 2012). Participation in FFS enhanced the adoption per cent of production practices in mango production which ranged from 36 to 100 per cent. FFS which

Figure 1. The findings pertinent to the item-wise adoption level of the FFS beneficiaries (in percentage)



emphasis participatory learning aiming to share knowledge and skill at farmer's field produces more tangible results (Jothilkashmi and Akila, 2022). The skill transfer activities and demonstrations in FFS may have increased the confidence level to adopt the practices in contrast to conventional extension approaches which increased knowledge and awareness and not influenced adoption behavior (Shelly, 2020 and Chander and Chand, 2020).

After conducting of FFS, a cent per cent adoption of technologies like mulching, fruit harvesting using tools and artificial ripening of fruits using ethylene gas was noticed among farmers. Mulching practice gained popularity amongst mango growers because of lack of irrigation facilities. Traditional manual harvesting methods are labour-intensive and inefficient. Harvesting tools offers a promising solution, with the potential to significantly reduce harvesting costs and contribute to overall production efficiency further use of ethylene gas is a simple and low cost method for uniform accelerated ripening as an alternative to banned calcium carbide method which encouraged the farmers for complete adoption of above technological solutions.

Karan singh *et al* (2010) found that majority of farmers did not adopt practices such as summer ploughing, application of fertilizers, inter cop, plant growth regulators, green manuring, insect pests, diseases, physiological dis orders and marketing procedures where as Kawale (2011) reported that most of the beneficiaries adopted the practices taught in FFS namely, varieties, land preparation, fertilizer application, irrigation practices and harvesting of fruits.

\From very low level of adoption (4 % before FFS) to high level of adoption (76 % after FFS) was observed for eco-friendly management of fruit flies through pheromone traps mainly because it caused significant economic losses by lowering the market value of fruits and as a result, diminishing farmer's revenues. The total estimated losses caused by these fruit flies were up to 27-42 per cent and in severe cases, it may reach upto 90 per cent in mango. FFS conducted in onion reduced the pesticide usage, expense and increased income while maintaining the same yield (Sanglestsawai *et al,* 2015).

Even after completion of FFS, merely 36 per cent of the participants were adopted the technologies related to spongy tissue

management, post-harvest treatment with hot water, increasing shelf life of the fruits with plant wax, processing and values addition. This may be due to non-availability of critical inputs and complex procedure. Divya and Arunachalam (2020) also reported that none of the respondents have adopted technologies like, dipping fruits in 52±1ºC hot water immediately after harvest for 5 minutes owing to their lack of awareness.

Farmer field school enhanced the knowledge and adoption of technological solutions by mango farmers resulting in higher productivity and better income which is in line with Kawale *et al*, (2011). The FFS is a better approach to enhance farmers technical knowhow of complex technologies/ practices (Godtland *et al*, 2003) and adoption of the same. The findings of Bhuiyan and Maharjan (2022) revealed that FFS farmers had a lower agroecological impact from pesticide use and their behaviour in farming practices was improved. FFS was demonstrated to be a key strategy in strengthening agricultural extension services, which will contribute to promoting sustainable agriculture.

CONCLUSION

This study revealed that there were varied levels of knowledge among farmers against the mango cultivation. Since farmers were willing to learn and adopt new management strategies, new strategies were introduced via appropriate extension methods such as Farmer's Field School. There was significant improvement in farmer's knowledge after attending FFS on various aspects of mango production. Further, appreciable per cent increase in adoption of production technologies were noticed. Hence, this study suggested that participatory education approach like FFS may be adopted to strengthen productivity in mango crop.

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Received on 29/3/2024 Accepted on 15/8/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 909-913

DOI : 10.5958/2349-4433.2024.00155.5

Prevalence of Hemorrhagic Gastroenteritis in Canine Population of Garividi Region of Andhra Pradesh

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ABSTRACT

The present study was taken from March 2023 to February 2024 to determine the prevalence of hemorrhagic gastroenteritis (HGE) in dogs that were presented to Veterinary Clinical Complex, College of Veterinary Science, Garividi with the purpose to determine the prevalence and associated etiologies causing hemorrhagic gastroenteritis in the area. A total of 1292 dogs were presented to the VCC with the history of anorexia, dullness, vomiting, hematemesis, blood tinged/ brownish colored diarrhea and putrid odour feces. The overall prevalence of HGE was 19.2 per cent among the presented cases. The prevalence in young ones (< 6 months) was higher than the adult dogs (above 3 years) with prevalence ranging from 62.1 to 2.4 per cent, respectively. The prevalence was higher in male (75.8%) than female (24.2%) dogs. Mongrel breed of dogs showed high prevalence of 40.72 per cent followed by Spitz, Labrador, German shepherd and lowest in Pug, Husky and Terrier breeds of dogs with 1.21 per cent. HGE due to Canine Parvovirus infection (45.2%) followed by intestinal parasitic infestation (27.8%), combined infection of parvovirus and intestinal parasites (12.5%), other conditions (9.7%) and Isosporiosis (4.8%) were the etiologies that resulted in HGE in dogs.

Key Words: Dogs, Gastroenteritis, Hemorrhagic, Intestinal parasites, Parvovirus, Prevalence

INTRODUCTION

Gastroenteritis is the most common problem which is encountered in all age groups and breeds of canine population. It is characterized by anorexia, vomition, diarrhoea which may be hemorrhagic, dehydration, lethargy and sometimes fever. Weight loss or stunting is commonly observed in dogs that are more severely affected (Bhat *et al,* 2013). Various etiological factors have been reported to be associated with canine gastroenteritis like bacterial, viral infections, parasitic infestations, irritant drugs, dietary errors and ingestion of toxic materials (Ettinger and Feldman, 2010). But in most of the cases exact etiology remain elusive. Irrespective of etiology, it leads to electrolyte imbalance and dehydration. Earlier many prevalence studies have been done regarding gastroenteritis in dogs but the results are different in each and every study because of the differences in regional climate, breed predisposition in those particular areas, time of study etc. The purpose of this study was to present an analysis of selected data from a total number of cases of hemorrhagic gastroenteritis in dogs presented to a teaching hospital regarding breeds, age group, sex and etiology in north coastal part of Andhra Pradesh.

Hemorrhagic Gastroenteritis (HE) refers to non-specific inflammation of the gastrointestinal tract (stomach, intestines). Clinical signs often develop as an acute or chronic condition and may persist for a few days. Gastroenteritis can be highly contagious and can spread through saliva, vomit and faeces in infections. The transmission may be by direct contact with another dog or through dogs licking or sniffing surfaces (fences) or drinking from

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Table 1. Prevalence of hemorrhagic gastroenteritis in dogs.

Sr. No.	Parameter	No. of Dogs	Prevalence (%)
A.	**Age**		
1.	< 6 m	154	62.1
2.	6 m to 1 yr	61	24.6
3.	1 yr to 3 yrs	27	10.9
4.	> 3 yrs	6	2.4
B.	**Sex**		
5.	Male	188	75.8
6.	Female	60	24.2
C.	**Breed**		
7.	Mongrel	101	40.72
8.	Spitz	63	25.4
9.	Labrador	48	19.35
10.	German Shepherd	27	10.9
11.	Pug	03	1.21
12.	Siberian Husky	03	1.21
13.	Terrier	03	1.21

shared water bowls, whereas parasitic infestations results from irregular deworming schedule. The diagnosis is typically based on a dog's history or by excluding other potential causes of vomiting and diarrhoea. In most cases, a specific underlying cause is not identified, but patients respond to supportive care.

MATERIALS AND METHODS

Dogs presented to Veterinary Clinical Complex, College of Veterinary Science, Garividi during the period from March 2023 to February 2024 with signs of generalized weakness, anorexia, dullness, vomiting or hematemesis, blood tinged/ brownish colored diarrhea and putrid odour feces were considered for the study. Clinical examination of the dogs revealed pale pink mucus membranes, dehydration and sunken eyeballs in majority of animals. Temperature of 103°F and tachycardia were evident in few cases. Based on history of vaccination, change in diet, clinical signs and condition of the animal, hematology and fecal examination were carried out to rule out bacterial, viral, protozoal and parasitic infections. The data generated in the present study was analyzed using statistical analysis.

RESULTS AND DISCUSSION

A total number of 1292 dogs were presented with gastrointestinal signs were taken for the study. Out of total gastrointestinal cases, 248 (19.2%) dogs showed hemorrhagic gastroenteritis. The prevalence of gastroenteritis in dogs were reported as 12.24 per cent by Deepika *et al* (2020) and a prevalence of 23 per cent acute hemorrhagic gastroenteritis by Dupont *et al* (2021). The difference in prevalence recorded by different workers might be due to different geographical locations, difference in feeding pattern, climatic variation, genetic variation of the animals and cases presented to the clinics.

Age-wise prevalence

The highest prevalence was recorded in young ones of less than 6 months of age (62.1%) followed by dogs of age group 6 months to 1 years (24.6%) and 1 to 3 years (10.9%). Lowest prevalence is reported in dogs of more than 3 years of age (2.4%). The findings were similar to Deepika *et al* (2020) who reported 72.18 percent of gastroenteritis in dogs less than one year of age. The highest prevalence in young dogs could be due to immune suppression and/ or dietary deficiency making them prone to bacterial, viral infections and endoparasites (Table 1).

Sex-wise prevalence

Prevalence of HGE in dogs is higher in males (75.8%) than females (24.2%) which might be due to more presentation of males than females to the clinics. The findings were in accordance

Table 2. Etiological prevalence of HGE in dogs.

Etiology	No. of Dogs	Prevalence (%)
Parvoviral Infection (CPV)	112	45.2
Intestinal parasite	69	27.8
CPV + Intestinal Parasite	31	12.5
Isospora	24	9.7

with observations of many earlier studies on gastroenteritis (Bhat *et al*, 2015 and Tagorti, 2019).

Breed wise prevalence

Breed-wise prevalence of hemorrhagic gastroenteritis in dogs from March 2023 to February 2024 is depicted in Table 1. Highest prevalence of hemorrhagic gastroenteritis was recorded in Mongrel (40.72%) followed by Spitz (25.4%), Labrador (19.35%) and German shepherd (10.9%). Pug, Siberian husky and terrier breeds had lowest prevalence of 1.21 per cent each. Sayed Ahmed *et al* (2020) reported highest prevalence of HGE due to canine parvoviral infection in native dogs. The higher prevalence in non-descript breeds might be due to the higher population density of this breed. No specific comment can be made on breed susceptibility as the population density of the breed varies from one geographical area to another area.

Etiological Prevalence

Based on the hematological, biochemical, fecal examination and CPV antigen test kit (Canine Snap®), the diagnosis is made and treated as per the etiology. Canine Parvovirus infections (45.2%) followed by intestinal parasitic infestation (27.8%), combined infection of CPV and intestinal parasites (12.5%), other conditions (9.7%) and Isosporiosis (4.8%) were the etiologies reported in the present study that resulted in HGE in dogs (Table 2)

The prevalence of HGE was highest due to canine parvoviral infection. Sayed-Ahmed *et al* (2020) reported the overall prevalence of CPV infection in dogs as 59.7 per cent. The higher prevalence of CPV infection in non-vaccinated dogs might be due to a lack of protective immunity. In vaccinated dogs, CPV infection might occur due to incomplete or ineffective primary vaccination course, or a failure of vaccination. The characteristic clinical signs of CPV disease are bloody diarrhea, vomiting, and dehydration (Khare *et al*, 2019 and Inbaraj *et al*, 2023). In the present study, 27.8 per cent prevalence of HGE was noted due to intestinal parasites. Daniel *et al* (2011) and Suganya *et al* (2019) reported prevalence of 16.5 per cent and 23.72 per cent endoparasitism, respectively. Diarrhea with dark, tarry feces, anemia, loss of appetite, weight loss, and weakness develop in longterm disease with hookworms in dogs. The prevalence of intestinal parasites could be due to the nature of the environment, poor levels of hygiene and overcrowding especially in communities that are socio-economically disadvantaged and improper deworming schedules (Traub *et al*, 2014). Mixed infection of intestinal parasites and parvoviral infection is seen in 12.5 per cent of the cases. deCastro *et al* (2007) reported concurrent CPV infection and intestinal parasites and stated that the presence of intestinal parasitism act as predisposing or aggravating factor for CPV infection.

HGE due to other causes i.e., gastric ulcers, prolonged usage of NSAIDS and bleeding disorders was seen in 9.7 per cent cases in the present study. Boysen (2009) reported that the most commonly reported cause of GI hemorrhage in dogs is GI ulceration. However, the severity of GI hemorrhage associated with ulcers varies with the degree and extent of mucosal erosion. NSAIDs, hepatic disease, neoplasia, stress ulcers and inflammatory bowel disease also causes hemorrhagic gastroenteritis.

The lowest prevalence (4.8%) of HGE is caused by *Isospora* spp., in the present study. Canine intestinal coccidiosis was a cause of haemorrhagic diarrhea in young immuno-compromised dogs (Mitchell *et al*, 2007). Buehl *et al* (2006), reported 8.7% prevalence of coccidiosis in dogs, whereas Nisar *et al* (2009) reported 18 per cent prevalence of coccidiosis in dogs. This could

be attributed to irregular use of anti-coccidal drugs, breeds, geographic conditions and awareness of the owners about the disease.

CONCLUSION

The present case study determined the prevalence of hemorrhagic gastroenteritis in dogs and their contributing etiologies as it is multi-factorial which includes endoparasites, viral, bacterial, protozoal, concurrent infections, which leads to clinically generalised weakness, anemia, severe dehydration, immunosuppression, secondary bacterial infections and mortality in extreme cases.

ACKNOWLEDGEMENT

The authors are thankful to the Associate Dean, College of Veterinary Science, Garividi and Department of VCC and VLD for providing necessary facilities to carry out the study. I also wish to extend my thanks to the pet owners who were patient and sincere on carrying out the study.

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Received on 7/10/2024 Accepted on 22/11/2024

J Krishi Vigyan 2024, 12(4) : 914-919
DOI : 10.5958/2349-4433.2024.00156.1
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Prevalence of Primary Dysmenorrhea and its Impact on Daily Chores of Women

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ABSTRACT

Primary dysmenorrhea refers to the common menstrual cramps experienced by most women during the menstrual period. To ascertain the prevalence and impact of primary dysmenorrhea among women, the present survey was carried out with a sample of 589 women aged between 15- 45 years. A standardized questionnaire was used to obtain the relevant data online. The results revealed that the prevalence of dysmenorrhea was 80.4%. The pain intensity was severe among 23.5% of subjects, whereas moderate and mild pain intensity was experienced by 45.5% and 31% of the subjects respectively. The subjects were reported to be experiencing menstrual pain for 1-3d. The impact of primary dysmenorrhea was observed in terms of loss of concentration in work (57%), being absent from work (28.4%) and inability to participate in social activities (28.3%). Apart from this impact on the daily chore activities, the women showed symptoms like back pain (64.4%), extreme tiredness (57.6%), mood swings (50.8%), acne (37.8%) and abdominal bloating (29.4%). It can be concluded from the current study that the majority of women experience moderate to severe pain during the menstrual time to the extent that the daily routine is disturbed and it would be appropriate to formulate pain management strategies to overcome the distress.

Key Words: Gastrointestinal discomfort, Menstrual symptoms, Menstrual pain, Mood swings, Primary dysmenorrhea. swings, Primary dysmenorrhea.

INTRODUCTION

Primary dysmenorrhea is one of the most common complaints in women causing physical and mental issues and absence from social activities, It describes the painful, repeated cramping that occurs during menstruation in the lower abdomen and waist without any evidence of a pelvic or pathological disease (Chen, 2014; Ryan, 2017). It differs in intensity and effect ranging from a minor annoyance to a serious handicap. Menstruation begins at puberty and ends at menopause with an average duration of 28d for every cycle. Most of the time, systemic symptoms accompany the discomfort, which often begins with menstrual bleeding and lasts for two to three days (Ryan, 2017). The syndrome is characterized by symptoms such as mood swings, headache (60%) nausea and vomiting (80%), tiredness (45%), irritability (30%)and diarrhea (50%) and less frequently, dizziness and collapse in addition to lower back and stomach cramps (Berkley, 2013; Parker *et al,* 2010).

Dysmenorrhea appears to be the most common gynecological disorder in women irrespective of age and nationality (Proctor and Farquhar, 2002; Patel *et al,* 2006). The prevalence of primary dysmenorrhea may vary, in female adolescents it was 20% to 90% (Kazama, 2015), Studies from India reported the prevalence range between 50-87.8% (Agarwal and Agarwal, 2010), 85% in Nigeria (Loto, 2008; Yasir, 2014) and in Iran, between 74 to 90 percent (Mohammadinia,2013) with 10–20% of them reporting severe pain and were unable to work or engage in other activities for one to three days, it impaired their activities (Habbi *et al*, 2015;

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Berkley 2013). In Indonesia, 9.36% of women have secondary dysmenorrhea and 54,8% of women have primary dysmenorrhea (Dana, 2023). Although dysmenorrhea is not considered a life-threatening disorder, it may reduce the quality of life and satisfaction as can interfere with daily activities as well as familial or social relationships (Lacovides, 2014). Dysmenorrhea has a wide range of effects and is significant in ways that go beyond its socioeconomic effects (Raine-Fenning, 2005).

The female menstrual cycle happens to allow the ovum released from the follicle and to prepare the uterus for possible pregnancy. It starts at puberty, between the ages of 10-16, and ends at menopause around 51. One menstrual cycle usually occurs from 21 to 35 d, with an average length of 28 d (Thiyagarajan *et al*, 2020). Various attempts were made to alleviate the pain of primary dysmenorrhea. Non-pharmacological efforts were also carried out including hot water bottles (Chaudhuri *et al*, 2013), exercise (Chaudhuri *et al*, 2013; Brown and Brown, 2017), acupuncture (Zhang *et al,*2018), yoga (Yang and Kim, 2016), physiotherapy [Azima *et al*,2015; Ortiz *et al*,2015), using fruits (Wrisnijati *et al*,2019), and herbs (Chen *et al*,2016).

The etiology of primary dysmenorrhea is not yet fully understood. An imbalance of hormone-like prostaglandins probably causes the symptoms, thereby increasing uterine contractions that cause menstrual pain (Wantini *et al*, 2021; Baird *et al*, 1996). Given the elevated incidence of PD in females, the current investigation aimed to determine the frequency of primary dysmenorrhea in Indian women and assess its influence on their day-to-day household tasks.

MATERIALS AND METHODS

The current study was conducted as a cross-sectional study, among 589 women participants throughout India. The data were collected through online methods by using google forms. The study's goal and protocol were elucidated to the participants in detail. They were requested to complete the questionnaire, which was designed to collect data in terms of demographic information related to their family status, family size and type, chronological age, age at menarche, menstrual history, menstrual characteristics such as pain severity, duration, and features, monthly symptoms, the effect of dysmenorrhea on everyday tasks, and techniques for managing menstrual discomfort were explained. Before data collection, ethical approval was obtained from the Institutional Human Ethics Committee (IHEC) of Acharya N. G. Ranga Agricultural University, Lam, Guntur (IHEC Ref Code No: IHEC/PG/FN/2022-2). To ensure the confidentiality of the participants, no personal identifying information was collected. SPSS for Windows version 23.0 (Statistical Package for Social Sciences Inc., Chicago, USA) was used to conduct statistical analyses on the data that were gathered after exporting the data to an Excel document created using Microsoft Office. The study used descriptive analysis, utilizing percentages to analyze qualitative variables and the mean and standard deviation to represent quantitative data. Furthermore, correlation was used to find out the interaction between different parameters.

RESULTS AND DISCUSSION

In total, 589 participants consented to participate in this study and correctly filled in the questionnaire in Google Forms. The data on the general profile of the participants showed that 55.4% of the participants have completed their professional degree 34.8% have completed graduation and the remaining 9.8 % of participants were pursuing intermediate and high school education. Among the participants 33% had attained the age of menarche at 13 yrs, 28.8% at 14 yrs and 18.2% at 12 yrs, 6.8% participants at 11 yrs, the remaining were at 13.1% of participants attained menarche at the age of 15 yrs and above and with a mean age of 13.31± 1.48 yrs at menarche. It was found that 83.8% of the subjects had their menstrual cycle regularly. Out of 589 participants, 472 (80.4%) women reported pain during menstruation and 54.7% experienced it due to their family history of pain. The most reported pain locations during menstruation were the lower abdomen (70.2%), lower back (43.4%) and pain in legs (40.7%). Dysmenorrhea is said to be influenced by a variety of factors including

Table 1. Dysmenorrhea and associated characteristics. (n=472)

Sr. No.	Characteristics	Number of participants	Percentage
A.	Pain length		
1.	1 day	184	34.4
2.	1-2 days	165	39.0
3.	2-3 days	94	20.8
4.	Entire period	29	6.1
B.	Frequency of occurrence		
5.	Every month	366	77.5
6.	Rarely	106	22.4
C.	Pain intensity		
7.	Mild	146	31.0
8.	Moderate	215	45.5
9.	Severe	111	23.5
D.	Degree of bleeding		
10.	Normal	341	72.2
11.	Heavy	105	22.2
12.	Less	26	5.6

Table 2. Interrelationship between menstrual age and menstrual characteristics.

Variable	Age	Intensity of pain	Pain symptoms	Bleeding length
Age	1			
Intensity of pain	-0.015 , 0.726 ^{NS}	1		
Pain symptoms	-0.104* , 0.012 ^{S}	0.038 , 0.365 ^{NS}	1	
Bleeding length	0.077 , 0.064 ^{NS}	0.187** , 0.000 ^{S}	-0.129** , 0.002 ^{S}	1

**Indicates significant level is at 0.05*

***Indicates significant level is at 0.01*

nutritional status and hormonal factors. In the present study, the women with dysmenorrhea reported consistent pain during periods.

The data (Table 1) depicted the associated characteristics of menstrual pain. It was found that 47.4% of the subjects experienced pain on the first day, 15.8% reported menstrual pain only on the second day and 20.5% of subjects expressed pain at irregular intervals on all 3 or 4 days of menstruation. The data showed that 45.5% of the women experienced moderate pain, whereas one-third (31%) experienced mild pain and 23.5% of the participants suffered from severe pain during the periods. Earlier studies reported the prevalence of dysmenorrhea between 45 and 92% in India and other countries (Ullah, 2021; Omar, 2020; Abreu-Sánchez, 2020; Gebeyehu,2017; Ahuja, 2016; Yasir, 2014).

The data indicated the interrelationship between the menstrual age of participants and with intensity of pain, symptoms and bleeding length. Pain symptoms were found to be significantly negatively correlated with the menstrual age of women and the length of menstrual bleeding. It was recorded that the intensity of pain was found to be highly positively significant with bleeding length. As the bleeding length increased, the intensity of pain was reported to be increased. The rest of the variables were non-significant.

The results (Table 3) indicate the most common dysmenorrhea-associated symptoms reported in the study. Women suffering from dysmenorrhea experienced several associated symptoms because of the uterine contraction that occurs during menstruation which was painful and accompanied by symptoms like tiredness, mood swings, dizziness, loss of appetite, headache, abdominal distention, nausea, back pain, diarrhea, and acne. Symptoms such as sweating, bloating,

Table 3. Distribution of women based on other symptoms during dysmenorrhea.

Sr. No.	Symptom	Number	Percentage
1.	Tiredness (fatigue)	315	57.6
2.	Mood swings	278	50.8
3.	Dizziness	111	20.3
4.	Loss of Appetite	125	22.9
5.	Headache	144	26.3
6.	Abdominal distention	161	29.4
7.	Nausea	53	9.7
8.	Backpain	352	64.4
9.	Diarrhea	40	7.3
10.	Acne	207	37.8

Table 4. Impact of dysmenorrhea.

Sr. No.	Activity	Number	Percentage
1.	Loss of concentration in class/work/household activities	312	57.2
2.	Absent to school/college/work	155	28.4
3.	Inefficient in carrying out tasks/homework	191	35.0
4.	Absent in social activities	154	28.3

painful/tender breasts, supra-pubic cramping, and depression were reported by other authors (Vlachou *et al*, 2019; Iacovides *et al*, 2014). This variation can be explained by the fact that the perception of dysmenorrhea is entirely subjective.

The effect of dysmenorrhea in women affects the quality of life (QoL) and also limits daily activity like absenteeism from school/work, social withdrawal, decreased academic performance, and increased health care medical costs which are the negative effects of menstrual pain. The effects of dysmenorrhea on the women who took part in this study were presented in Table 5. Loss of concentration in the classes or workplaces was reported by 57.2% of the participants, 35% of the participants reported inefficiency in carrying out tasks/homework, absence from work/school was reported by 28.4% of the respondents, while participation in social activities was found to be affected in 28.3% of the women. Studies have indicated that menstrual pain restricts the movement and usual activity pattern of females. In line with these findings, a study by Joshi *et al* (2015) reported that dysmenorrhea has significantly affected the quality of life which was seen in terms of decreased physical mobility, loss of concentration and poor social relationships.

CONCLUSION

The current study showed a high prevalence of dysmenorrhea among the women. Varying levels of occurrence of pain were observed in terms of duration, frequency, intensity and degree of bleeding. The pain symptoms were seen irrespective of the age and the length of bleeding while the pain intensity increased with an increase in bleeding length. The pain symptoms severely affected the quality of life concerning academics, work and social activities. Evolving appropriate pain management strategies, may it be in the form of medicine, diet, nutraceuticals or other integrative or complementary approaches may go a long way in helping women who are suffering from primary dysmenorrhoea.

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Received on 29/10/2024 Accepted on 10/11/2024

J Krishi Vigyan 2024, 12(4) : 920-922
DOI : 10.5958/2349-4433.2024.00157.8
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Productive performance of White Pekin Ducks Reared under a Semi-Intensive System in Assam

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ABSTRACT

Productive performance of White Pekin ducks reared under semi-intensive system in Jorhat and Majuli districts of Upper Assam has been studied through Front Line Demonstration (FLD) programme organized by Krishi Vigyan Kendra (KVK) Jorhat during 2020 to 2024. Study envisaged the key performance indicators including body weight gain at various ages, mortality rate, feed intake, feed conversion ratio (FCR), gross return per duck, gross cost per duck, and benefit-cost ratio (BCR) and compared against local Pati ducks. The BCR for White Pekin ducks was found to be 1.63, indicating significantly higher profitability compared to a BCR of 1.19 for local ducks. It has been revealed that White Pekin ducks has significant advantages in respect of other performance parameters like growth rate, FCR, and economic returns over the local breeds.

Key Words: Benefit-cost ratio, Evaluation, Performance, Semi-intensive system, Upper Assam, White Pekin duck.

INTRODUCTION

In different regions of India, farmers tend to favour duck farming instead of chicken farming because ducks experience fewer disease outbreaks, exhibit lower mortality rates, and are easier to manage. Duck farming holds substantial importance in the agricultural landscape of Assam, particularly for small and marginal farmers who rely on it for income, food security, and nutritional benefits. The indigenous Pati duck, although widely reared, has limitations in meat production due to slower growth rates and lower feed conversion efficiency. On the other hand, the White Pekin duck, recognized as a broiler breed, is celebrated for its rapid growth and high meat yield, making it more suitable for commercial purposes (Nath *et al*, 2022). White Pekin ducks are renowned for their high-quality meat and are raised globally in commercial duck farms. While there are a significant number of literatures (Stęczny *et al*, 2017; Kokoszyński *et al*, 2019; Rabbani *et al*, 2019) regarding different aspects of white pekin duck production in a commercial feeding setup within a confined system, there is limited knowledge about the growth performance of this duck breed when raised in a semi-intensive system.

This study aimed to evaluate the productive performance of White Pekin ducks under a semi-intensive system in the Jorhat and Majuli districts of Upper Assam, specifically comparing their performance with that of local Pati ducks. The study used statistical analysis to assess significant differences in growth rate, feed conversion efficiency, and overall economic viability between the two breeds. The objective of the study was to popularize the breed among the small and marginal farmers of the districts and enhance the income as well as nutritional security.

MATERIALS AND METHODS

Study Area and Flock Composition

The study was conducted between 2020 and 2024 in Jorhat and Majuli districts of Assam, under the auspices of the front-line demonstration (FLD) programme organized by KVK Jorhat. A total of 900 White Pekin ducks were reared in a

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Table 1. Body Weight of White Pekin vs Local Pati Ducks at Different Ages.

Age (Days)	White Pekin (kg)	Local Pati (kg)	p-value
1	0.068 ± 0.005	0.053 ± 0.004	< 0.01
15	0.390 ± 0.012	0.225 ± 0.007	< 0.01
45	1.76 ± 0.20	0.635 ± 0.12	< 0.01
60	2.71 ± 0.25	0.710 ± 0.15	< 0.01

Table 2. Feed Intake, FCR, and Mortality Rate of White Pekin vs Local Pati Ducks.

Parameter	White Pekin	Local Pati	p-value
Feed Intake (kg)	6.16	2.75	< 0.01
FCR	2.70:1	3.87:1	< 0.01
Mortality Rate (%)	2.00	6.00	< 0.05

semi-intensive system, which allowed them access to natural foraging during the daytime while providing supplementary feed to meet their nutritional needs. The ducks were housed in well-ventilated shelters at night to ensure their comfort and safety.

Data Collection

Data were meticulously collected on various performance parameters, including body weight at 1 day, 15 days, 45 days, and 60 days, along with feed intake, feed conversion ratio (FCR), mortality rate, gross return, and gross cost per duck. This data collection aimed to create a comprehensive profile of the performance of White Pekin ducks, which was then compared against the performance metrics of local Pati ducks reared under similar conditions.

Statistical Analysis

Descriptive statistics, including means and standard deviations, were computed to evaluate the performance parameters for both breeds. A two-sample t-test was employed to compare the means of the two groups, with p-values calculated to assess the significance of differences observed. A significance level of 0.05 was established for all statistical tests to ensure robust conclusions.

RESULTS AND DISCUSSION

Body Weight Gain

The results indicated that White Pekin ducks exhibited significantly higher body weights at all assessed stages compared to local Pati ducks. Specifically, at 60 d of age, White Pekin ducks reached an average weight of 2.71 kg, whereas local Pati ducks averaged only 0.71 kg. The observed differences in body weight were statistically significant ($p < 0.01$), demonstrating the superior growth rates of White Pekin ducks.

The significant differences in body weight indicate that White Pekin ducks were better suited for commercial meat production compared to local Pati ducks, making them a more favorable option for farmers seeking higher yields.

Feed Intake and Feed Conversion Ratio (FCR)

In terms of feed efficiency, White Pekin ducks demonstrated a higher total feed intake, averaging 6.16 kg per duck over 60 days, compared to only 2.75 kg for local Pati ducks. Despite the higher feed intake, White Pekin ducks achieved a significantly better feed conversion ratio (FCR) of 2.70:1, while local Pati ducks had an FCR of 3.87:1 ($p < 0.01$). This efficiency indicated that White Pekin ducks convert feed into body mass more effectively, which is crucial for profitability in duck farming. Ghosh *et al* (2022) has also reported similar results.

The superior feed conversion ratio of White Pekin ducks not only underscores their efficiency in feed utilization but also highlights their potential for increased profitability for farmers who rear them.

Economic Performance

Economic evaluation further substantiated the advantages of rearing White Pekin ducks. The gross return per White Pekin duck was Rs. 670/-, significantly higher than the gross return of Rs. 400/- local Pati duck ($p < 0.01$). Although the gross cost per duck for White Pekin was Rs. 412/- compared to Rs. 336/- for local Pati ducks, the resultant benefit-cost ratio (BCR) was more

Table 3. Economic Comparison of White Pekin vs Local Pati Ducks

Economic Parameter	White Pekin	Local Pati	p-value
Gross Return (Rs)	670.0	400.0	< 0.01
Gross Cost (Rs.)	412.0	336.0	< 0.05
Benefit-Cost Ratio (BCR)	1.63	1.19	< 0.01

favorable for White Pekin ducks at 1.63 versus 1.19 for local ducks.

The higher BCR for White Pekin ducks indicates their superior profitability, despite the slightly elevated costs associated with their rearing, reinforcing the economic viability of choosing this breed for meat production.

CONCLUSION

The findings of this study clearly indicated that White Pekin ducks, when reared under a semi-intensive system in Upper Assam, significantly outperform local Pati ducks across various performance metrics. The statistical analysis confirmed these differences were highly significant ($p < 0.01$), particularly concerning growth performance and feed conversion ratios. The ability of White Pekin ducks to achieve faster growth rates translates directly into higher gross returns and improved benefit-cost ratios, rendering them a more viable option for commercial meat production. The increasing adoption of White Pekin ducks in the Jorhat and Majuli districts underscores their profitability and aligns with the needs of local farmers seeking sustainable income sources.

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Received on 2/11/2024 Accepted on 20/11/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 923-927

DOI : 10.5958/2349-4433.2024.00158.4

Quantitative Analysis of Fatty Acids in Pumpkin (C*ucurbita pepo* subspp *pepo* var styrica) Seed Oil

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ABSTRACT

Hull-less pumpkin (*Cucurbita pepo* subspp *pepo* var styrica) seeds have a high pharmaceutical value and consumed as snack seeds. It is newly added member in *Cucurbita* spp, as being evolved by natural single recessive mutation in the 19th century. It is notable for high seed oil content and the absence of hard seed coat have smoothened the process of oil extraction. Its seeds and seed oil are rich in fatty acid content. In present experiment, 46 advance breeding lines of hull less seeded pumpkin were characterized to assess fatty acid content. Four predominant fatty acids found in oil of 46 pumpkin genotypes in variable range were oleic acid (22.9-50.1%), stearic acid (2.2-5.5%), palmitic acid (6.6-14.70%) and linoleic acid (34.3-48.3%) and all together made (79.50-99.80%) of total fatty acid content. The pumpkin seed oil contained 15.04% saturated fatty acids (palmitic and stearic acid) and 82.93% unsaturated fatty acids (linoleic and oleic acid). Among 46 genotypes, PWT-22(50.1%), PWT 14(48.3%) and PWT-41(5.5% and 14.76%) were highest in oleic acid, linoleic acid, stearic acid and palmitic acid respectively.

Key Words: Hull-less,Fatty acid,Pumpkin, Oil Seed.

INTRODUCTION

Cucurbitaceae is a highly diverse family that consists of at least 119 genera and over 825 species (Andres, 2003) of plants. *Cucurbita* genus (2n = 40) belongs to family cucurbitaceae and native to America (Whitaker, 1947). Pumpkin variety *Cucurbita pepo* subsp *pepo* var styriaca was emerged due to spontaneous mutation as a result of recessive gene during the 19th century in Austria. Its seed and the product prepared using seeds are widely consumed, as they have high pharmaceutical value. It is helpful to mitigate several prostrate diseases (Nitsch-Fitz, 1979). This accidental mutation resulted in huge change in morphology of seed (Fruhwirth and Hermetter, 2007). However, the seeds obtained were having very thin outer layer, which has smoothen the process of oil extraction. They are rich in their oil content as compared to other *Cucurbita pepo* spp. (Murkovic *et al*, 1996). The seed and seed oil of styrian pumpkin is mostly green in colour (Loy, 2004) and has high content of fatty acids. Mainly four fatty acids are present in considerable amount *i.e.*, palmitic, stearic, oleic, and linoleic acids (Stevenson *et al*, 2007). Linoleic acid is an essential fatty acid for humans and required for formation of cellular membranes, vitamin D and various hormones (Murkovic *et al*, 1996). Pumpkin seed oil is served as an antioxidant (Willis *et al,* 2009), antidiabetic (Pericin *et al*, 2009), antifungal (Wang and Ng, 2003), antibacterial and anti-inflammatory (Caili *et al*, 2006). The aim of this study was to find advance breeding lines of *Cucurbita pepo* with high oil content and content of unsaturated fatty acids.

MATERIALS AND METHODS

Experimental material

The experimental material consisted of 1 hulled (PCK-1) and 45 hull-less seeded genotypes of pumpkin (*Cucurbita pepo* subsp *pepo* var styriaca) grown at Vegetable Research Farm of Punjab Agricultural University, Ludhiana. The harvesting was done at full crop maturity, later after drying seeds were stored at room temperature in air tight containers. Oil used for fatty acid assessment was extracted by using method given by Folch *et al* (1957).

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Figure 1: (a) Seed of hulled genotype PCK-1 (b) Seed of hull-less genotype Lady Godiva

Preparation of fatty acid methyl esters (FAMEs)

Fatty acid methyl easters (FAMEs) were prepared from the seed oil samples of hull-less seeded pumpkin for determination of fatty acid content. One milliliter petroleum ether was added to 50 mg oil sample, then 1.5 ml sodium ethylate (0.02 M sodium hydroxide in 99.5 % ethanol) was added. After properly shaking this mixture solution, it was kept for rest for half an hour at room temperature. Then, 1.5 ml of Nacl (8%) solution was added and shaked to mix it. After the distinction of two visible layers, upper layer containing petroleum ether was taken into other tube and was kept to evaporate. Obtained precipitates were dissolved in one milliliter ether. Three microliter from this solution was injected into GC by using Hamilton microsyringe.

Analysis of FAMEs

FAMEs were determined with a gas chromatograph (Varian CP 3800, USA). Gas chromatograph consisted of a flame ionisation detector (FID) with a fused silica capillary column (50 m -0.25 mm i.d.), coated with CP-SIL 88 as the stationary phase. Temperature of the oven was kept at 200˚ C for 13 min. The injector and FID were at temperature of 250˚ C. For identification of peak, a reference standard FAME mix (Supelco Inc.) was run under the alike circumstances. The samples were analysed for Palmitic acid (C16:0), Stearic acid (C18:0), Oleic acid (C18:1) and Linoleic acid (C18:2) the FAMEs were represented as relative area percentage.

Statistical data

Data analysis was done by using SPSS software and Duncan's multiple range tests were used to compare means for each trait and significance was accepted at $p \leq 0.05$ to find out the variation among genotypes.

RESULTS AND DISCUSSION

The fatty acid profile predicted four predominant fatty acids in oil of 46 genotypes of hull-less seeded pumpkin *i.e.,* oleic acid (22.9-50.1%), stearic acid (2.2-5.5%), palmitic acid (6.6-14.70%) and linoleic acid (34.3-48.3%) and all together made (79.50-99.80%) of total fatty acid content (Table 1). The pumpkin seed oil contained 15.04% saturated fatty acids (palmitic and stearic acid) and 82.93% unsaturated fatty acids (linoleic and oleic acid). On an average, linoleic acid (41.64%) was higher among all, followed by oleic (41.29%), palmitic (10.9%) and stearic acid (4.07%), respectively.

The average fatty acid content results revealed that linoleic acid (41.64%) was highest followed by oleic acid (41.29%), palmitic acid (10.97%) and stearic acid (4.07%) (Figure 2). Among 46 genotypes, PWT-22 (50.1%) has showed maximum oleic acid content followed by

Table 1. Fatty acid profile of seed oil from hull-less seeded pumpkin.

Sr No	Genotype	Oleic acid (18:1) (Mean±SD) [A]	Stearic acid (18:0) (Mean±SD) [A]	Palmitic acid (16:0) (Mean±SD) [A]	Linoleic acid (18:2) (Mean±SD) [A]
1	PWT 1	41.6±2.91 defghijkl	4±0.26 bcdefghij	11.00±0.66 efghijkl	43.2±2.51 bcdefgh
2	PWT 2	40.2±0.13 hijklm	4.2±0.40 abcdefghij	10.70±0.26 fghijklm	38.7±1.98 jklmn
3	PWT 3	43.5±1.06 bcdefghi	4.8±0.13 abcde	11.90±1.72 defgh	39.6±0.93 hijklm
4	PWT 4	45.2±1.19 bcd	3.5±0.40 efghijkl	8.80±0.26 no	42.3±0.93 cdefghij
5	PWT 5	39.7±0.53 ijklm	4.7±0.26 abcdefg	11.80±1.19 defghi	43.4±2.51 bcdefgh
6	PWT 6	43.8±1.59 bcdefgh	4.3±0.40 abcdefghij	11.90±0.13 defgh	38.2±1.06 klmn
7	PWT 7	44.1±0.66 bcdefg	3.8±0.40 cdefghij	10.50±0.79 ghijklmn	40.9±1.59 efghijklm
8	PWT 8	39±1.45 klm	4.3±0.26 abcdefghij	10.70±1.06 fghijklm	43.3±2.12 bcdefgh
9	PWT 9	41.5±1.85 defghijkl	4±0.79 bcdefghij	11.10±0.79 efghijkl	43.1±0.66 bcdefghi
10	PWT 10	43.4±0.66 bcdefghi	2.4±0.79 klm	11.00±0.93 efghijkl	41.4±1.72 defghijkl
11	PWT 11	43.1±0.79 cdefghij	3.5±0.53 ghijklm	9.60±0.66 klmn	43.5±2.12 bcdefg
12	PWT 12	44.9±1.59 bcde	3.1±0.40 jklm	6.60±0.66 p	41.3±2.25 efghijkl
13	PWT 13	42.4±2.51 defghijk	4±0.66 bcdefghij	10.70±0.66 fghijklm	42.4±1.98 cefghlj
14	PWT 14	35±3.18 no	3.8±0.40 cdefghij	11.80±1.46 defghi	48.3±2.12 a
15	PWT 15	37.4±2.38 mn	3.9±0.79 cdefghij	11.40±1.59 efghij	46.6±1.19 ab
16	PWT 16	33.9±2.91 o	2.4±0.26 lm	7.60±0.66 op	35.6±1.19 no
17	PWT 17	42.1±1.72 defghijkl	3.4±0.53 hljklm	9.00±0.66 mno	45.2±1.72 abcd
18	PWT 18	41.3±1.59 efghijkl	3.6±0.66 efghijkl	10.60±0.79 fghijklm	43.7±0.26 bcdef
19	PWT 19	22.9±3.04 q	3.5±0.79 ghijklm	11.50±1.06 efghi	41.6±1.98 defghijkl
20	PWT 20	46.9±3.18 b	3.9±0.93 cdefghij	11.30±0.53 efghijk	37.2±2.91 mno
21	PWT 21	42.1±1.59 defghijkl	3.4±0.40 fghijklm	10.40±0.93 ghijklmn	42.9±3.04 bcdefghi
22	PWT 22	50.1±3.18 a	4.1±0.53 bcdefghij	10.40±0.93 ghijklmn	34.3±3.57 o
23	PWT 23	45±0.13 bcde	5.0±0.93 abcd	11.10±0.26 efghijkl	37.9±3.44 lmn
24	PWT 25	46.3±1.98 bc	4.4±0.40 abcdefghij	9.70±0.66 jklmn	39.3±2.38 ijklm
25	PWT 26	46.2±1.19 bc	4.4±0.00 abcdefghij	10.30±0.79 hijklmn	38.8±1.95 jklmn
26	PWT 27	40.3±2.51 ghijklm	4.5±0.79 abcdefghij	12.40±0.93 bcdef	42.3±0.53 cdefghij
27	PWT 28	42±0.66 defghijkl	4.1±0.26 abcdefghij	**13.70±1.72 abc**	39.7±1.72 ghijklm
28	PWT 29	43.4±1.06 bcdefghi	4.7±0.66 abcdefg	11.00±0.66 efghijkl	40.1±1.19 fghijklm
29	PWT 30	41.6±1.98 defghijkl	3.9±0.26 cdefghij	10.90±0.40 efghijkl	43.3±0.53 bcdefgh
30	PWT 31	41±0.27 fghijklm	3.8±0.13 cdefghij	12.50±1.19 bcde	41.9±2.25 defghijk
31	PWT 32	44.8±0.53 bcdef	5.3±1.06 ab	10.10±0.40 ijklmn	39.6±3.17 hijklm
32	PWT 33	39.4±1.32 jklm	4.5±0.26 abcdefgh	12.10±0.93 cdefg	43.7±1.46 bcdef
33	PWT 34	38.5±1.19 lm	3.6±0.40 defghijk	10.50±0.13 ghijklmn	44.1±1.59 bcde
34	PWT 35	41.7±1.19 defghijkl	4.3±0.26 abcdefghij	11.10±0.40 efghijkl	42.7±1.19 cdefghi
35	PWT 36	43.4±0.93 bcdefghi	4.8±0.66 abcdef	10.40±0.40 ghijklmn	41.2±1.72 efghijkl
36	PWT 37	39.8±1.06 ijklm	4.3±0.40 abcdefghij	11.70±1.06 defghi	42.3±0.93 cdefghlj
37	PWT 38	41.6±1.19 defghijkl	4.5±0.53 abcdefghi	11.30±0.40 efghijk	42.3±2.12 cdefghlj
38	PWT 39	41.3±1.19 efghijkl	4.9±0.93 abcde	11.20±0.79 efghijk	42.5±3.44 cdefghlj
39	PWT 40	33.5±3.18 o	5.1±0.40 abc	13.80±1.46 ab	46.1±0.53 abc
40	PWT 41	39.1±1.59 klm	5.5±1.32 a	14.70±1.72 a	37.9±1.59 lmn
41	PWT 42	39.9±3.04 ijklm	4.3±0.26 abcdefghij	13.30±0.26 abcd	42.1±0.66 defghij
42	PWT 43	43.4±0.93 bcdefghi	4±0.40 bcdefghij	9.40±0.93 lmn	42.9±1.19 bcdefghi
43	PWT-44	30.2±3.84 p	4.6±0.66 abcdefgh	13.30±0.40 abcd	41.5±1.46 defghijkl
44	PWT-45	43±1.72 cdefghij	4.4±0.26 abcdefghi	10.10±0.53 ijklmn	42±1.72 defghij
45	Lady Godiva	45.1±2.25 bcde	3.3±0.66 ijklm	10.30±0.53 hijklmn	41.2±1.72 efghijkl
46	PCK-1	44.8±0.93 bcdef	2.2±0.53 m	9.40±0.13 lmn	43.4±0.26 bcdefgh
	Mean	41.29	4.07	10.97	41.64

[A] *Mean± SD (Standard deviation); values labeled with different letters are significantly different from the control level by Duncan test at 95.0% confidence.*

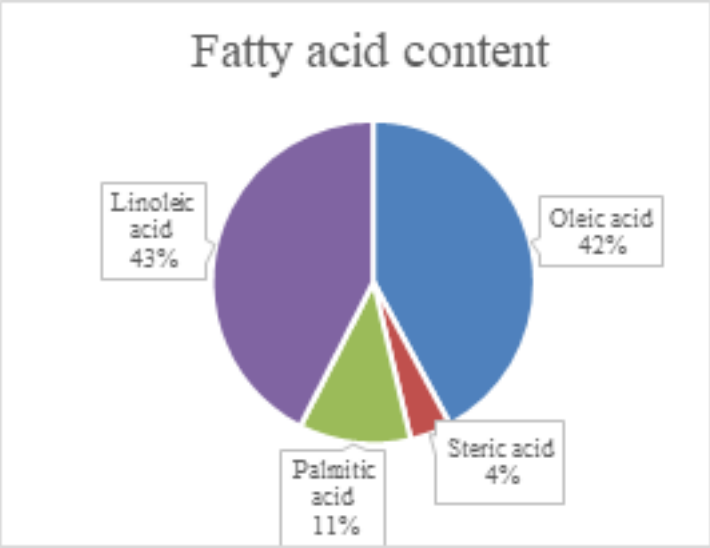

Figure 2: Average fatty acid content in oil samples of 46 pumpkin genotypes

PWT-20 (46.9%), PWT-25 (46.3%) and PWT-26 (46.2%), whilst, PWT-19(22.9%) was having the least value for oleic acid content followed by PWT-44 (30.2%) and PWT-40(33.5%). However, PWT-41 (5.5%) was having highest stearic acid content followed by PWT-32 (5.3%) and PWT-40 (5.1%). On the other hand, PWT-46 (2.2%) has developed minimum value for stearic acid content followed by PWT-16 (2.4%) and PWT-10 (2.4%). In palmitic acid, PWT-41 (14.70%) was on the top among all 46 genotypes followed by PWT-40 (13.80%) and PWT-28 (13.70%), whereas, PWT-12 (6.6%) was lowest yielder of palmitic acid followed by PWT-16 (7.6%) and PWT-4 (8.8%). PWT-14 (48.3%) developed maximum value for linoleic acid followed by PWT-15 (46.6%) and PWT-40 (46.1%). Nevertheless, PWT-22 (34.3%) was at the bottom among all the genotypes followed by PWT-16 (35.6%) and PWT-20 (37.2%) for linoleic acid content.

Hull-less seed cultivars were enriched with oil having abundance of fatty acids. Its fatty acid composition was affected by many aspects such as the genotype, growth conditions (area and climate) and the harvesting stage (Schuster *et al*, 1983). The total saturated and unsaturated fatty acid content was nearly similar to Ardabili *et al* (2011) reported 19.4% saturated and 10.7% unsaturated fatty acid content and the result pattern was resembling to Stevenson *et al (*2007). Earlier analysis of various hull-less pumpkin seed oils reported that unsaturated fatty acids, linoleic acid (43.1-55.6%) percentage was more than oleic acid (20.4-37.8%) (Lazos, 1986), but Ardabili *et al* (2007) has reported linoleic acid and oleic acid at negligible difference similar to present study outcomes.

CONCLUSION

Hull-less pumpkin seeds contain many nutritional components and they are rich source of oil content, which contain four major fatty acids (oleic, stearic, palmitic and linoleic acid). In this experiment, results revealed that the unsaturated fatty acids (82.93% linoleic and oleic acid) are significantly higher in quantity than saturated fatty acids (15.04% palmitic and stearic acid). On an average basis, they have higher linoleic acid content as compared to oleic acid.

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Received on 31/7/2024 Accepted on 5/10/2024

J Krishi Vigyan 2024, 12(4) : 928-931
DOI : 10.5958/2349-4433.2024.00159.0
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Seedling Root Dip in Phosphorus and Micronutrient Treatment in Lowland Rice Based Cropping System in Lawngtlai District Mizoram

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ABSTRACT

A field experiment has been conducted with high yielding variety of rice (cv RCM 6) during 2023-24 *kharif* season to determine impact of Phosphorus (P) treatment in association with vermicompost and seedling root dip in PSB on length of root at 30 and 45 day after transplanting, height of the plant, number of tiller per hill at 30, 45, 60 DAT and at harvest including seed yield. The experiment was carried out at Sihtlangpui, Krishi Vigyan Kendra Farm, Lawngtlai district, Mizoram. The height of the crop was significantly higher as 72.6, 112.3, 145.6 and 144.6 cm at 30, 45, 60 days after transplant and at harvest respectively in T3 over control and T2. The same trend was seen in number of tillers per hill. The length of the root also increased significantly from control at 30 and 45 DAT. The highest yield (4.9 t/ha) was observed in T3- Seedling root dip + Vermicompost + RDF which was significantly higher over control. It was evident that dipping the seedling root in Phosphorus Solubilizing Bacteria (500ml/L) mixed well with 5kg compost incorporated with recommended dose of fertilizer (80:60:40 NPK/ha) and vermicompost (10t/ha) during land preparation resulted in highest yield and could be recommended to farmers to augment the yield of lowland rice in Lawngtlai distict.

Key Words: Height, Phosphorus Solubilizing Bacteria, Tillers, Vermicompost, Yield.

INTRODUCTION

Rice is a *Kharif* season crop adapted to warmer region during the monsoon season. It is mainly grown from June to September. In India the maximum rice producing states includes Odisha, West Bengal, Bihar, Andhra Pradesh, Uttar Pradesh, Punjab, Chhattisgarh and Tamil Nadu with production of 7.168 million MT during 2019-20 which constitute 7.42% and 6.03% respectively to the total area as well as production of rice in India (Laitonjam *et al*, 2022). Mizoram is a hilly state of North East India sharing International border with Myanmar and Bangladesh as well as national border with Tripura, Assam and Manipur. Lawngtlai District is situated at the South end of the State. It is located between the coordinates of 92.30^0 -93^0 E Longitude and 21.58^0 – 22.60^0 N latitudes. The distance from the capital Aizawl is 296 kms with an area of 2557.10 sq.km and is covering 12.13 per cent area of the State (Bhalerao *et al,* 2015). The weather in Lawngtlai district is ideal for growing rice crop with temperatures ranging from 8-24^0C during winter and 18-32^0C during summer months. The average annual rainfall is 2,947mm.

Phosphorus is a primary and essential element for the growth of plant and development. However, large portion of it is unavailable for uptake by crops as it gets fixed (50-90% of added P fertilizer) in the soil and remain in insoluble pool especially in acidic soil of North East India. The Phosphorus remains fixed in the form of insoluble phosphates of Fe^{+2} and Al^{+3} in acidic soil (Kalidas and Thakuria, 2018). This phosphorus fixation leads to low P efficiency, as low as 15-20%. The use of phosphate solubilizing microbes perform an important vital role in solubilizing the insoluble form of phosphorus. Inoculating the roots of the crop with Phosphorus Solubilizing Bacteria and other microbial inoculants in these soil became necessary and advised to maintain and also restore the effective microbial population for solubilizing the fixed phosphorus to produce sustainable yield of rice crop (Raghuveer *et al,* 2015). They further reported that increase in phosphorus level increased the dry matter yield and this can be

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explained from better root proliferation of P treated crops. Similarly, Kalidas and Thakuria (2018) also reported that dipping rice seedling root in compost microbe slurry before transplanting enhances rice yield. Verma *et al* (2017), Koushik *et al* (2021), Ramteke *et al* (2018) reported that incorporating integrated nutrient management with inorganic and organic nutrient management practice gave best and higher yield in lowland rice as well as better biological and physical health of the soil. Thus, the present analysis was undertaken to study the length of the plant root, number of tiller per hill present, height of the crop, and lowland rice yield as affected by phosphorus treatment coupled with other nutrient management practices as well as microbial inoculation of root of rice.

MATERIALS AND METHODS

The experiment was conducted at the field located at Sihtlangpui, KVK Research and Demonstration Farm during the year 2023-24 to study the impact of different amount of Phosphorus treatments in Lowland Paddy at Lawngtlai District. The study area is situated at 22°25'2"N 92°56'12"E. The Experimental field has clay loam textured soil with moderate to high acidic soil (5.2 pH) possessing relatively high Organic Carbon content (1.19%). The chemical analysis of the soil (top 15 cm) showed available nitrogen (188.16kg/ha) determined by Alkaline Potassium permanganate ($KMnO_4$) method, Phosphorus (42.7kg/ha) determined by Bray P1 method and Potassium (724 kg/ha) by Flame photometer (Jackson, 1973). This experimental study was set out in randomized block design (RBD) with three treatments viz., T1- Control, T2- Phosphorus root dip + Vermicompost, T3- Phosphorus root dip + Vermicompost + RDF with three replications (R1, R2 and R3). Recommended dose of fertilizer (80:60:40 NPK/ha) was applied on T3 at transplanting period while nitrogen has been applied in split doses, by broadcasting at 30 and 45 days after transplanting. Well rotten vermicompost (10t/ha) was applied at land preparation in T2 and T3. Similarly, root dipping is done in Phosphorus Solubilizing Bacteria (500ml/L) for 1 hour right before transplanting mixed with well rotten compost (5kg) slurry. The length of the root was recorded at 30 and 45 DAT to check the effect of root dipping in Phosphorus, the height of the plant was measured at 30, 45, 60 DAT as well as at harvest period. Similarly, the number of tillers is recorded at 30, 45, 60 DAT and then when harvested. The data of yield were recorded at harvest *i.e.,* 91 DAT. The statistical analysis was done with one-way ANOVA through statistical software OPSTAT developed by CCS HAU, Hisar (Sheoran *et al,* 1998) and Statistical Error Mean (SEm±) and critical differences were computed.

RESULTS AND DISCUSSION

Length of the root

The length of the root measured after 30 days after transplanting showed significant increase over control (Table 2). Length of the root in control was 11.6cm whereas in T2 and T3 the length of the root was 13cm and 16cm, respectively. Similarly, the length of the root measured at 45 days after transplanting also showed gradual increase over control ranging from 27.3 cm to 31.6 cm. This could very well be the result of positive impact of dipping the root in PSB solution. This finding was in line with Verma *et al* (2017), Singh and Thakuria (2018), Aung *et al* (2020).

Height of the plant

The height of rice crop at 30 DAT ranges between 54.6 to 72.6 cm which were statistically comparable ($p>0.05$, 1 way ANOVA). Similarly, the 45 DAT plant height ranged from 76 to 112.3 cm and 94.6 to 145.6 cm at 60 DAT as well as 95 to 144.6 cm during harvest. The height of the plant gradually and significantly increased with increase in dose of nutrients from Control (T1) to Phosphorus root dip + Vermicompost + RDF (T3). This can be attributed to higher availability of plant growth promoting nutrients with advancing dose of treatments. These findings validated the findings of Meena *et al* (2015)

Number of tillers/hill[1]

The data showed that the number of tillers per hill increased gradually till 45 days after transplanting and a decreasing trend at 60 days after transplanting following increase at the day of

Table 1. Plant height and Numberof tillers/hill at 30, 45, 60 DAT and at the time of harvest in paddy under different treatments

Treatment	Plant height (c m)				Number of tillers/hill			
	30DAT	45DAT	60DAT	Harvest	30DAT	45DAT	60DAT	Harvest
T1	54.6	76	94.6	95	10.3	14.3	11.6	16.3
T2	60.3	82.6	105.6	108.3	11	14.6	12.3	17.6
T3	72.6	112.3	145.6	144.6	12.3	16.3	14.6	26
SEm±	2.06	3.92	3.13	2.95	0.30	0.60	0.45	1.65
CD@5%	8.32	15.81	12.64	11.9	1.25	NS	1.82	6.65

Table 2. Data of Length of Root at 30 and 45 DAT and Yield at harvest

Treatment	Length of Root (cm)		Yield (t/ha)
	30 DAT	45 DAT	Harvest
T1	11.6	27.3	2.5
T2	13	29	3.3
T3	16	31.6	4.9
SEm±	0.60	0.94	0.17
CD@5%	2.45	NS	0.72

harvest (Table 1). The decreasing trend can be attributed to aging and senescence resulting to drying of secondary and tertiary tillers. The highest tiller number per hill was recorded against the combined application of Phosphorus seedling root dip + Vermicompost + RDF (T3) at varying stages of crop development. The magnitude of increase over control were 17%, 13%, 22% and 45% at 30, 45, 60 DAT and at the time of harvest respectively. This increase in number of tillers could be due to better supply of phosphorus (P) with other nutrients and bio organic sources efficiently utilized by rice crop for better growth, multiplication and development of cells. Similar findings were reported by Haque (2021).

Seed yield

The highest grain yield was recorded against treatment with Phosphorus seedling root dip + Vermicompost + RDF which was 4.9 t/ha which exhibited a superiority of 64% and 39% over Control and Seedling root dip + Vermicompost treatment (Table 2). The seed yield showed a gradual significant increase with advance in treatment (T1<T2<T3). This can be attributed to higher photosynthetic activity due to higher leaf area and number of effective tillers ultimately resulting in higher dry matter production which directly lead to higher seed yield. Similar opinion was asserted by (Hague, 2021; Bayan and Lourduraj 2000.

CONCLUSION

It was concluded from the present investigation that incorporating vermicompost in soil and treating the root of rice crop with effective microbes like Phosphorus Solubilizing Bacteria (PSB) along with augmenting with recommended dose of fertilizer shows better yield and could be recommended to farmers.

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Received on 26/8/2024 Accepted on 15/10/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 932-940

DOI : 10.5958/2349-4433.2024.00160.1

Socio-Behavioural Attributes Regarding Detection of Milk Adulteration in Barnala District of Punjab

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ABSTRACT

The study was undertaken in Dhaner village of Barnala district of Punjab in which beneficiary farmers were selected for investigating their socio-behavioural attributes regarding detection of milk adulteration. The results elucidated that the mean age of farmers was 44.16 yrs, majority of the farmers were functionally literate whereby able to read and write Punjabi, had both agriculture and dairying as their occupation with mean land holding of 2.75 ha and herd size of 5.16 animals. Majority of farmers were having high level of perception and medium level of knowledge regarding detection of milk adulteration. There was a wide range of constraints which were analyzed using Garrett's Ranking Technique. Relational analysis suggested that perception varied significantly ($p<0.05$) with experience in dairy farming, herd size and per animal milk production. In case of knowledge, significant relationship ($p<0.05$) was established between age, education, experience in dairy farming, herd size and per animal milk production. The study concluded that detection of milk adulteration is not only vital for consumers but for producers as well for quality assurance. For building capacities of the farmers regarding detection of adulteration, multifarious extension activities may be carried out.

Key Words: Adulteration, Dairy, Detection, Farmer, Socio-behaviour.

INTRODUCTION

Detection of milk adulteration is influenced by socio-behavioural attributes that shape the perceptions, knowledge, and practices toward identifying and addressing the issue. These attributes involve social, cultural, economic, and psychological factors that affect awareness and action regarding milk adulteration. Many people, especially in rural or economically disadvantaged areas, may lack awareness about milk adulteration and its health risks. Higher awareness levels are often found in urban populations, who may have better access to information. Individuals may not know simple detection methods, such as using lactometer or household tests (Das *et al,* 2016). Education on these tests significantly impacts the ability to detect adulteration. People with high income and education may be more inclined to purchase branded milk products that are perceived to be safer and may also invest in testing kits or equipment. The intention to test milk for adulteration depends on the perceived ease and importance of testing (Kumari *et al,* 2020). In this study, the socio-behavioural attributes of the respondents regarding detection of milk adulteration have been investigated to understand their perception, knowledge and constraints regarding detection of milk adulteration.

MATERIALS AND METHODS

An *ex-post facto* research design was used to investigate the various socio-personal attributes of the respondents regarding detection of milk adulteration. A village namely Dhaner from Barnala district of Punjab was selected as the interventions related with value addition of milk was undertaken only in the said village. The random sampling method was used to select a total of 30 respondents which were investigated for the various socio-behavioural attributes like age, education, occupation, land holding, experience in dairying, perception, knowledge and constraints faced by them regarding detection of milk

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Table 1. Distribution of respondents according to age, education and occupation.

Sr. No.	Parameter	Frequency (N=30)	Percentage
1.	**Age (Years)**		
	Young 20-40	11	36.67
	Middle 40-60	17	56.67
	Old More than 60	2	6.67
2.	**Education**		
	Illiterate	3	10.00
	Functionally literate	16	53.33
	Primary	5	16.67
	High School	6	20.00
3.	**Occupation**		
	Agriculture only	3	10.00
	Agriculture and dairying	18	60.00
	Dairying only	9	30.00

adulteration. The primary data were collected using a pre-tested semi-structured interview schedule. The data were analyzed using various statistical tests like frequency, percentage, mean, standard error, mean score, etc. The mean score was calculated by the formula used by Singh *et al* (2023) in equation 1.

$$Mean\ Score = \frac{Obtained\ Score}{Total\ Obtainable\ Score}$$

The relationship between the variables was established using correlation and regression. Furthermore, Garett's Ranking Technique was used to rank the felt constraints. The Garrett's Ranking Technique was used in which formula given in equation 2 was used to calculate the percent position

$$Percent\ Position = \frac{100(Rij-0.5)}{Nj}$$

Where,

Rij = Rank given for the i^{th} variable by j^{th} respondents

Nj = Number of variables ranked by j^{th} respondents

Further, subjected to calculation of scores using Garrett Table.

RESULTS AND DISCUSSION

Socio-personal attributes

The results revealed that the mean age of the respondents was 44.16 yrs (Table 1). The majority of the respondents (56.67%) were middle aged followed by 36.67 per cent young and 6.67 per cent old aged respondents. The results were in concurrence with those reported by Singh *et al* (2020a) in which the mean age was found to be 47.78 yrs. Further, the results were in partial concurrence with those reported by Shelly *et al* (2024).

It was found that majority of the respondents (53.33%) were functionally literate which means that they were able to read and write in local language which was Punjabi. Around 20 per cent of the respondents were high school graduates and only 10 per cent were illiterates. It was inferred from the results that the respondents can be made more aware about the detection of milk adulteration by providing them literature in local language. The same fact was reported by Singh *et al* (2024a) wherein it was suggested that education and awareness can lead to accelerated adoption of technologies.

Further, majority of the respondents (60%) were having the combination of agriculture and

Table 2. Distribution of respondents according to type and size of family.

Sr. No.	Parameter	Frequency (N=30)	Percentage
1.	**Type of family**		
	Joint	5	16.67
	Nuclear	25	83.33
2.	**Size of family**		
	Small (2-4 members)	10	33.33
	Medium (5-7 members)	16	53.33
	Large (7-10 members)	4	13.33
	Mean±SE, 5.40±0.29		
3.	**Landholding** (in ha)		
	Landless, Nil	10	33.33
	Marginal, <1	10	33.33
	Small, 1-2	9	30.00
	Semi-medium, 2-4	0	0.00
	Medium, 4-10	1	3.33
	Large, >10	0	0.00
	Mean±SE, 2.75±0.13		

Table 3. Distribution of respondents according to experience in dairy farming

Sr. No.	Experience in dairy farming	Years	Frequency (N=30)	Percentage
1.	Low	0-7	2	6.67
2.	Medium	8-14	8	26.67
3.	High	15-21	20	66.67
4.	Mean±SE	15.00±0.98		

Table 4. Distribution of respondents according to herd size.

Sr. No.	Parameter	Number of animals	Frequency (N=30)	Percentage
A.	**Herd size**			
	Small	0-4	13	43.33
	Medium	5-8	16	53.33
	Large	9-12	1	3.33
	Mean±SE	5.16±0.43		
B.	**In-milk animals**			
	Low	0-1	10	33.33
	Medium	2-3	18	60.00
	High	3-6	2	6.67
	Mean±SE	2.00±0.17		

dairying as their primary occupation. This combination was common in many agrarian states of the country as livestock provides daily income to the farmers and supports the rural economy and the results were in line with those reported by Singh *et al* (2020a) and Joshi *et al* (2022).

Table 5. Milk related statistics

Sr. No.	Parameter	Mean±SE (l)
1.	Milk produced per animal /day	8.80±0.42
2.	Milk produced on farm /day	17.70±0.67
3.	Milk produced per animal /lactation	2684.00±130.30
4.	Milk sold /day	14.06±1.34
5.	Milk retained /day	3.33±0.15
6.	Annual income /farm from sale of milk (in Rs.)	205373±19673

Table 6. Distribution of respondents according to their perception regarding detection of milk adulteration.

S.No.	Perception Item	Agree	Neutral	Disagree	OS	MS	Rank
1	The milk adulteration kit is easy to understand and use.	30 (100)	0 (0.00)	0 (0.00)	60	1.00	I
2	Milk adulteration can be checked rapidly using the kit.	30 (100)	0 (0.00)	0 (0.00)	60	1.00	I
3	The reagents in the test kit are easy to store and long - lasting.	30 (100)	0 (0.00)	0 (0.00)	60	1.00	I
4	The awareness camps organized by the Veterinary University, Ludhiana helped in understanding and using milk adulteration kits.	28 (93.33)	2 (6.67)	0 (0.00)	58	0.97	II
5	Milk adulteration is a serious problem during festivals.	27 (90.00)	3 (10.00)	0 (0.00)	57	0.95	III
6	It is easy and economical to test milk adulteration at home.	27 (90.00)	3 (10.00)	0 (0.00)	57	0.95	III
7	The milk available in the market is safe for consumption.	0 (0.00)	30 (100)	0 (0.00)	30	0.50	IV
8	The test kit is easily available.	0 (0.00)	30 (100)	0 (0.00)	30	0.50	IV
9	The test results can be replicated again and again.	2 (6.67)	28 (93.33)	0 (0.00)	28	0.47	V
10	Milk vendors distribute safe and unadulterated milk.	0 (0.00)	22 (73.33)	8 (26.67)	22	0.37	VI

Figures in the parenthesis denotes percentage; OS: Obtained Score; MS: Mean Score

Likewise, majority of the respondents (83.33%) were dwelling in nuclear family which was prevalent type of family structure in the country (Table 2). The mean number of family members in a family in the study area was found to be 5.40. The results revealed that majority of the

respondents (53.33%) had medium size of family with 5 to 7 members which primarily included husband, wife, children and one or both of the parents. The findings were in line with those reported by Singh *et al* (2018a) and Singh *et al* (2024a).

The perusal of land holding of the respondents revealed mean landholding to be 2.75 ha. Around 33.33 percent of respondents were landless and similar number were found to be marginal with land holding of less than one ha. Only 3.33 per cent of the respondents were having medium size of land holding (Table 2). The findings were in line with those reported by Singh *et al* (2020a) and Shelly *et al* (2024).

The study was conducted regarding milk adulteration and the experience in dairy farming was also taken as a variable. After analysis, it was found that the mean experience of the respondents was 15 years and majority of the respondents (66.67%) were having high level of experience of more than 15 years in dairy farming (Table 3). This may be due to the fact that in rural set-ups agriculture and dairy farming are still the age-old occupations and the herd owned by a family is transcended from one generation to another.

As far as herd size of the respondents was concerned, the mean was calculated to 5.16 animals (Table 4). Majority of the respondents (53.33%) were having medium level of herd size. Reduction in number of farm families rearing livestock and number of livestock heads in rural areas of Punjab is a matter of concern.

In-milk animals refer to the dairy animals which were giving milk during the investigation. The perusal of Table 4 revealed that the majority of the respondents (60.00%) were having 2 to 3 animals in milk. However, the mean number of in-milk animals in the study area were calculated to 2.00. The data were collected for milk production attributes as well and presented in Table 5. The means of production attributes were calculated and was found that the average milk produced per animal per day in the study area was 8.80 l. The average milk produced on one farm per day was 17.70 l. In one lactation cycle of 305 d, the average milk produced per animal was 2684 l. The respondents reportedly sold 14.06 l of milk per day whereas around 3.33 l of milk was retained per farm family. The annual income per farm family from sale of milk was Rs. 205373/-. The milk related statistics are in line with those reported by Singh *et al* (2024b), wherein the income of the dairy farmers was calculated taking into consideration the milk production by the animals and the mean income of the small dairy farmers were calculated to be around Rs. 2.75 lakh.

Behavioural attributes

Perception regarding detection of milk adulteration

The respondents were asked regarding their perception on detection of milk adulteration and found that all the respondents agreed to the fact that milk adulteration kit was easy to use, adulteration can be checked rapidly using the kit and reagents in the kits were easy to store and long lasting. These perception items were ranked I with Mean Score (MS) of 1.00 (Table 6). All the respondents were having neutral perception for the fact that milk available in the market was safe for consumption and test kit was easily available. The MS for both the items was 0.50. Further, among all the perception items, lowest perception was calculated for the fact that milk vendors distribute safe and unadulterated milk.

The level of perception was also calculated for the respondents and results revealed that majority of the respondents (60%) were having level of perception regarding detection of milk adulteration, followed by 30 percent with low and 10 percent with high perception. Perception is one behavioural attribute which gives the reflection about an individual. Perception form opinion and opinion leads to acceptance of a technology (Singh *et al,* 2023), therefore, an agreeing perception for any technology gives an indication about its acceptance which in the present case is milk adulteration kit.

Table 7. Distribution of respondents according to their knowledge regarding detection of milk adulteration

S.No.	Knowledge Item	Obtained Score	Mean Score
1	Hydrogen peroxide is permitted as a preservative in milk.	0	0.00
2	How many drops of reagent are added to the milk sample to be tested for starch?	0	0.00
3	Adulterated milk can be checked by smell and appearance.	8	0.27
4	Stripes can be used to test milk adulteration.	26	0.87
5	Name the colour obtained if milk is adulterated with urea?	27	0.90
6	Sugar upon confirmation gives a yellow colour in the milk.	27	0.90
7	Name the colour obtained if milk is adulterated with starch?	28	0.93
8	Whether heating of milk is required for starch or not?	28	0.93
9	What are the sources of starch contaminants in milk from a household?	30	1.00
10	Name two commonly used milk adulterants?	30	1.00

Knowledge regarding detection of milk adulteration

An analysis regarding knowledge on milk adulteration was done and Mean Score (MS) was calculated for the knowledge items, the results of which are presented in Table 7. Items with high MS signifies high correct responses for that knowledge item. A MS of 1.00 was calculated for two commonly used milk adulterants and sources of starch contaminants in milk, which means that all the respondents correctly replied to this knowledge item. However, zero MS was calculated for knowledge item on hydrogen peroxide as preservative in milk and drops of reagent added to the milk for testing starch which means that none of the respondents replied these items correctly.

The overall knowledge regarding milk adulteration was calculated and it was found that majority of the respondents (70%) were having medium level of knowledge followed by 23.33 percent with high knowledge and 6.67 percent with low level of knowledge. The results obtained was found to be good as the Farmer FIRST Project was being implemented in the said village since 2016 and respondents visited the camps and trainings organized. Moreover, Shelly *et al* (2024) has commented that trainings play a vital role in augmenting the knowledge of the beneficiaries. Further supplemented by studies by Kumari *et al* (2020) and Brar *et al* (2021). Induja *et al* (2024) has reported that the lack of information on value addition of milk is also one of the felt constraint when milk processing is considered.

Constraints regarding detection of milk adulteration

For analyzing the constraints perceived by the respondents regarding detection of milk adulteration, around 10 constraints were documented and analyzed, for which the results are presented in Table 8. The Garrett Analysis was done for better understanding of the perceived constraints. It was found that limited shelf life of kits with Garrett Mean Score (GMS) of 75.20 was highly perceived constraint followed by detection of few adulterants by the test kits, unavailability of other testing material like stripes, difficulty in interpretation, lengthy test procedures, inability of test kits to detect adulteration in milk products, difficulty in obtaining test kits, difficulty in using test kits, cost of the kit and less number of trainings and literature on milk adulteration. In general, the

Table 8. Constraints faced by the respondents regarding detection of milk adulteration

S.No.	Constraint	TGS	GMS	Garrett Rank
1.	Limited shelf life of kits.	2256	75.20	I
2.	Test kits detect very few adulterants.	1923	64.10	II
3.	Unavailability of other testing material like stripes	1873	62.43	III
4.	Tests are difficult to interpret.	1632	54.40	IV
5.	Test procedures are lengthy.	1570	52.33	V
6.	Test kits do not detect adulteration in milk products.	1514	50.47	VI
7.	The test kit is not easily accessible.	1206	40.20	VII
8.	A test kit is difficult to use.	1134	37.80	VIII
9.	The test kit is costly.	933	31.10	IX
10.	Less trainings and literature on milk adulteration	540	18.00	X

TGS: Total Garrett Score; GMS: Garrett Mean Score

detection of milk adulteration in itself is a constraint due to unavailability of test kits as reported by Singh *et al* (2018b).

Relational analysis

As the current study was based on the perception of the respondents, a relational analysis was made between the dependent and independent variables presented in Table 9. It was found that all the independent variables viz. age, education, type of family, size of family, land holding, experience in dairy farming and herd size except per animal milk production was having positive correlation with the dependent variable i.e. perception regarding milk adulteration. Experience in dairy farming, herd size and per animal milk production were having significant correlation and regression with the dependent variable. The herd size is positively regressing on perception which means that if the herd size increases by 0.083 units, the perception regarding milk adulteration becomes more favourable and increases by one unit.

The relationship analysis was also calculated between independent variables and knowledge regarding detection of milk adulteration (Table 9). A positive correlation was found between all the variables and perception. A significant correlation was found between age, experience in dairy farming, herd size and per animal milk production. A highly significant correlation was found between education and knowledge. The regression for all the variables on perception was found to be positive. Education, experience in dairy farming and per animal milk production was found to be significantly regressing on perception regarding milk adulteration. The results revealed that increase in education by 0.220, experience in dairy farming by 0.407 and per animal milk production by 0.242 units increases perception by one unit.

CONCLUSION

Socio-behavioural factors significantly influence the detection of milk adulteration. Addressing these attributes through education, awareness programs, community initiatives, and providing affordable detection tools can enhance public engagement and empower consumers to take active steps in ensuring milk safety. Moreover, the detection of adulteration is not only important for consumers but also for the producers to meet up the quality requirements. Although the respondents in the study area were sensitized and trained for detection of milk adulteration using

Table 9. Relational analysis of dependent and independent variables

Parameter	Perception		Knowledge	
Independent variable	r	B	r	B
Age	0.043	0.012	0.330*	0.031
Education	0.024	0.026	0.374**	0.220*
Type of family	0.098	0.090	0.098	-0.235
Size of family	0.065	0.196	0.059	-0.258
Land holding	0.150	0.086	0.158	0.212
Experience in dairy farming	0.205*	0.033*	0.211*	0.407*
Herd size	0.309*	0.083*	0.386*	0.065
Per animal milk production	-0.183*	-0.182**	0.242*	0.294*

**Significant at 5% level of significance;*
*** significant at 1% level of significance; r: Correlation coefficient; B: Regression coefficient*

adulteration kit developed by Guru Angad Dev Veterinary & Animal Sciences University, Ludhiana, Punjab, there is need to replicate the same model to other villages of the region as well, through multifarious extension activities.

ACKNOWLEDGEMENT

The authors acknowledge the support from Director, ICAR-ATARI Zone 1, Ludhiana for implementation of the Farmer FIRST Programme. Further, the financial support from ICAR, New Delhi is highly acknowledged.

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Received 15/10/2024 on Accepted on 21/11/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 941-946

DOI : 10.5958/2349-4433.2024.00161.8

Socio-Personal and ICT Engagement Factors among Postgraduate Students of Acharya N.G. Ranga Agricultural University

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ABSTRACT

Information and Communication Technologies (ICTs) have significantly transformed educational environments, offering new possibilities for learning and collaboration. However, their effectiveness differs among students due to socio-personal and ICT engagement factors. This study evaluated these factors among postgraduate students at Acharya N.G. Ranga Agricultural University (ANGRAU) in Andhra Pradesh. Conducted during 2022-2023 with an ex-post facto research design, the study involved students from the university's colleges of Agriculture, Agricultural Engineering & Technology, and Community Sciences. A total of 120 students were selected using proportionate random sampling. Data on socio-personal and ICT engagement factors were gathered through an interview schedule and analyzed using descriptive statistics, including mean, standard deviation, frequency, and percentage. The results showed a higher representation of female students and a medium level of ICT tool knowledge. Although students exhibit high awareness of ICT services, they underutilized these tools for academic purposes. ICTs were primarily used for online lectures and entertainment, with minimal engagement in formal online courses. The study recommends enhancing advanced ICT training, improving resource accessibility, and better integrating ICT into educational frameworks. Future research should assess the effectiveness of these interventions and develop strategies to maximize ICT's impact on postgraduate academic success.

Key Words: ICT, Postgraduate students, Socio-Personal, ICT engagement factors

INTRODUCTION

In the contemporary era, Information and Communication Technologies (ICTs) have become integral to the advancement of education, playing a vital role in improving academic performance and supporting scholarly activities (Liaw *et al*,2007). These technologies, encompassing a broad range of hardware, software, and digital tools including video and audio equipment have revolutionized the way information is processed, communicated, and utilized (Singh *et al,*2021). As institutions of higher learning, universities are pivotal in equipping students with the intellectual tools necessary for academic success, and libraries within these institutions have evolved from relying solely on static print materials to embracing dynamic and flexible online resources. In Agricultural Universities, postgraduate students increasingly depend on ICTs to facilitate their research, coursework, and collaborative projects (Gaikwad *et al*,2016). Despite the widespread integration of these technologies into the academic environment, the effectiveness of ICT utilization varies significantly among students. This variability is influenced by a range of socio-personal factors, including but not limited to gender, educational background, family income, and residential location. Additionally, ICT engagement factors such as the level of knowledge about ICT tools, accessibility, and the purpose and extent of ICT usage play a critical role in determining how these technologies impact academic performance.

Understanding the interplay between socio-personal characteristics and ICT

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engagement is crucial for identifying barriers and opportunities in educational settings. This research assessed these factors among postgraduate students at Agricultural University to provide a comprehensive analysis of how they influence academic excellence. The findings offered insights for educators and policymakers to enhance ICT integration and develop targeted support mechanisms. Ultimately, the study seeks to improve educational outcomes and academic success by leveraging a nuanced understanding of ICT utilization and socio-personal factors.

MATERIALS AND METHODS

The study was carried out in 2022-2023 by adopting an *ex-post facto* research design to explore the socio-personal and ICT engagement factors among postgraduate students at Acharya N.G. Ranga Agricultural University (ANGRAU). The university was purposefully selected due to its diverse postgraduate programs offered across various disciplines and colleges, making it an ideal setting for examining a wide range of socio-personal and ICT engagement factors. The study was conducted across several colleges within ANGRAU, specifically targeting the Colleges of Agriculture, Agricultural Engineering and Technology, and Community Sciences, all situated in Andhra Pradesh. The institutions included in the research were: the Agricultural Colleges in Bapatla, Tirupati, Mahanandi, and Naira; the College of Community Science in Guntur; and Dr. NTR College of Agricultural Engineering in Bapatla. These colleges were selected purposefully as they offer postgraduate programs, ensuring the study's relevance to the utilization of ICT tools among postgraduate education. A total of 120 postgraduate students were selected using a proportionate random sampling procedure. This method was employed to ensure that the sample was representative of the student populations across the different colleges and departments. Proportional representation from each institution facilitated a thorough analysis of both socio-personal characteristics and ICT engagement factors. The study examined a comprehensive set of variables categorized into two primary groups:

1. **Socio-Personal Characteristics:** Gender, medium of school education, parental education, family annual income, and residential background.
2. **ICT Engagement Factors:** Knowledge about ICT tools, accessibility of ICT tools, awareness of ICT services, purpose of internet use, expenditure on ICTs, experience with ICTs, time spent and purpose of using ICTs, courses studied through ICTs, and methods of learning internet skills.

Data were collected using a structured interview schedule designed to capture detailed information on these variables. The interview schedule was pre-tested to verify its reliability and validity, ensuring that it effectively gathered accurate and relevant data. Statistical analysis was performed on the collected data using descriptive techniques, including mean, standard deviation, frequency, and percentage. These techniques were employed to summarize the data and interpret patterns (Akhila *et al*, 2024 and Nasre *et al*, 2024) in socio-personal and ICT engagement factors, aiming to provide meaningful insights into how these factors influence ICT utilization and academic outcomes among postgraduate students.

RESUTS AND DISCUSSION

a) Socio-Personal Factors

The data (Table 1) indicated that over half of the respondents (55.83%) were female postgraduate students, compared to 44.17% male students. This gender distribution may reflect initiatives promoting female education or increased female interest in higher studies, as these findings were in agreement with Tamta and Ansari (2015). Regarding the medium of schooling, nearly two-thirds (64.17%) were educated in English, followed by Telugu (24.17%), with smaller proportions in Hindi (5.00%) and other languages (6.67%). This underscores the significance of English in higher education, suggesting a need for additional support for students from regional language backgrounds, aligning with Sharma and Hasan

Table 1. Distribution of postgraduate students according to their socio-personal factors (n= 120)

Sr. No	Variable	Category	Students	
			F	%
Socio - Personal Factors				
1	Gender	Male	53	44.17
		Female	67	55.83
2	Medium of school education	Telugu	29	24.17
		Hindi	6	5.00
		English	77	64.17
		Other	8	6.67
3	Education of parents	Illiterate	14	11.67
		Up to middle	24	20.00
		Higher secondary	30	25.00
		Graduation / Diploma	27	22.50
		Post graduation / Ph.D.	25	20.83
4	Family annual income	Low (< Rs. 2,00,000)	38	31.67
		Medium (Rs. 2,00,000 to Rs. 4,00,000)	53	44.1 7
		High (> Rs. 4,00,000)	29	24.17
5	Residential background	Rural	50	41.67
		Semi -urban	46	38.33
		Urban	24	20.00

* F=Frequency, %= Percentage

(2012). Parental education varied: 25.00% had higher secondary education, 22.50% had degrees or diplomas, 20.83% had postgraduate degrees or Ph.D., and 11.67% were illiterate. Higher parental education is linked with better academic support, consistent with Bello *et al*, (2017). Most students (44.17%) came from medium-income families, reflecting the economic constraints of rural areas. The residential background was balanced, with 41.67% from rural, 38.33% from semi-urban, and 20.00% from urban areas, highlighting challenges in resources and connectivity, as noted by Kumar (2009).

b) ICT Engagement Factors

Table 2 revealed that a significant majority of students (80.83%) were aware of ICT services, indicating a strong familiarity with digital tools, which is crucial for both academic and personal growth. However, there was still an opportunity to enhance awareness of advanced ICT tools such as statistical software and AI applications. Over half of the students (54.17%) possessed medium-level knowledge of ICT tools, 23.33% had high-level knowledge, and 22.50% had low-level knowledge. This suggested that while students were familiar with tools like Google Scholar and ResearchGate, there is room for improvement in utilizing advanced tools such as ChatGPT and statistical software, as noted in the study by Priyanka (2017). The data further revealed that 74.17% of students had medium accessibility to ICT tools, 15.83% had high access, and 10.00% had limited access, likely reflecting the availability of tools through university resources and free services, consistent with Mailavelan and Baskaran (2018). All students (100%) used the internet for entertainment, social networking, and banking, with significant portions also used it for knowledge enhancement (71.67%), research (65.83%), shopping (67.50%), and education (60.00%). However, only 46.67% used it for emailing, indicating a predominance of internet use for non-academic purposes. This pattern suggested that students might not be fully leveraging the internet's potential for educational

Table 2. Distribution of postgraduate students according to their ICT engagement factors (n= 120)

Sr. No	Variable	Category	Students	
			F	%
ICT Engagement Factors				
1	Awareness about ICTs services	Aware	97	80.83
		Not aware	23	19.17
2	Knowledge about ICTs tools	Low (< 3.83)	27	22.50
		Medium (3.83 to 10.05)	65	54.17
		High (>10.05)	28	23.33
3	Accessibility of ICTs tools	Less accessible (<30.98)	12	10.00
		Medium accessible (30.98 -39.06)	89	74.17
		Highly accessible (>39.06)	19	15.83
4	Purpose of internet use	For education	72	60.00
		For academics	72	60.00
		For enhancing knowledge	86	71.67
		For research work	79	65.83
		For entertainment	120	100.00
		For social networking	120	100.00
		For banking	120	100.00
		For shopping	81	67.50
		For sending emails	56	46.67
5	Expenditure incurred on use of ICTs	Low <314	24	20.00
		Medium 315-840	85	70.83
		High >840	11	9.17
6	Experience of ICTs use	6 months to 1 year	07	5.83
		1 to 2 years	18	15.00
		2 to 4 years	45	37.50
		More than 4 years	50	41.67
7	Time spent and purpose of using ICTs	Online live lectures (6 hrs per week)	111	92.50
		Live webinars (3 hrs per week)	78	65.00
		Classroom quizzes (2.5 hrs per week)	26	21.67
		Online exam preparation (5 hrs per week)	89	74.17
		Presentations (4.5 hrs per week)	99	82.50
8	Courses studied through ICTs	Studied any course	37	30.83
		Not studied any course	83	69.17
9	Method of learning internet skills	Trial and error	55	45.83
		Training from college officials	47	39.17
		Self-instruction	49	40.83
		Guidance from colleagues and friends	67	55.83
		Experts	68	43.33

* F=Frequency, %= Percentage

functions, aligning with findings from Chandrakar (2014).

Table 2 further showed that over two-thirds (70.83%) of students spent between Rs. 315 and Rs. 840 per month on ICT usage, indicated moderate expenditure on technology. Only 9.17% reported high expenditure (above Rs. 840), while 20.00% had low expenditure (below Rs. 314). This spending pattern may reflect costs related to smartphones, electronic devices, and subscription plans, with some students also investing in premium ICT tools like advanced paraphrasing tools and ChatGPT. Experience with ICTs varied: 41.67% had over four years, 37.50% had between two to four years, 15.00% had between one to two years, and 5.83% had six months to one year. This distribution aligned with their academic focus and interest in ICTs. Most students (92.50%) used ICTs for online live lectures, followed by 82.50% for presentations, 74.17% for exam preparation, 65.00% for webinars, and 21.67% for quizzes. Time spent weekly ranged from 6 hours for lectures to 2.30 hours for quizzes. Despite awareness, over two-thirds (69.17%) had not studied any courses through ICT, suggested underutilization of these tools. Common methods for acquiring internet skills included guidance from friends (55.83%) and self-instruction (40.83%), reflecting a preference for peer support and practical experience, results aligned with Beniwal (2016).

CONCLUSION

This study provided insights into socio-personal and ICT engagement factors among postgraduate students at Acharya N.G. Ranga Agricultural University (ANGRAU). It found a higher representation of females in postgraduate programs and that most students received education in English. Parental education levels varied, and most students came from medium-income families, potentially impacting their access to ICT resources. There was a balanced representation of rural and semi-urban students, aligned with the university's agricultural focus. While students demonstrated high awareness of ICT tools, their knowledge and access were moderate, highlighted the need for advanced training. Internet use was frequent for entertainment and social networking but limited for academic purposes. The study revealed a gap in integrating ICT into formal education, with many participating in online lectures but few enrolled in ICT-based courses. To enhance academic outcomes, it is crucial to improve ICT training, promote its educational integration, and address access disparities. Future research should evaluate ICT interventions and develop strategies to optimize technology use in academics.

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Received on 28/8/2024 Accepted on 21/10/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 947-950

DOI : 10.5958/2349-4433.2024.00162.4

Soil Amelioration through Multipurpose Trees: An Insight from Agroforestry Systems in Jharkhand, India

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ABSTRACT

In Jharkhand, the tradition of tree planting is well-established, with farmers actively managing native multipurpose trees as a defining characteristic of agricultural landscapes. A prominent characteristic of perennial component based land management systems is their ability to enhance the physico-chemical properties of soil and hence the site's production potential.This study examined nine Multipurpose tree species (MPTs)planted at a spacing of 2×2 m in agroforestry systems at the College of Veterinary Science and Animal Husbandry, BAU, Ranchi, located in a subtropical humid climate in Northeast India. Species such as *Millettia pinnata, Pterocarpus marsupium, Swietenia macrophylla, Acacia auriculiformis* and *Dalbergia sissoo* depicted potential as live fences around farm boundaries, providing nitrogen-rich foliage for mulching and manure. The presence of MPTs significantly improved soil properties, including enhanced soil humus and available nutrients, reduced soil erodibility, improved surface soil moisture and water retention capacity (0–30 cm depth). Notably, plots with Karanj (*Millettia pinnata*) exhibited higher concentrations of organic carbon (2.02%), nitrogen (174.68 kg/ha), and potassium (227.36 kg/ha). The study also revealed that the available soil nutrients get reduced with increasing soil depth. Overall, the findings underscored the importance of MPTs in enhancing the physicochemical attributes of soils.

Key Words: Agroforestry, Amelioration, MPTs, Timber, Rainfed, Erodibility.

INTRODUCTION

The physiography of Jharkhand is highly undulating, with sloping hills leading to a higher rate of soil erosion, and areas without tree cover on hilly slopes are vulnerable to erosion and reduced fertility. Alarge portion of Jharkhand's soilis acidic in composition with sandy loam texture, good drainage, poor water holding capacity and low consistency (Oraon *et al*, 2014). Plantation of multipurpose tree species in aforesaid areas can be one of the influential land-use management practices that can halt land degradation and soil erosion. MPTs aims to amplify tribal income and enhance forest cover by planting trees through agroforestry and nurturing forested areas. The contributions will create spaces for wildlife, and agroforestry will empower tribals, providing them with fruits, bark, and medicine for consumption and sale. MPTs can play a crucial role in minimizing soil erosion along gullies and streamsby being planted at the medium to high water mark. Their roots anchor the soil and reduce the impact of stormwater.Agroforestry is a sustainable land use practice that combines trees with crops or livestock, fostering an agroecological succession (FAO, 2013). Recognized for its economic, social, and environmental benefits (Abrha, 2017), agroforestry is globally promoted as a potential means to diversify and improve production systems (Mbow *et al,* 2014).These species should be widely adopted in agroforestry, especially in boundary plantations, as they have the capacity to thrive and survive in rainfed conditions. MPTs can alter the physico-chemical characteristics of soil

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Table 1. Species Description of Multipurpose tree species (MPTs).

Species	Family	Leguminous/Non leguminous	Use	Distribution	Altitude (m)	Rainfall (mm)	Temperature (^{0}C)
Neem	Meliaceae	Non- Leguminous	Fuel wood, fodder, agricultural tools, for making ayurvedic medicines.	India, Bangladesh, Burma, Sri Lanka, Malaysia, Indonesia	Up to 1500.	450 to 1200	21-32
Bakain	Meliaceae	Non-Leguminous	Pole, fuel wood, fodder and also as medicinal/insecticidal purposes	India, China, Tropical South America, and Southern Europe	Up to 1800	600-2400	23-26
Karanj	Fabaceae	Leguminous	Oil, fuel wood, dyeing agent	Asian subcontinent	Up to 1200	500-2500	27-38
Kathal	Moraceae	Non-Leguminous	Pulp is eaten as fruit and vegetable, Wood is used for making furniture, poles.	Southeast Asia	1600	1000-2400	19-29
Bijasal	Fabaceae	Leguminous	Skin diseases, diabetes, elephantiasis, leucoderma, toothache and appetizing	India, Nepal and Sri Lanka	200-500	750-2000	22-32
Gamhar	Lamiaceae	Non-Leguminous	Boat building, papermaking and in the matchwood industry, furniture	India, Bangladesh, Sri Lanka, Myanmar	Up to 1500	1200-4500	20-45
Mahogany	Meliaceae	Leguminous	Construction materials, plywood furniture and cabinet making, boat construction	Southern Mexico	50-1400	1200-1500	23-28
Shisham	Fabaceae	Leguminous	Fuelwood, shade, shelter, soil stabilization	Cameroon, Ethiopia, Indonesia, Iraq	1500	500-1500	40-45
Acacia	Fabaceae	Leguminous	Fuelwood, gum, fodder, timber, dyestuff	Australia	Up to 400	700-2000	17-34

by means of nutrient recycling and litter dynamics.Keeping in multipurpose use, the species is required to propagate in situ and ex situ and also make people aware of its sustainable utilization.

MATERIALS AND METHODS

Experimental Site

The research was conducted at the Agroforestry field, College of Veterinary Science and Animal Husbandry, BAU, Ranchi, under subtropical humid climate in Northeast India during 2020-2021.The three years old, nine MPTs were planted at a spacing 2m × 2m in randomized block design. The research site is characterized by warm, humid weather, receiving an average of 312 mm of rainfall annually, primarily during the monsoon season (June to September). The average maximum temperature varies between 17.5°Cand30°C. The soil has a bulk density of 1.28 g/cm^3 and is classified as sandy loam in texture.

Soil chemical properties

Using soil samples collected randomly from five locations within each plot (four corners and the centre), the chemical characteristics of the soil, including pH, organic carbon, and available nitrogen (N), phosphorus (P), and potassium (K) were carefully analysed. Soil samples were collected from 30 cm soil depth in all plots, then air-dried and ground to pass through a 2-mm sieve.The sieved soil was then thoroughly mixed before analysis and the composite samples were prepared to assess various soil chemical properties. The pH of the soil was measured using a digital pH meter with an aqueous soil solution prepared at a 1:2.5 soil-to-distilled water ratio. Soil organic carbon content was determined using the Walkley and Black method, while available nitrogen was quantified using the alkaline potassium permanganate method. Available phosphorus was measured using the ascorbic acid-reduced molybdophosphoric blue colour method, and available potassium was analysed using a flame photometer (Tondon, 1993).

Table 2. Chemical status of soil under study.

Treatments		Soil fertility status of 0 -30 cm soil				
		pH	O. C P. %	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O_5 (kg/ha)
Initial		5.1	0.63	123.94	12.45	68.76
Final		2020	2020	2020	2020	2020
T_1	Neem	5.66	1.18	148.62	4.783	123.94
T_2	Bakain	5.58	1.08	145.46	47.787	120.18
T_3	Karanj	6.69	2.02	174.68	45.851	227.36
T_4	Kathal	5.08	0.74	133.60	20.731	77.28
T_5	Bijasal	6.31	1.8	165.79	14.523	187.41
T_6	Gamhar	5.29	0.86	141.28	5.189	95.57
T_7	Mahogany	5.44	1.06	144.49	4.037	110.13
T_8	Shisham	5.77	1.18	151.46	3.709	132.90
T_9	Acacia	6.01	1.70	162.65	4.256	141.12

RESULTS AND DISCUSSION

Soil physical properties

The presence of MPTs caused a considerable change in the physical characteristics of soil. The potential of multipurpose tree species to ameliorate soil traits largely rely on accumulation of leaf litter and its pace of decomposition. Addition of organic matter through the decomposition of leaf litterhas increased the water retaining capacity of the soil and reducedthe bulk density especially through penetrating into deeper soil layers (Liyanage *et al*, 1997).

Soil chemical properties

Maximum soil pH(6.69) and organic carbon(2.02%) was recorded in Karanj, while least pH(5.08) and organic carbon (0.74%)was shown by Kathal. Litter fall, which generates weak organic acids during decomposition, may contribute to the decline in pH and organic carbon. As well, Karanj registered the highest available nitrogen (174.8 kg/ha)& available potassium(227.36 kg/ha), while Kathal recorded the least available nitrogen (133.60 kg/ha) & available potassium(77.28kg/ha). Available phosphorus (47.78 kg/ha) was recorded highest in Bakain plot(47.78 kg/ha), and the least was observed in Shisham (45.85 kg/ha). The presence of MPTS has been shown to improve soil fertility by enhancing the available N, P and K content, increasing organic matter, and playing a key ecological role in controlling erosion, mitigating climate change, and conserving biodiversity (Lelamo, 2021).

CONCLUSION

It can be concluded that after three years of plantation, soils under *Azadirachta indica*, *Melia azedarach*, *Millettia pinnata*, *Artocarpus heterophyllus*, *Pterocarpus marsupium*, *Gmelina arborea*, *Swietenia macrophylla*, *Dalbergia sissoo*, and *Acacia auriculiformis* exhibited a gradual improvement in key physico-chemical properties. Specifically, these plantations contributed to a notable increase in soil pH, which can enhance nutrient availability, as well as a significant enrichment in organic carbon levels. Furthermore, the presence of these multipurpose tree species led to an improvement in the soil's nutrient status, including the availability of essential nutrients such as nitrogen, phosphorus, and potassium, thus fostering better overall soil fertility. This progressive enhancement of soil quality highlights the potential of these MPTs in promoting sustainable soil health and fertility over time.

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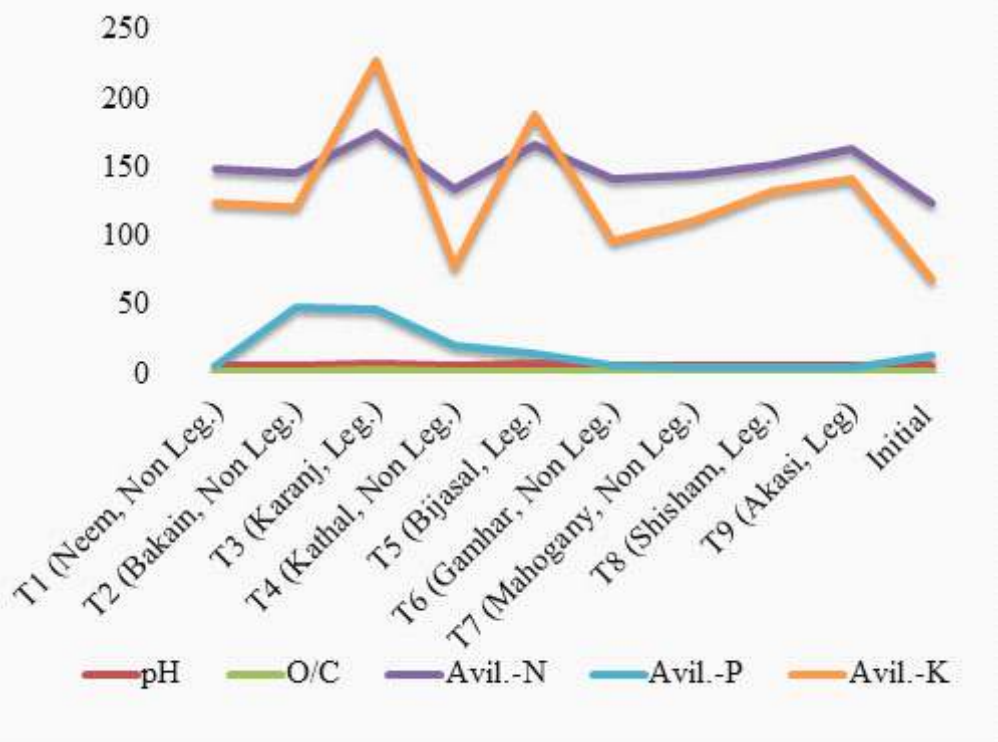

Fig 1. Chemical status of soil under study

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Received on 29/10/2024 Accepted on 18/11/2024

J Krishi Vigyan 2024, 12(4) : 951-955
DOI : 10.5958/2349-4433.2024.00163.0
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Sustainable Rural Livelihood through Backyard Poultry Farming

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ABSTRACT

An improved variety of backyard poultry namely Rajasri bird was demonstrated to rural farm women of SC community in Ranga Reddy district for improving their livelihoods in the year 2023. A total of 1300 birds were distributed to 65 identified SC beneficiary women farmers. Each unit comprised of five male and fifteen female chicks (20 birds in each unit), one bamboo basket, 5 kg chick starter feed, feeder, and waterer. In the present study, Rajasri birds achieved sexual maturity at 174±14 d with an average body weight of 1250 to 1350 g. The average annual egg production/ bird was 155 to165 eggs per year with an average weight of 45 to 55 g and mortality rate of 2.7% in Rajasri birds. The findings indicated a substantial rise in income of Rs. 17,825 per household annually from the selling of eggs and male birds, as well as a notable increase in the intake of eggs and meat among rural scheduled caste families.

Key Words: Chicks, Eggs, Families, Livelihood, Poultry, Rajasri birds,Women.

INTRODUCTION

Backyard poultry farming has a long-standing tradition in rural India. The majority of backyard poultry farming involves the raising of native bird species, which typically exhibit suboptimal production performance. The productivity of indigenous birds in terms of egg production is only 70 -80 eggs per bird/ year and meat production is also very low (Pankaj *et al*, 2019). Nonetheless, enhancing backyard poultry production is achievable through the introduction of superior chicken varieties, which can lead to increased yields of both meat and eggs. The practice of raising local poultry birds in backyards serves as a significant source of livelihood for the rural population of Telangana. The highest quality chicken meat and eggs are sourced from the backyard poultry sector, commanding a premium market price. The practice of rearing backyard poultry has enhanced food security and the economic conditions of rural families in India (Pica-Ciamarra and Dhawan, 2010). The increasing interest in Indigenous poultry products, coupled with minimal investment in the backyard poultry sector, highlights the necessity for a variety that can deliver strong productivity despite limited resources.

Further, backyard poultry offers rural farmers, landless individuals, and women a means to generate supplemental money for their families. Nonetheless, the issues of inadequate weight increase, reduced egg production per bird, and elevated chick mortality among Indigenous birds are significant obstacles in backyard poultry that must be addressed through the introduction of an enhanced diversity of birds exhibiting superior performance metrics. To enhance the livelihoods and nutritional security of rural communities via backyard poultry farming, the Rajasri variety was developed, characterized by medium size, elongated shanks, and vibrant plumage akin to Indigenous birds (Srinivas *et al*, 2017). Furthermore, it is an oviparous avian species with a reproductive output of 160-180 eggs annually. The eggs are brown, akin to desi eggs, and these birds can endure harsh climatic conditions. This study wasa conducted to assess the performance of Rajasri birds and their influence on the livelihood and nutritional security of rural SC families within the free-range system in Ranga Reddy district, Telangana.

MATERIALS AND METHODS

A total of 1,300 birds were allocated to 65 recognized beneficiaries from the SC community in the villages of Chittapur and Chandkhanguda,

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located in Manchal Mandal, Ranga Reddy district, at no cost. Each unit consisted of five males and fifteen females (20 birds in total), along with one bamboo basket, 5kg of chick starter feed, a feeder, and a waterer. A training program was conducted before distribution to inform farmers about vaccination, management, and disease prevention in birds. The investigation was conducted from March 2023 to January 2024, during which data regarding the production performance of Rajasri birds were gathered from beneficiaries using a semi-structured interview schedule. The collected data were then subjected to appropriate statistical analysis (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

Age at sexual maturity

The present investigation revealed that the age at sexual maturity (ASM) for Rajasri birds under scavenging conditions varied from 150 d to 180 d, with an average of 165 d, as shown in Table 1. Sharma *et al* (2004) noted that the range was between 167.3 and 169.3 d; however, a portion of the beneficiaries (24.44%) reported that birds reached sexual maturity after more than 6 months. This could be attributed to inadequate scavenging feed base resources in that region. The early age at sexual maturity of 150 – 165 d (26.66%) and 165-180 d (48.88%) observed in Rajasri birds may be linked to the supplementary feeding with chick starter feed provided to the farmers, along with the availability of maize and broken rice for the poultry birds. In contrast, Dilip *et al* (2013) found that the age at sexual maturity in Rajasri birds was lower than that of Aseel (187.43±1.54) and Kadaknath (196.12±1.75) birds.

Body weight at sexual maturity

A significant proportion of the beneficiaries (75.55%) recorded a body weight ranging between 1300 to 1400g at the sexual maturity of the birds (Table 1). Bhat *et al* (2007) reported that the body weights of Vanaraja birds were 3150 g for males and 2550 g for females at 190 days of age under free-range conditions. Reaching sexual maturity at a lower body weight serves as a positive indicator for the potential of increased egg production.

Mortality

The current study revealed that Rajasri exhibited a lower susceptibility to environmental stress and demonstrated an ability to evade predators effectively. The average mortality of the birds was observed to be 1 to 3 per cent (66.66%) and 4 to 6 per cent (33.33%) as indicated in Table 1. In a similar vein, Bhat *et al* (2007) documented a mortality rate of 3-5 per cent under field conditions. In contrast, Tom Pennycott (2004) noted increased mortality associated with scavenging in the farmer's backyard. The guidance provided to farmers on vaccination schedules, disease management, feed supplementation, and ongoing support from scientists could be contributing factors to the decrease in mortality rates.

Egg production and Egg weight

In the current investigation, 55.55% of the beneficiaries produced 15-18 eggs per bird per month, while 24.44% of beneficiaries exceeded 18 eggs per bird per month. Nevertheless, a limited number of respondents indicated fewer than 10 eggs per bird per month (Table 1). The findings align with those of Padhi *et al* (1999), who documented an annual egg production of 153 eggs in Nicobari hens, as well as Sumita *et al* (2019), who identified the Rode Island Red breed as having the highest egg production potential, yielding 194 eggs per bird per year. According to the findings of Vij *et al* (2006), the Brown breed of chicken in Punjab yields an annual egg production of merely 60-80 eggs. Comparable findings were documented by Sharma *et al* (2004) and Jha and Prasad (2013). A significant proportion of the beneficiaries, specifically 48.88%, recorded an egg weight ranging from 45 to 55g in field conditions, as illustrated in Table 1. Comparable findings have likewise been documented by Wani *et al* (2007) and Kumari and Subrahmanyeswari (2014). Thakur *et al* (2016) documented that the average egg production at 32, 40, 52, and 72 weeks of age in Vanaraja chickens was 32.13±0.11, 50.08±0.32, 89.29±1.02, and 181.12±1.53, respectively. In contrast, the Desi chicken exhibited corresponding values of 11.21±0.03, 25.82±0.18, 42.57±0.72, and 76.27±0.85, respectively. The average egg weight of Vanaraja

Table 1. Production parameters of Rajasri birds.

Sr. No.	Parameter	Number of Beneficiaries	Percentage (n = 45)	SEM
1.	Age at sexual maturity (days)			
	150 – 165	12	26.66	14.36
	165 – 180	22	48.88	
	>180	11	24.44	
2	Body weight at sexual maturity in (g)			
	1100 – 1200	11	24.44	25.00
	1300 – 1400	34	75.55	
	>1500	11	24.44	
3	Mortality percent			
	1 – 3	30	66.66	32.5
	4 – 6	15	33.33	
4	No. of eggs produced / bird/month			
	10 – 15	9	20.00	20.98
	15 – 18	25	55.55	
	>18	11	24.44	
5	Egg weight (g)			
	40 – 45	9	20.00	16.52
	45 – 50	22	48.88	
	50 – 55	14	31.11	

at 32, 40, and 52 weeks of age was notably ($P \leq 0.05$) greater than that of Desi birds. Chaturvedi *et al* (2015) indicated that the egg productivity of desi birds was measured at 36.5±0.2 eggs.

Economics of Rajasri birds rearing under free range system

The revenue generated from the sale of adult males amounted to Rs. 3200/-, while the sale of eggs yielded Rs. 14,625/- at a rate of Rs. 6.5/- per egg, as noted among the majority of the beneficiaries (Table 2). The annual net profit from 20 birds amounted to Rs. 16,825, resulting in a net profit per bird of Rs. 84.25, which the farmers regarded as a financially sustainable venture (Table 2). Daida *et al* (2012) indicated that the income per day per beneficiary amounted to Rs. 28.51, excluding bird costs. Pica Ciamarra and Dhawan (2010) conducted a calculation of net income on a per hen basis within the framework of scavenging/semi-scavenging management, revealing that the income fluctuated between Rs.570 and Rs.1662, adjusted to 2007 price levels. Praveen *et al* (2018) indicated that the net average income produced by tribal women farmers through backyard poultry annually amounts to Rs. 7454/-. The superior returns can be attributed primarily to enhanced profits from egg sales, as the volume of egg production increased, coupled with a reduction in mortality rates. The typical yearly consumption of eggs per household rose from 100 eggs annually to 600 eggs each year. The rearing of Rajasri birds demonstrated a noteworthy ($p<0.05$) enhancement in egg production, accompanied by increased hatchability rates, which in turn led to a significant ($p<0.05$) boost in supplementary income and nutritional security for rural families (Kumari and Subrahmanyeswari, 2014).

Table 2. Economics of Rajasri birds rearing under free range system.

Sr.No.	Parameter	Amount (Rs.)
1	Night shelter, feed grains, vaccines (Rs. 50/- bird/annum)	1,000/-
2	About 2250 eggs from 15 females @ 6.5/- each (150 /annum/ bird)	14,625/-
3.	By sale 5 males @ Rs. 320/ - kg. (each bird 2 kg)	3,200/-
4.	Total income per annum	17,825/-
5	Net profit per annum	16,825/-
6	Net profit per bird	841.25/-

Reports indicated that synthetic crossbred high-yielding birds were well-suited for backyard rearing systems and can be profitable (Padhi *et al*, 2003). Comparable results were noted by Chatterjee *et al* (2002). Rajbongshi *et al* (2020) indicated that backyard farming possesses the potential to enhance the economic conditions of a significant number of tribal rural families, as it is characterized by low or negligible input requirements. The study also highlighted that the chosen progressive farmer achieved an annual net profit of Rs. 1,17600/- through poultry rearing. According to Lok Prakash *et al* (2020), Kadaknath farming functions similarly to a cash crop within the livestock sector. The Kadaknath breed, characterized by its disease resistance and robust nature, requires minimal input while commanding a high market price due to increasing demand, rendering its rearing a lucrative agricultural endeavor. The heightened revenue from the cultivation of indigenous birds may be attributed to the superior productivity and reproductive efficacy of the Rajasri.

CONCLUSION

The findings of this study indicated that the Rajasri bird thrives in scavenging conditions, contributing positively to the socio-economic status of rural families within the SC community. An observable significant increase in subsidiary income (@ Rs.17,825/-family/annum) was noted through the sale of eggs and male birds. A notable increase in the consumption of eggs and meat was observed among the families benefiting from the program. In addition to selling eggs and meat, the farmers were generating income by sustaining the enterprise through the reproduction of chicks using local hens for brooding.

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Received on Accepted on

J Krishi Vigyan 2024, 12(4) : 956-964
DOI : 10.5958/2349-4433.2024.00164.7
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Weather-Based Rice Yield Prediction in Kerala Using ANN, SMLR and Normal Regression

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ABSTRACT

Rice is the staple food crop in Kerala which accounts for nearly all of the state's food grain production and is mainly cultivated under rainfed conditions during the *Kharif* season. The critical influence of weather on rice productivity necessitates accurate and timely yield forecasts to aid agricultural planning. This study aimed to develop district-level rice yield prediction models for Kerala by analyzing the effects of essential weather variables: temperature, rainfall, relative humidity, and solar radiation on yield outcomes. Three statistical methods were employed: normal regression, Artificial Neural Networks (ANN) and Stepwise Multiple Linear Regression (SMLR). Among these models ANN demonstrated the highest predictive accuracy, with superior R^2 values across all districts, indicating its robustness in modeling yield variability based on weather parameters. The ANN model has the ability to capture complex, nonlinear relationships among weather variables underscores its reliability as a tool for rice yield forecasting in all districts of Kerala. This enhanced forecasting potential holds substantial value for proactive agricultural planning and decision-making, allowing stakeholders to better manage resources and mitigate climate risks to ensure stable rice production in the state.

Key Words: Rice, Yield prediction, Statistical model, SMLR, ANN.

INTRODUCTION

Rice is the Kerala's staple food cultivated extensively across the state and accounts for nearly all of its food grain production, with a recorded yield of 6.3 lakh tonnes (GOK, 2022). Yoshida *et al* (1981) highlighted rice's sensitivity to climate factors such as temperature, rainfall, and solar radiation, crucial for its productivity in tropical regions. Being a subtropical crop, rice thrives at temperatures between 20 to 40°C but can suffer under extremes. Bhattacharya and Panda (2013) found that rice yield rose with increased rainfall in subtropical areas but excessive rain with strong winds during flowering could reduce yield. Khavse *et al* (2014) found that weather accounts for about 67% of crop yield variation, underscoring the importance of reliable yield forecasts to guide effective agricultural planning.

Forecasting yield before harvest aids policymakers in managing food supplies and preparing for surplus or scarcity (Dutta *et al,* 2001). Yield prediction methods typically involve empirical statistical and crop simulation models. While simulation models are process-based and provide precise results, they require extensive input data, limiting their application over broad spatiotemporal ranges. Statistical models, on the other hand, need less data and can serve as a practical alternative and are generally developed using crop and weather data through simple regression (Lobell and Burke, 2010; Shi *et al,* 2013), and need calibration for reliability (Das, 2018). Rai *et al* (2013) demonstrated that models incorporating multiple weather variables improved rice yield predictions. This study aims to develop and evaluate statistical models, including Normal Regression, Artificial Neural Networking (ANN), and Stepwise Multi-Linear Regression (SMLR), to forecast *Kharif* rice yields in Kerala.

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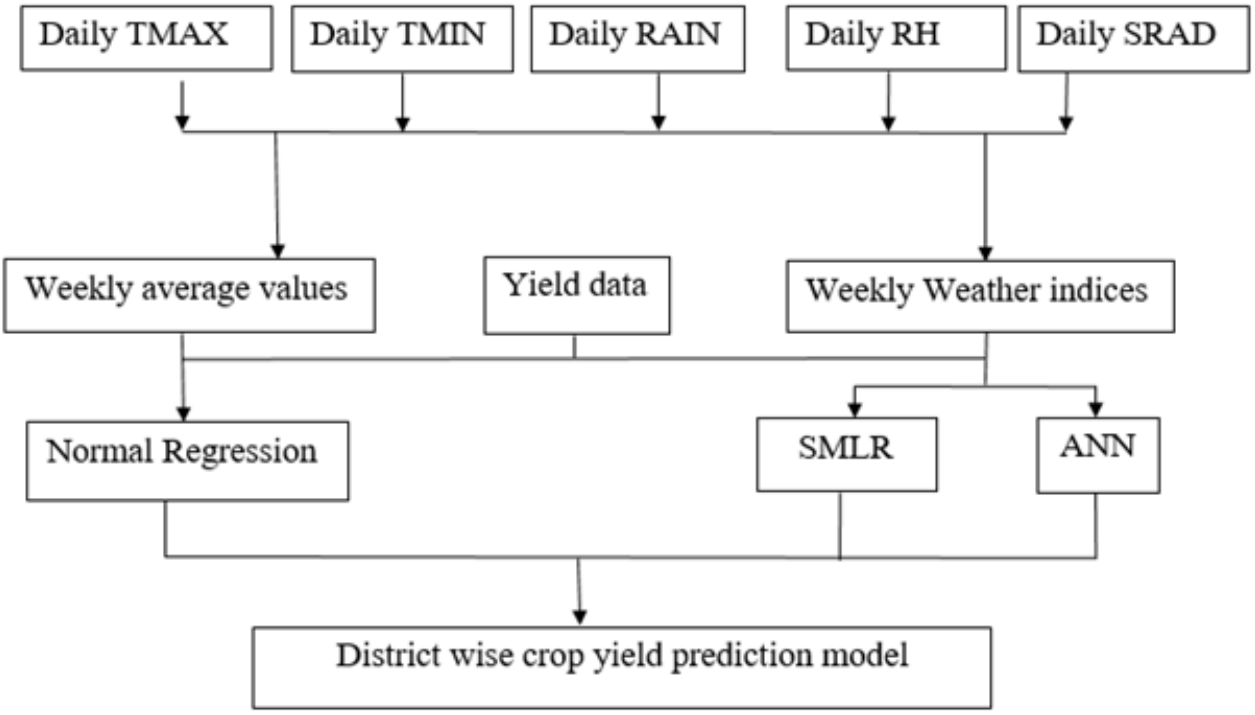

Fig.2. Flow chart representing the development of the statistical model

MATERIALS AND METHODS

Study area

Kerala, situated in southwestern India, lies between 8°18' and 12°48' N latitude and 74°52' and 77°22' E longitude, encompassing a total area of 38,863 square kilometers (Ajithkumar, 2015). The state is divided into 14 districts, with weather data analyzed across each one for this study. Kerala is further classified into five distinct agro-climatic zones: the Northern, Central, High-Range, Problematic, and Southern zones.

Data and methodology

Rice yield data for the *Kharif* season between 1998 and 2021 was gathered from Kerala's Agri Eco-stat website (ecostat.kerala.gov.in) and the Ministry of Agriculture and Farmers Welfare's Area and Production website (aps.dac.gov.in). Data includes all Kerala districts except Wayanad, as no *Kharif* rice cultivation occurs there. The daily weather data from 1998 to 2021 (23 years) was obtained from NASA's Prediction of Worldwide Energy Resources (NASA/POWER; power.larc.nasa.gov) for each district of Kerala, excluding Wayanad. Key weather parameters—maximum temperature, minimum temperature, rainfall, and relative humidity—were recorded daily. These daily data points were then aggregated into weekly values, focusing on the weeks within the Kharif season (20^{th} to 37^{th} Standard Meteorological Week, SMW) to calculate weather indices. Figure 2 illustrates the process flow.

Calculation of weather indices

Two weather indices were developed for each weather variable: the simple index (Z10) and the weighted index (Z11). The simple weather index was calculated by summing individual weekly weather data values (see Equation 1). For the weighted weather index, the sum of the product of each weekly weather value and its correlation with yield was taken (see Equation 2). Table 1 provides an overview of the weather variables and the combinations used in creating these indices.

Table 1. Simple and weighted weather indices.

Parameter	Unweighted weather indice	Weighted weather indices
Tmax	Z10	Z11
Tmin	Z20	Z21
Rain	Z30	Z31
RH	Z40	Z41
SRAD	Z50	Z51
Tmax * Tmin	Z120	Z121
Tmax * Rain	Z130	Z131
Tmax * RH	Z140	Z141
Tmax * SRAD	Z150	Z151
Tmin * Rain	Z230	Z231
Tmin * RH	Z240	Z241
Tmin * SRAD	Z250	Z251
Rain * RH	Z340	Z341
Rain * SRAD	Z350	Z351
RH * SRAD	Z450	Z451

$$Z_{10}=\sum_{k=1}^{n} W_k \quad \text{..... Equation1}$$

$$Z_{11}=\sum_{k=1}^{n} X_k W_k \quad \text{.....Equation2}$$

W= Weekly weather

X= Correlation coefficient between yield and weather variables

Statistical Models for yield prediction

Normal Regression

Normal regression was conducted using SPSS (Statistical Package for the Social Sciences), a versatile tool used across various fields for data analysis and transformation (Hinton, 2004). The model equation was formulated using the relationship between yield and weather variables from 1998 to 2021.

Artificial Neural Networking (ANN)

ANN was applied using a three-layer structure comprising input, hidden, and output layers (Fig. 3). Each layer consists of interconnected neurons or nodes, with the number of nodes in the input and output layers depending on the data set. The key challenge in ANN modeling lies in selecting the optimal number of hidden neurons. In this study, the 'train' function from the 'caret' package (method 'nnet') in R Studio (Kuhn, 2008) was used to determine these nodes. Thirty-two variables served as input layers, while yield was the response variable. From a total of 24 observations, 17 were designated as training data (for calibration), and 7 as testing data (for validation or prediction).

Stepwise Multi Linear Regression method (SMLR)

Stepwise Multiple Linear Regression (SMLR) is an iterative method used to construct a regression model by sequentially selecting the most significant weather variables for the final model. As described by Singh *et al* (2014), this method involves adding or removing explanatory variables one at a time, testing for statistical significance after each iteration to identify the optimal set of predictors. In this study, SMLR was conducted using SPSS software, with 20 years (1998-2017) of yield data and 30 corresponding weather indices used for model calibration. The stepwise process yielded multiple models, from which the one with the highest R^2 value was chosen to formulate the equation for yield prediction.

RESULTS AND DISCUSSION

Normal Regression

Using the Normal Regression method, yield prediction models were developed for various districts in Kerala, as displayed in Table 1. The coefficient of determination (R^2) values for these models ranged between 0.143 in Alappuzha

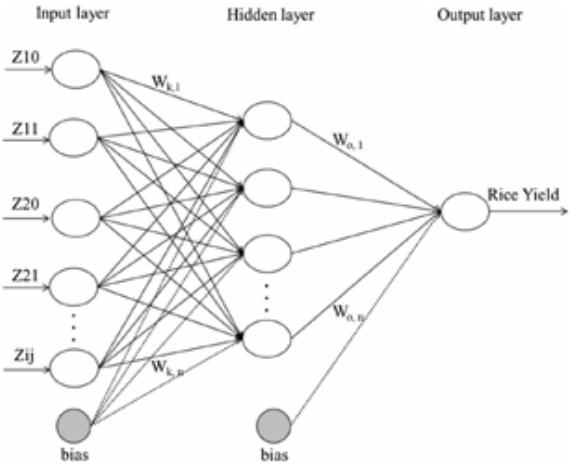

Fig. 3. Schematic representation of ANN

to 0.657 in Idukki. Figure 4 illustrates the combined actual and predicted weather data across all districts.

Stepwise Multiple Linear Regression (SMLR)

Yield prediction models for each district in Kerala, developed using SMLR, are summarized in Table 2. The coefficients of determination (R^2) were significant at the 1% probability level for all districts except Wayanad, with R^2 values ranging from 0.573 in Kozhikode to 0.925 in Thiruvananthapuram. These models identify the key weather variables impacting yield in each district.

In Thiruvananthapuram, yield was influenced by minimum temperature, time series, and the interaction between minimum temperature and solar radiation. Kollam sees yield influenced by time and the interaction of relative humidity with solar radiation. Pathanamthitta yield was shaped by maximum and minimum temperatures and combinations of minimum temperature with relative humidity and rainfall with solar radiation. Alappuzha yield depends on time, relative humidity combined with maximum temperature, and solar radiation.

In Kottayam, influential factors include time, solar radiation, and the interaction of minimum temperature with solar radiation. Idukki yield was driven by maximum temperature and the combination of minimum temperature with relative humidity. Ernakulam was influenced by minimum temperature, time, and the interaction of maximum temperature with solar radiation. Thrissur showed yield dependence on maximum temperature, time, and its relation to relative humidity.

Palakkad yield was affected by time and the interaction of maximum temperature with relative humidity and rainfall. Malappuram yield was highly impacted by maximum temperature, especially in combination with relative humidity and solar radiation. In Kozhikode and Kannur, time and the interaction of rainfall with solar radiation were influential factors. Lastly, Kasargod yield was impacted by minimum temperature, time, and the combination of minimum temperature and solar radiation with relative humidity.

Artificial Neural Networks (ANN)

ANN models were developed to predict crop yield across Kerala districts using weather variables (denoted as Z variables). The models' performance was optimized by selecting between 2 to 9 hidden neurons, and predictive accuracy was assessed using the R^2 (coefficient of determination) and RMSE (root mean square error) (Table 3). The R^2 ranged from 0.784 (Kottayam) to 0.998 (Kannur), while RMSE values ranged from 8.485 (Kannur) to 293.3171 (Alappuzha). The comparison of actual and predicted yield has been shown in Figure 6.

Thiruvananthapuram: Maximum temperature and its combination with relative humidity positively influenced yield. However, minimum temperature, relative humidity, and the interaction between rain and solar radiation had a negative effect.

Kollam: Minimum temperature and the combination of maximum temperature with relative humidity were positive influences, while rain and solar radiation negatively affected yield.

Pathanamthitta: Maximum temperature in combination with minimum temperature and rainfall with solar radiation positively impacted yield, while minimum temperature and combinations of maximum temperature with relative humidity had negative effects.

Alappuzha: Maximum temperature, relative

Table 1. Yield prediction models for different districts of Kerala using Normal regression method.

District	Equation	R^2 value
Thiruvananthapuram	-24814.525+[(-72.457*SRAD)+ (1117.9*Tmax) + (-886.66 *Tmin) + (-0.42*Rain) +(229.814*RH)]	0.402
Kollam	-9394.00022+[(-50.9268717*SRAD)+(268.791473*Tmax)+ (-128.5654598*Tmin)+(-0.210876242*Rain)+ (94.76093136*RH)]	0.154
Pathanamthitta	15935.97461+[(151.4430698*SRAD)+(218.620536*Tmax) + (-102.2300204*Tmin) + (0.411234259 * Rain) + (-97.2348 *RH)]	0.266
Alappuzha	-18698.22033+[(-174.1216152*SRAD)+ (-1285.11114*Tmax)+(2273.5951*Tmin)+(-0.596109923*Rain) +(17.68290016*RH)]	0.143
Kottayam	-41430.91748+[(-46.8756684*SRAD)+(1389.712194*Tmax)+ (-1408.48217*Tmin)+(-0.83358467*Rain) +(447.0837839*RH)]	0.482
Idukki	10592.7036+[(115.0532401*SRAD)+(93.01397708*Tmax)+ (-280.0157007*Tmin)+(0.382678687*Rain)+ (-28.58750841*RH)]	0.657
Ernakulam	4378.98573+[(-39.83024951*SRAD)+(-51.08197118*Tmax)+ (-25.17810597*Tmin)+(-0.003984433*Rain) +(3.30839941RH)]	0.499
Thrissur	-4475.196083+[(-157.4413573*SRAD)+(261.8551*Tmax)+ (-36.76465031*Tmin)+(-0.42951265*Rain)+ (34.82497276*RH)]	0.556
Palakkad	-8039.61987+[(-155.24489*SRAD)+(438.3396118*Tmax)+ (-257.7852899*Tmin)+(0.343905266*Rain)+ (68.14430203*RH)]	0.318
Malappuram	119.2199927+[(-103.530073*SRAD)+(38.04420186*Tmax)+(148.3815033*Tmin)+ (-0.149697116*Rain)+ (-6.00067641*RH)]	0.365
Kozhikode	1877.362669+[(-131.5805962*SRAD)+(515.9208771*Tmax)+(555.7013247*Tmin)+ (-0.1001878*Rain) +(13.77365569*RH)]	0.349
Kannur	-38350.38441+[(-143.7347362*SRAD)+(1095.848947*Tmax)+ (-558.9084821*Tmin)+(0.004723617*Rain) +(288.8652*RH)]	0.362
Kasaragod	-27085.38714+[(-98.92614686*SRAD)+(987.8737241*Tmax)+ (-448.1913974*Tmin)+(0.0538434*Rain) +(167.4537938*RH)]	0.457

SRAD= solar radiation (MJm^{-2}), Tmax - Maximum temperature (°C), Tmin- Minimum temperature (°C), Rain- Rainfall

humidity, and the product of rain with solar radiation positively influenced yield, while the combination of rain and solar radiation had a negative influence.

Kottayam: Maximum temperature and solar radiation combined with relative humidity had positive effects, while minimum temperature and rain with relative humidity were negative influences.

Idukki: Relative humidity, solar radiation, and the combination of maximum temperature with solar radiation had positive effects, while both maximum and minimum temperatures negatively impacted yield.

Ernakulam: Relative humidity and combinations of maximum temperature, rain, and relative humidity showed positive effects, while minimum temperature and the combination of rain with solar radiation were negative influences.

Thrissur: Relative humidity, as well as

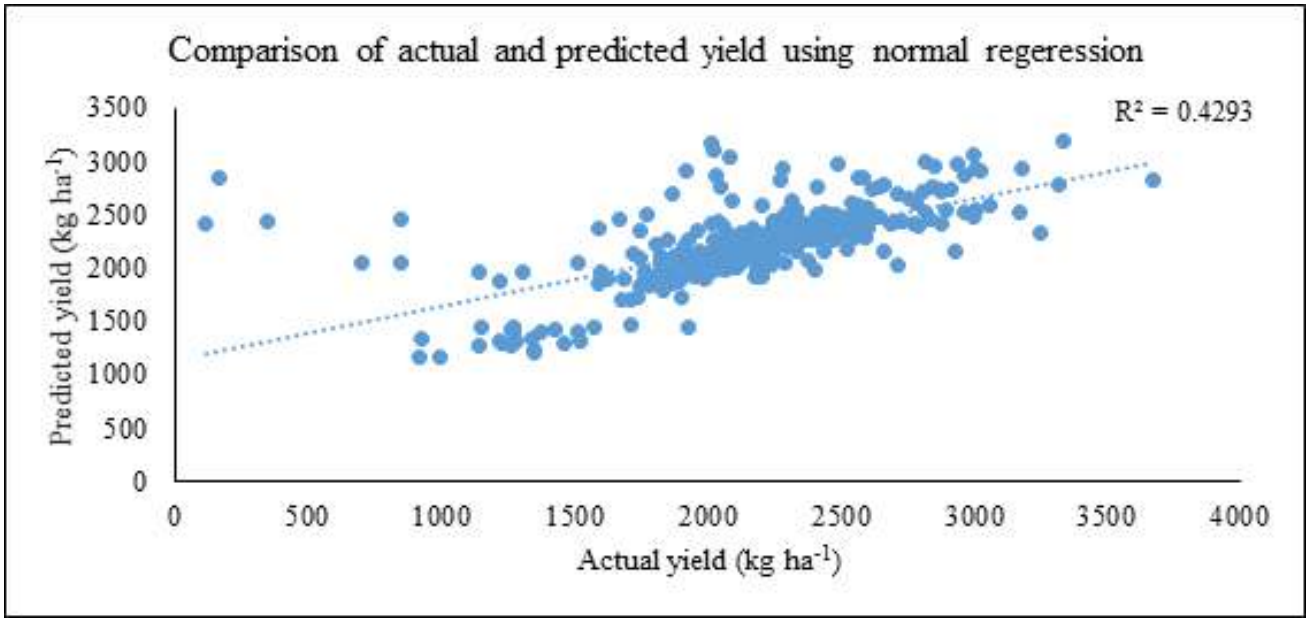

Fig. 4. Comparison of actual and predicted yield by normal regression

Table 2. Yield prediction models for different districts of Kerala using SMLR

Districts	Equation	R^2 value
Thiruvananthapuram	6887.346+(40.129*Time)+(0.53*Z251) +(28.845*Z21)	0.925
Kollam	1834.602+(22.814*Time) +(0.241*Z451)	0.75
Pathanamthitta	21688.97+(4.432*Z241) +(256.647*Z21) + (-0.08*Z351) +(-156.086*Z11)	0.888
Alappuzha	22852.28+(1.306*Z451) +(81.268*Time) +(3.332*Z141)	0.791
Kottayam	109.983+(45.653*Time) +(253.301*Z51) + (-8.932*Z251)	0.876
Idukki	6418.853+(43.203*Z11) +(1.219*Z241)	0.77
Ernakulam	4788.089+(0.293*Z151) +(7.922*Time) +(-5.901*Z20)	0.817
Thrissur	1186.741+(96.06*Z11) + (0.016*Z450) +(17.413*Time) +(1.267*Z141)	0.916
Palakkad	6157.388+(41.239*Time) +(0.115*Z131) + (-0.102*Z140)	0.937
Malappuram	4794.502+(1.697*Z141) +(18.828*Time) + (-0.124*Z140) +(0.388*Z151)	0.901
Kozhikode	1332.789+(0.093*Z351) +(21.323*Time)	0.573
Kannur	1782.151+(41.151*Time) +(0.051*Z351)	0.832
Kasaragod	5213.971+(79.516*Z21) +(17.67*Time) +(0.284*Z451) +(-0.199*Z240)	0.872

combinations of maximum temperature, rain, relative humidity, and solar radiation, positively affected yield, while the combination of relative humidity and solar radiation had a negative effect.

Palakkad: Combinations involving maximum temperature, rain, relative humidity, and solar radiation positively influenced yield, but relative humidity alone and the interaction of maximum and minimum temperatures had negative impacts.

Malappuram: Minimum temperature, rainfall, solar radiation, and their combination with relative humidity had a positive effect, but minimum temperature alone was a negative influence.

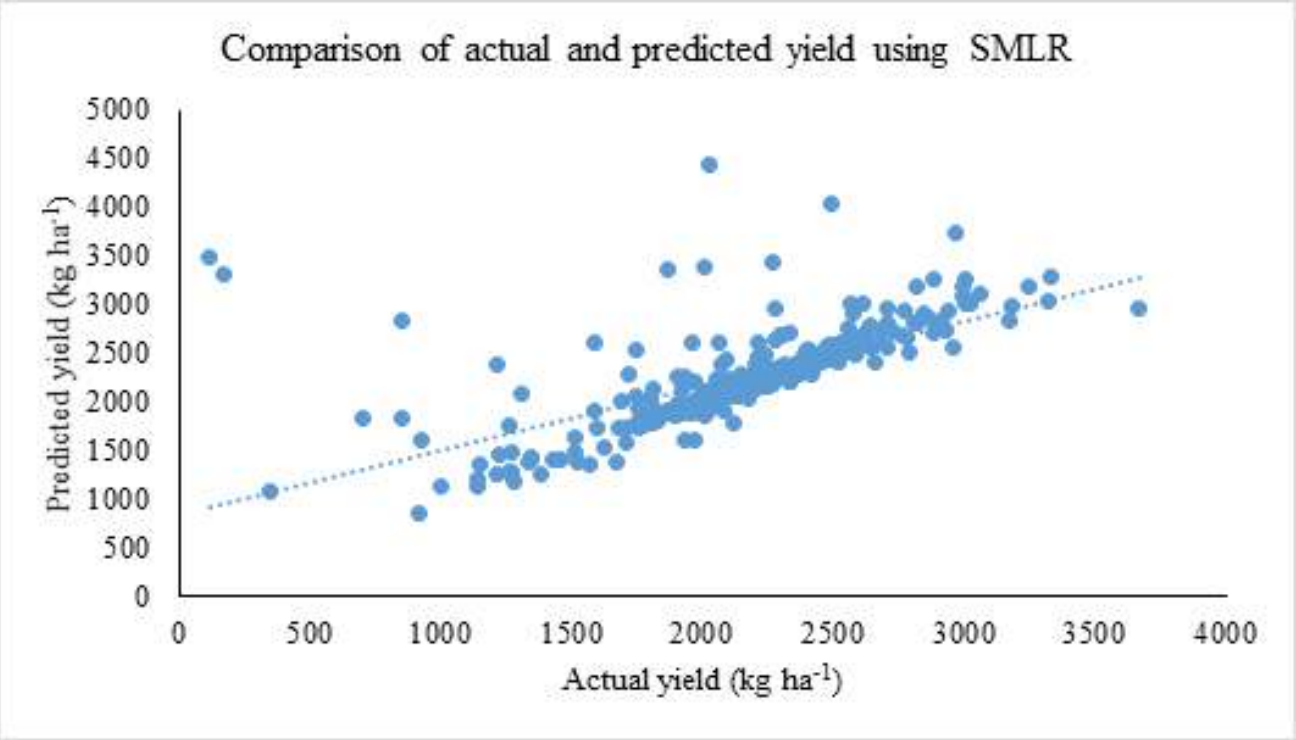

Fig. 5. Comparison of actual and predicted yield by SMLR

Table 3. ANN model: Number of hidden neurons, R^2 and RMSEC

District	No. of Hidden neurons	R^2 ($p < 0.01$)	RMSEC (kg ha^{-1})
Thiruvananthapuram	9	0.997	14.68938
Kollam	6	0.996	16.21406
Pathanamthitta	7	0.846	106.2033
Alappuzha	8	0.838	293.3171
Kottayam	2	0.801	267.8696
Idukki	5	0.898	53.3485
Ernakulam	9	0.994	16.29997
Thrissur	4	0.989	20.79367
Palakkad	9	0.975	29.32695
Malappuram	6	0.934	36.10754
Kozhikode	9	0.986	23.20222
Kannur	8	0.998	8.485507
Kasargod	8	0.997	13.03234

Kozhikode: Maximum temperature combined with relative humidity positively affected yield, while rain and solar radiation had negative effects.

Kannur: Minimum temperature and relative humidity were strongly positive influences, whereas combinations of maximum temperature, minimum temperature, and relative humidity had negative effects.

Kasargod: Minimum temperature, rainfall, and solar radiation positively influenced yield, while combinations of rainfall, relative humidity, and solar radiation showed a negative effect.

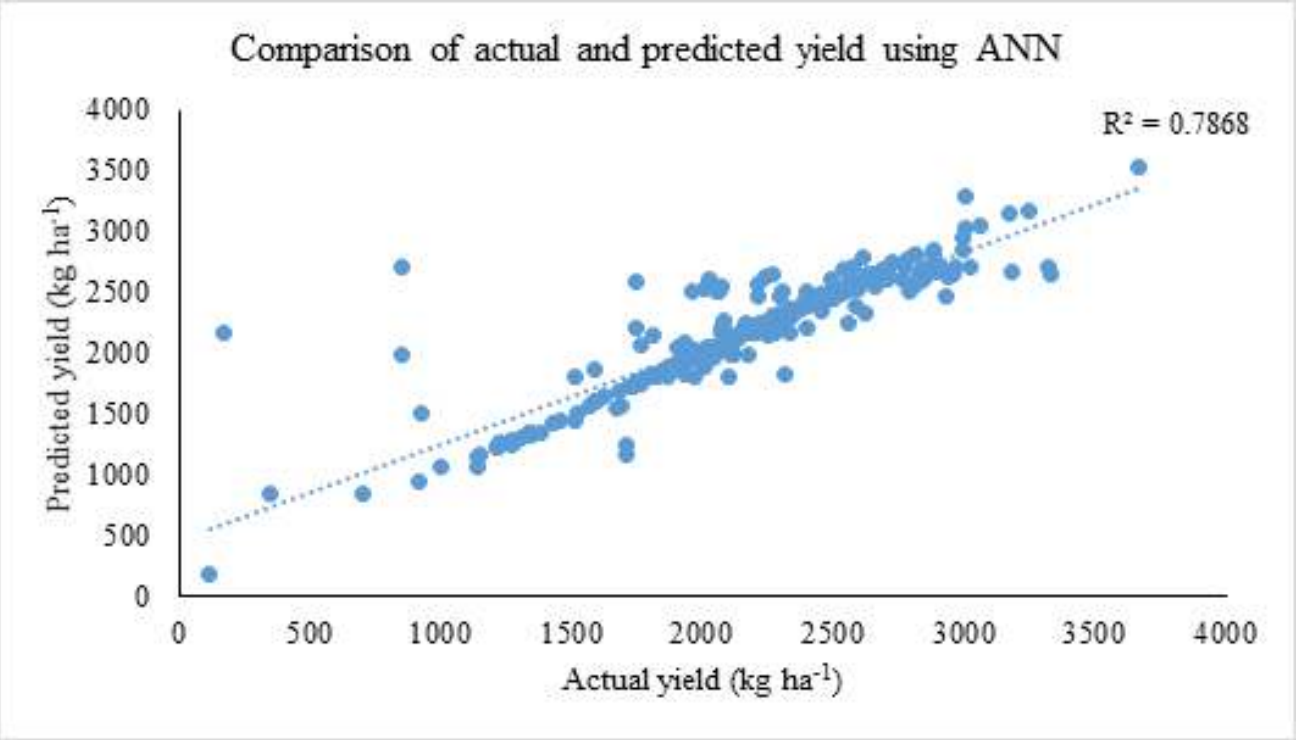

Fig. 6. Comparison of actual and predicted yield by ANN

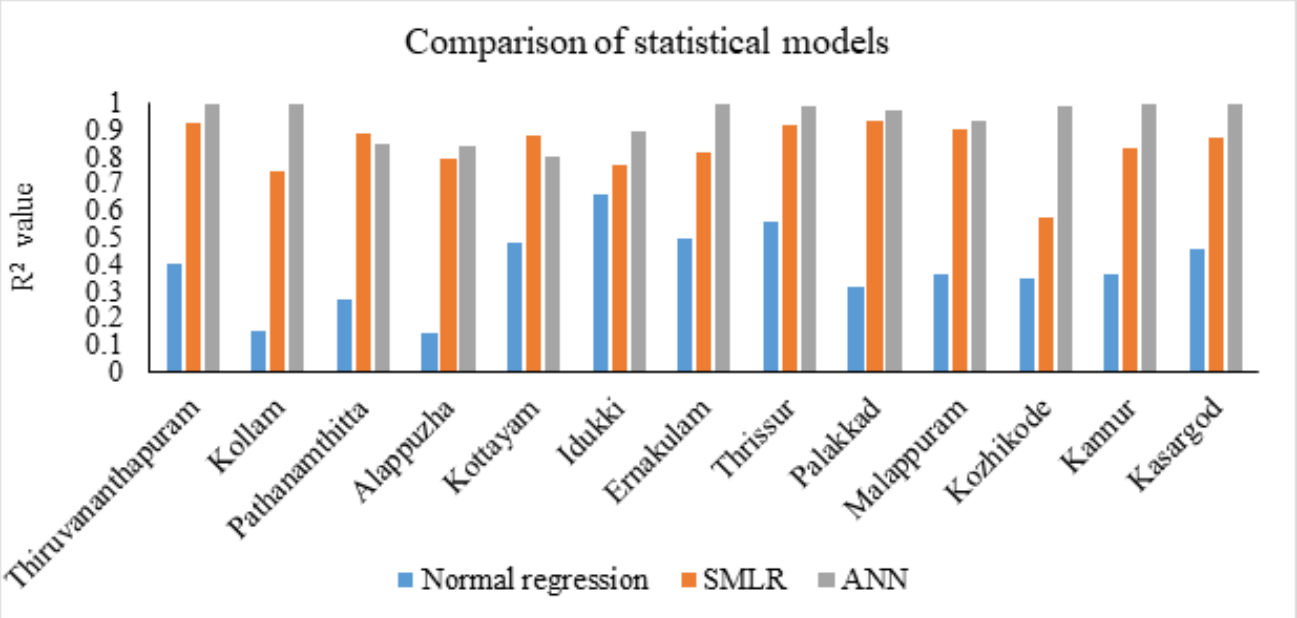

Fig. 7. Comparison of statistical models

Comparison of yield obtained from R2 value of Normal regression, ANN and SMLR

Across all districts in Kerala, the R^2 values were consistently higher in the ANN models compared to those from Normal Regression and SMLR. This indicates that ANN provided a more accurate fit for the yield prediction, making it the most effective modeling approach for all districts in Kerala (Fig. 7).

CONCLUSION

This study developed yield prediction models for rice across Kerala's districts using

three statistical methods: Normal Regression, Artificial Neural Networks (ANN), and Stepwise Multiple Linear Regression (SMLR). Weather parameters such as temperature, rainfall, relative humidity, and solar radiation were used to assess their impact on yield. ANN consistently showed the highest R^2 values among the models, indicating superior predictive accuracy across all districts. Thus, the ANN model proved to be the most effective approach for accurately predicting rice yield in Kerala, highlighting its potential as a reliable tool for agricultural forecasting in the region.

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Received on 31/10/2024 Accepted on 20/11/2024

J Krishi Vigyan 2024, 12(4) : 965-969
DOI : 10.5958/2349-4433.2024.00165.3
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Yield and Marketing Attributes of Different Pea Varieties under Organic Conditions of Mid Hills

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ABSTRACT

An assessment of different vegetable pea varieties under organic conditions of hills was conducted during *rabi* season of 2021-22 and 2022-23. Eight vegetable pea varieties namely PM 128, Vivek Matar 11, Vivek Matar 12, Vivek Matar 13, Arkel, PC531, PSM 3 and PMR 85 with 3 replications were assessed in Randomized Block Design (RBD). The sowing was done in mid-November in both the years. Vivek Matar 13 was the first to flower 50 per cent (83.6 days in 2021-22 and 82 days in 2022-23) and gave first harvest (116 days in 2021-22 and 114.7 days in 2023) in both the years, followed by Arkel and PM 128. Significant differences were found in yield among different varieties of vegetable pea and Vivel Matar 13 gave the height yield that was statistically *at par* to Vivel Matar 11 and Vivel Matar 12. For quality attributes depending on consumer preference and marketability, Vivek Matar 13 and PMR 85 gained highest points and ranked as excellent followed by Vivek Matar 11 and Vivek Matar 12. Maximum gross return, net return and B:C was calculated for Vivek Matar 13, followed by Vivek Matar 11 and Vivek Matar 12.
Key Words: Consumer preference, Economic analysis, Organic conditions, Vegetable pea Yield.

INTRODUCTION

Vegetable pea or garden pea (*Pisum sativum*L.var. *hortense*) is an important *rabi* season vegetable.The high percentage of digestible protein (7.2 g), carbohydrates (15.8 g), vitamin A (139 I.U.), vitamin C (9 mg), magnesium (34 mg) and phosphorus (139 mg) per 100 g of edible portion (Gopalkrishnan, 2007), makes it a nutritive and favourite vegetable. Vegetable pea is a winter season crop and temperature of 15-25°C is favourable for its flowering and fruiting. The crop can withstand low temperature and even frost during its vegetative stage, but during flowering it is very sensitive to frost. An abrupt increase in temperature during fruiting reduces the yield and number of pickings, while longer cool spell above frosting increases its yield and number of pickings**.**

Considering these climatic requirements, location specific assessment of vegetable pea varieties in a holistic manner that not only includes the yield, but flowering and fruiting duration and marketing attributes need to be investigated. In addition to these objectives, varietal performance of vegetable pea under organic conditions has very meagre studies. Therefore, the present study of practical significance was carried out for two consecutive years to find out the complete performance of various vegetable pea varieties under organic conditions of mid hills of Uttarakhand.

Organic farming is a method which primarily aims to cultivate the land and raising crops to keep the soil alive and in good health without adding any synthetically produced chemicals or fertilizers. Generally, for small and marginal farmers of India and particularly of hills, organic farming is most pertinent as they are resource poor to provide costly inputs for enhancing yield.

The inclusion of legume vegetables in the farming system has added advantage of fixing atmospheric nitrogen into the soil and make it available for companion or succeeding crops and will also help to sustain organic matter levels and promote good soil tilth (Seaman, 2011). This also helps the soil from soil erosion. Farmers should

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S. No.	Quality preference	Marks	Expected Price (Above or Below percentage of average market rates)
1.	Excellent	5	Above 30 %
2.	Very good	4	Above 20 %
3.	Good	3	Average market price
4.	Fair	2	Below 20 %
5.	Poor	1	Below 30 %

Table 1. Yield and marketing attributes of different varieties of vegetable pea.

Sr. No.	Entry	Flowering (50%) duration (Days)			Duration of first harvest (Days)			Yield (q/ha)		
		2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
1	PM 128	88.3 ^{b}	88.7 ^{b}	88.5	122.4 ^{b}	121.5 ^{b}	122.0	60.00 ^{a}	65.22 ^{a}	62.6
2	Vivek Matar 11	93.0 ^{c}	94.7 ^{c}	93.85	128.6 ^{c}	128.3 ^{c}	128.5	76.33 ^{c}	82.22 ^{c}	79.3
3	Vivek Matar 12	94.3 ^{c}	93.8 ^{c}	94.1	130.3 ^{c}	129.7 ^{c}	130.0	75.78 ^{c}	81.11 ^{c}	78.4
4	Vivek Matar 13	83.6 ^{a}	82.0 ^{a}	82.8	116.0 ^{a}	114.7 ^{a}	115.4	77.67 ^{c}	83.33 ^{c}	80.5
5	Arkel	89.7 ^{b}	88.7 ^{b}	89.2	122.3 ^{b}	121.3 ^{b}	121.8	66.89 ^{b}	73.20 ^{b}	70.0
6	PC531	94.3 ^{c}	94.7 ^{c}	94.5	127.6 ^{c}	127.3 ^{c}	127.5	67.89 ^{b}	74.00 ^{b}	70.9
7	PSM 3	90.7 ^{b}	91.0 ^{b}	90.9	129.3 ^{c}	129.3 ^{c}	129.3	65.78 ^{ab}	71.11 ^{ab}	68.4
8	PMR 85	94.5 ^{c}	93.7 ^{c}	94.1	128.6 ^{c}	129.0 ^{c}	128.8	61.33 ^{ab}	65.56 ^{a}	63.4
CD (0.05)		3.5	4.4	--	2.7	2.6	--	6.21	7.11	--

*Values within columns having common letter are statistically *at par*.

select the crops which are easy to grow, according to their needs, marketing opportunities and season for the organic farming. Vegetable pea is a good leguminous vegetable crop for the organic farming especially in hills, which helps in sustaining the soil fertility, fits well in cropping system and also gives good economic yield to fetch good price in the market.

MATERIALS AND METHODS

Krishi Vigyan Kendra (ICAR-VPKAS), Kafligair- Bageshwar is situated in the mid Himalayas between 29º45'07" N latitude and 79º44'03" E longitude at an altitude of 1245 meters above the mean sea level and represents humid sub- temperate climate with average annual rainfall of 1256 mm. The summers are somewhat warmer, while mid-winters are chilly with frosting of around 30-40 days.

The experiment was conducted during *rabi* season of 2021-22 and 2022-23, which is most suitable season for the growth, yield and marketing of vegetable pea in mid hills. Eight vegetable pea varieties namely PM 128, Vivek Matar 11, Vivek Matar 12, Vivek Matar 13, Arkel, PC531, PSM 3 and PMR 85 with 3 replications were assessed in Randomized Block Design (RBD). The sowing was done during mid-November in both the years. The selected field had not received any chemical or synthesized fertilizer for last 5 years. The preceding crop was buckwheat and the succeeding crop was french bean. Well rotten compost was applied @ 25 t/ ha during ploughing.

Seed treatment of all the varieties was done with *Trichoderma harzianum@* 10 g/ kg seed and regular prophylactic sprays of *Neem* oil (2 ml/L) at 15 days interval were also applied equally. The sowing geometry was 30 cm x 10 cm and the plot size was 3.00 m x 2.00 m (6.00 m^2). All the intercultural operations including weeding and hoeing were similar for all the plots.

Observations for flowering and harvesting duration, yield attributes and marketing related quality characteristics including pod length and number of seeds per pod were recorded and analysed statistically. Consumer preference along with expected price and economic analysis were

Table 2. Quality characteristics and expected price based on consumer preference for different varieties of vegetable pea.

Variety	Photo	Pod Length (cm)		No. of seeds per pod		Consumer preference and Marks		Expected Price (Rs./ q)	
		2021	2022	2021	2022	2021	2022	2021	2022
PM 128		7.20[a]	7.12[a]	6.3 [a]	6.1 [a]	Good - 3	Good - 3	3300.00	3700.00
Vivek Matar 11		8.53[b]	8.53[b]	7.3 [b]	7.2 [b]	Very Good - 4	Very Good - 4	3960.00	4440.00
Vivek Matar 12		8.50[b]	8.41[b]	7.5 [b]	7.4 [b]	Very Good - 4	Very Good - 4	3960.00	4440.00
Vivek Matar 13		9.67[c]	9.62[c]	8.7 [c]	8.3 [c]	Excellent - 5	Excellent - 5	4290.00	4710.00
Arkel		8.37 [ab]	8.33[b]	5.6 [a]	5.7 [a]	Good - 3	Good - 3	3300.00	3700.00
PC531		8.60[b]	8.52[b]	5.3[a]	5.5 [a]	Good - 3	Good - 3	3300.00	3700.00
PSM 3		8.40[b]	8.32[ab]	5.5 [a]	5.8 [a]	Good - 3	Good - 3	3300.00	3700.00
PMR 85		9.50[bc]	8.83[bc]	8.3[c]	8.2[c]	Excellent - 5	Excellent - 5	4290.00	4710.00
CD	--	1.18	1.20	0.9	0.7	--	--	--	--

*Values within columns having common letter are statistically *at par*.

Table 3. Economic analysis for different varieties of vegetable pea.

Variety	Cost of cultivation (Rs./ ha)			Gross return (Yield x Expected price) (Rs./ ha)			Net return (Rs./ ha)			B: C		
	2021	2022	Average	2021	2022	Average	2021	2022	Average	2021	2022	Average
PM 128	1,10,885	1,12,325	1,11,605	1,98,000	2,41,314	2,19,657	8,7115	1,28,989	1,08,052	1.79	2.15	1.97
Vivek Matar 11	1,16,775	1,19,236	1,18,006	3,02,267	3,65,057	3,33,662	1,85,492	2,45,821	2,15,657	2.59	3.06	2.83
Vivek Matar 12	1,15,676	1,18,577	1,17,127	3,00,089	3,60,128	3,30,109	1,84,413	2,41,551	2,12,982	2.59	3.04	2.82
Vivek Matar 13	1,17,855	1,19,945	1,18,900	3,33,204	3,92,484	3,62,844	2,15,349	2,72,539	2,43,944	2.83	3.27	3.05
Arkel	1,12,928	1,14,730	1,13,829	2,20,737	2,70,840	2,45,789	1,07,809	1,56,110	1,31,960	1.95	2.36	2.16
PC531	1,13,681	1,14,920	1,14,301	2,24,037	2,73,800	2,48,919	1,10,356	1,58,880	1,34,618	1.97	2.38	2.18
PSM 3	1,12,215	1,13,348	1,12,782	2,17,074	2,63,107	2,40,091	1,04,859	1,49,759	1,27,309	1.93	2.32	2.13
PMR 85	1,11,357	1,12,360	1,11,859	2,63,106	3,08,788	2,85,947	1,51,749	1,96,428	1,74,089	2.36	2.75	2.56

also documented. For consumer preference and expected price a panel of ten-woman judges was assigned to rank the overall acceptability of pods on five-point scale (Pande, 2024) and accordingly the expected price was assigned depending on the prevailing average market rates, which are as follows;

RESULTS AND DISCUSSION

Floweringduration and yield

The data (Table 1) clearly showed that Vivek Matar 13 was the first to flower 50 percent (83.6 days in 2021-22 and 82 days in 2022-23) and gave first harvest (116 days in 2021-22 and 114.7 days in 2023) in both the years, which was significantly shorter to all the other varieties. For the duration of 50 percent flowering and first harvest, Vivek Matar 13 was followed by Arkel and PM 128.Vivek Matar 13 has also been documented as early maturity variety by Joshi *et al* (2019). Das *et al* (2014) has also observed significant differences in flowering and harvesting duration for various varieties of similar leguminous vegetable *i.e.,* french bean.

Significant differences were found in yield among different varieties of vegetable pea.Vivek Matar 13 gave significantly highest yield of 75.78q/ ha and 81.11q/ha in 2021-22 and 2022-23, respectively, that was statistically *at par* to Vivel Matar 11 and Vivel Matar 12. It was followed by PC 531 and Arkel, while the lowest was recorded in PM 128 during both the years.Muthuramu *et al* (2015), Kushwah *et al* (2017) Pachiappan *et al* (2020),Kumar (2022) and Anitha and Hanumantharaya (2022) have also reported differences in yield attributes of various vegetable pea and french bean varieties.

Quality characteristics

Quality is the most important parameter that decides the value of vegetables, especially of vegetable pea. Pod length, number of seeds per pod and appearance are the major factors that plays significant role in valuing the price of vegetable pea. Wide range of price differentiation has been observed in market for vegetable pea. The data (Table 2) showed that the varieties had significant differences. This eventually influenced the consumer preference and accordingly the expected price was assigned depending on average market price. Although, none of the assessed variety of vegetable pea ranked below good, but Vivek Matar 13 and PMR 85 scored highest with excellent grade during both the years due to long pod length, a greater number of seeds per pod and attractive appearance. Consequently, these two were awarded with highest price of Rs. 4,290/ q and Rs. 4,710/ q for the year 2021-22 and 2022-23, followed by Vivek Matar 11 and Vivek Matar 12.

Economic analysis

Economic analysis is the most important stage to find out the suitability and applicability of tested treatments. As the price of seed and other intercultural operations were almost similar for all the varieties, the calculated differences among various varieties are due to cost occurred in harvesting and packaging. Cost of cultivation was higher for those varieties that gave greater yield. Thus, the maximum cost of cultivation (Rs. 1,17,855/ ha in 2021-22 and Rs. 1,19,945/ ha in 2022-23) was calculated for Vivek Matar 13, while the minimum of Rs. 1,10,885/ ha and Rs. 1,12,325/ ha in 2021-22 and 2022-23, respectively was in PM 128.

Not only yield but price depending on quality and consumer preference also played the major role for getting the gross returns. Maximum gross return, net return and B:C was calculated for Vivek Matar 13. The average gross return of Vivek Matar 13 was Rs. 3,62,844/ ha, net return was Rs. 2,43,944/ ha and B:C was 3.It was followed by Vivek Matar 11, Vivek Matar 12 and PMR 85. PM 128 remained least profitable with average net return of Rs. 1,08,052/ ha and its B:C was 1.97.

CONCLUSION

The holistic assessment of various vegetable pea varieties showed that yield as well as pod length, number of seeds per pod and appearance played important role in deciding the profitability of vegetable pea production in mid hills. Possibly, the varieties that mature late and did not have required level of heat tolerance for mid to late spring temperature gave comparatively less yield. Vivek Matar 13 showed very good balance of yield, quality and marketability under

organic conditions of mid hills. However, other varieties that gave almost similar yield but had longer maturity duration may be utilized for extended marketing opportunities for distant places. Considering the importance of consumer preference and marketing attributes, pod length, number of seed per pod and pod appearance should be the major identifying parameters for developing new varieties of vegetable pea. Moreover, tolerance towards increasing temperature of mid to late spring also needs to be taken in varietal development.

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Received on 28/10/2024 Accepted on 15/11/2024

J Krishi Vigyan 2024, 12(4) : 970-977
DOI : 10.5958/2349-4433.2024.00166.X
ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

Yield and Quality of Sweet potato Influenced by Tillage and Nutrient Management in Sandy Loams of Onattukara in Kerala

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ABSTRACT

An experiment was conducted to examine the effect of different tillage practices and nutrient management on yield and quality of sweet potato in the Onattukara sandy plains. The experiment was laid out in split plot design with three main plot treatments, four subplot treatments and four replications. The main plot treatments were reduced tillage (T_1), ridge tillage (T_2) and conventional tillage (T_3). The subplots treatments were 100% RDF (n_1), n_1 + magnesium sulphate @ 0.2% foliar spray @ 30 DAP (n_2), n_1 + borax @ 0.2% foliar spray @ 30 DAP (n_3) and n_2 + borax @ 0.2% foliar spray @ 30 DAP (n_4). The results revealed that, in the *Onattukara* sandy loam soils of Kerala, higher number of tubers per vine, marketable tubers per vine, tuber yield per hectare and vitamin C can be obtained, when sweet potato vines were planted under reduced tillage (only one shallow primary tillage) and supplied with the recommended dose of fertilizers (FYM @ 10 t/ha, N, P_2O5 and K_2O @ 75:50:75 kg/ha) along with one foliar application of magnesium sulphate followed by borax (both @ 0.2%) at 30 days after planting.

Key Words: Borax, Magnesium sulphate, *Onattukara*, Quality, Sweet potato

INTRODUCTION

Sweet Potato [*Ipomea batatus* L. (Lam)] is a herbaceous root crop belonging to the Convolvulaceae family. The crop has a duration of 90 to 130 days depending on the variety. Sweet potato is grown throughout the tropical and subtropical countries for its edible tubers. In India, it is cultivated as an important food crop for humans and also as feed for domestic animals. The tubers of sweet potato are having a number of health benefits as it contains several antioxidants and anti-inflammatory properties. Soil compaction of agricultural soils is a well-recognized global problem. One of the most effective ways to reduce compaction is tillage. Tillage helps to optimize the productivity of crops by reducing the physical, chemical and biological stresses on the soil. Sweet potato being a root crop responds differently to tillage. *Onattukara* region of Alappuzha district has sandy loam soils and is ideally suited for cultivation of sweet potato. Being sandy loam, the soil has high porosity and hence the retention of nutrients in soil is very low. Deficiency of essential nutrients in soil is a major constraint for crop production, especially sweet potato. The response of sweet potato to tillage and nutrient management in the problem zone of Onattukara has not received adequate research attention. Hence, the present study was undertaken with the objective of assessment of different tillage practices and nutrient management on the yield and quality of sweet potato in the Onattukara sandy plains.

MATERIALS AND METHODS

A field experiment entitled 'Tillage and nutrient management for yield and quality of sweet potato in Onattukara Sandy Plains' was conducted in the Instructional Farm attached to Onattukara Regional Agricultural Research Station, Kayamkulam, Kerala during November 2023 to

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March 2024. Onattukara tract is considered as a problem soil region due to the sandy loam nature of the soil and higher water table. The crops cultivated here yield best when the full recommended dose of nutrients were supplied to them. The experiment was laid out in split plot design with three types of tillage as the main plot treatments, four nutrient management measures as subplot treatments and were replicated four times. The main plot treatments were reduced tillage (T_1), ridge tillage (T_2) and conventional tillage (T_3). The subplots treatments were 100% RDF (n_1), n_1 + magnesium sulphate @ 0.2% foliar spray @ 30 DAP (n_2), n_1 + borax @ 0.2% foliar spray @ 30 DAP (n_3) and n_2 + borax @ 0.2% foliar spray @ 30 DAP (n_4).

The experimental field was previously cropped with rice before raising sweet potato. After the harvest of rice crop, the stubbles were incorporated into the main field by a shallow primary tillage and dolomite @ 1 t/ha was uniformly applied. The whole experimental area was divided as per treatments into reduced tillage, ridge tillage and conventional tillage. One additional tillage to a depth of 30 cm was done, to bring the soil to a fine tilth in conventionally prepared plots. Raised beds were prepared for planting sweet potato vines in reduced tillage and conventional tillage plots. For ridge tillage, ridges were formed at the time of land preparation. Manures and fertilizers were applied as per KAU (2016). As a basal dose, well decomposed FYM @ 10 t/ ha along with half N, full P and full K of the recommended dose of chemical fertilizers (75:50:75 N, P_2O_5, K_2O kg/ha) was given to all the plots. The remaining half N was given as split dose at one month after planting along with foliar application of magnesium sulphate and borax as per the treatments. Vines of sweet potato *var*. Sree Arun was used as planting material for the main field. Sree Arun is a high yielding, early maturing variety with pink skin and cream flesh released from ICAR-CTCRI (Central Tuber Crops Research Institute) Thiruvananthapuram, Kerala. The sweet potato vines were planted at a spacing of 60 cm x 20 cm. Interculture, weeding and earthing up was done at 30 DAP before foliar application of nutrients.

Five observational plants from each plot were tagged for observation. At harvest, the total number of tubers from each observational plants were counted and the average was worked out to find the number of tubers per vine. The total numbers of marketable tubers per plant were worked out by counting the number of marketable tubers from each observational plants and their average was calculated. The tubers with less than 2.5 cm diameter were considered as non-marketable tubers. The tuber yield obtained from the net plot area of all the treatments were measured separately and was expressed in t/ha. The net weight of vines was also calculated and expressed in t/ha. For estimating the quality, starch content, total sugars, vitamin C, carotene content, crude protein and crude fibre was analysed. The starch content of the tubers was estimated by AOAC (1975) on fresh weight basis. The total sugars were estimated as per the method described by Ranganna (1977) and was expressed as percentage on fresh weight basis. Vitamin C content was estimated on fresh weight basis by following the spectrophotometric method and the values were expressed in mg/100 g. The carotene content (mg/100g) on dry weight basis was determined as per the method described by Sadasivam and Manickam (2008). The plant crude protein content at harvest was calculated using Micro-Kjeldahl digestion and distillation method (Simpson *et al*, 1965) and was expressed as percentage. Plant crude fibre was analysed using Weende method (AOAC, 1990) and was expressed in percentage on dry weight basis.

RESULTS AND DISUSION

Effect on Yield and Yield Attributes

The number of tubers per vine was significantly influenced by tillage (Table 1). Reduced tillage (T_1) produced significantly higher number of tubers per vine (3.51) and was found to be on a par with ridge tillage (3.48). Conventional tillage (T_3) could produce only 1.39 tubers per vine. There was an overall increase of 152.2 percent in the number of tubers per vine due to reduced tillage. The presence of stubbles of previous rice crop in reduced tillage might have provided an ideal soil physical condition for the development of sweet potato tubers per vine. Peter

(2008) had earlier reported higher number of cassava tubers per plant under zero tillage followed by ridge tillage. Ahmed *et al* (2012) had also observed increased tuberous roots from reduced tillage and ridge tillage due to the loose top soil in which storage roots were grown. The foliar application of magnesium sulphate followed by foliar application of borax (n_4) had significantly influenced the number of tubers per vine. The treatment n_4, recorded significantly higher number of tubers per vine (3.08 tubers per vine) and is 18.46 percent higher than the control (n_1). Magnesium, a constituent of the ring structure of chlorophyll, along with boron, which helps in the regulation of carbohydrates and translocation of starches, might have contributed to the increased production of photosynthates leading to a higher number of tubers per vine in n_4 treatment. El-Metwaly and Mansour (2019) had earlier reported an increased number of tubers per plant in potato due to application of magnesium sulphate in soil and as foliar spray. Sharaf-Eldin *et al* (2019) had reported an increase in number of tubers per vine in sweet potato due to foliar application of boron @ 50 ppm. No significant difference for interaction was obtained for the number of tubers per vine.

Marketable Tubers

The data on number of marketable tubers are given in Table 1 and Table 2. The number of marketable tubers per vine followed a similar trend as that of number of tubers per vine. Significantly higher number of marketable tubers per vine (3.35) was observed for ridge tillage and was found to be on a par with reduced tillage (T_1 - 3.31). This might be due to the reduced soil compaction and better aeration in reduced and ridge tillage compared to the conventional tillage. Plants in conventional tillage could produce only 1.28 number of marketable tubers per vine. Similar results of increased number of marketable tubers per vine was observed by Anikwe *et al* (2007) in cocoyams that were raised in ridge seed beds. Foliar application of magnesium sulphate and borax (n_4) had significant influence on the number of marketable tubers per vine (2.92). There was an overall increase of 19.18 percent in the number of marketable tubers per vine compared to n_1 (100%RDF). The application of magnesium sulphate along with boron had significantly increased the number of tubers per vine and this was reflected in the production of significantly higher number of marketable tubers per vine. Foliar application of magnesium sulphate might have increased the production of photosynthates which led to an increase in number of marketable tubers per vine. In addition to magnesium sulphate, foliar application of boron might have helped in translocation of more starches to the tuber. In the Onattukara region of Alappuzha district, Kerala, cracking of sweet potato tubers due to deficiency of boron is a serious problem faced by farmers. This affects the marketability of tubers in the area. The tubers obtained in the treatment n_4 was free from tuber cracking. Similar results of increased total marketable yield in sweet potato was also reported by Sharaf-Eldin *et al* (2019), when boron (@ 50 ppm) was sprayed as foliar at 60 and 90 DAP. Findings by Singh *et al* (2024) also suggested that spraying of $MgSO_4$ and $CaNO_3$ @ 2% increased the marketable yield of potato. The interaction effects were found to be significant for the number of marketable tubers per vine (Table 2). The treatment combination T_2n_4 was found to produce significantly higher number of marketable tubers per vine (3.70) and this was found to be at par with the treatment T_1n_4 (3.60). Thus, for obtaining increased number of marketable tubers per vine, sweet potato vines should either be raised in ridges or under reduced tillage and should be supplied with the full recommended dose of fertilizers along with one foliar application of magnesium sulphate (@ 0.2 %) and borax (@ 0.2 %) at 30 days after planting. Regardless of the nutrient management, conventional tillage produced lower number of marketable tubers per vine. There was an increase of 208.33 percent of number of marketable tubers per vine in T_2n_4 over T_3n_1.

Tuber Yield

Among tillage, significantly higher tuber yield per hectare (20.28 t/ha) was recorded for reduced tillage (T_1) (Table 1). The yield attributes of sweet potato *viz*. number of tubers per vine and number of marketable tubers per vine were observed to be significantly higher for reduced

Table 1. Effect of tillage and nutrient management on yield and yield attributes of sweet potato

Treatments	Number of tubers per vine	Number of marketable tubers per vine	Tuber yield (t/ha)
Tillage			
T_1 – reduced tillage	3.51	3.31	20.28
T_2 – ridge tillage	3.48	3.35	17.41
T_3 – Conventional tillage	1.39	1.28	5.99
SEm (±)	0.09	0.09	0.12
CD (0.05)	0.294	0.313	0.404
Nutrient management			
n_1 – 100% RDF	2.60	2.45	13.59
n_2 – n_1 + MgSO4 @ 0.2% foliar spray	272	2.53	14.27
n_3 – n_1 + borax @ 0.2% foliar spray	2.77	2.68	14.77
n_4 – n_2 + borax @ 0.2% foliar spray	3.08	2.92	15.62
SEm (±)	0.05	0.05	0.24
CD (0.05)	0.145	0.313	0.696

*RDF – Recommended dose of fertilizers

tillage. These increased yield attributes had led to the production of significantly higher tuber yield per hectare due to reduced tillage in sweet potato. The incorporation of biomass like stubbles of previous crop of rice, might have also improved the soil environment, creating higher moisture retention in soil thereby, increasing the yield of sweet potato from reduced tillage. There was an overall yield increase of 233.22 percent in reduced tillage compared to conventional tillage. Conventional tillage could produce only 5.99 tonnes of tubers per hectare which might be due to soil compaction that restricted the root growth and reduced its access to nutrients. Gopika (2024) had also reported significantly higher tuber yield (16.20 t/ha) in Chinese potato with reduce tillage along with surface retention of cowpea. Nutrient management had significantly influenced the tuber yield per hectare in sweet potato. Among the treatments, n_4 produced significantly higher tuber yield of 15.62 t/ha. Magnesium, being a part of chlorophyll helps in photosynthesis and aids in the formation and development of sink organs such as seeds and roots (Ceylan *et al*, 2016). During photosynthesis, light energy is converted to chemical energy for producing sugar which needs to be transported to the sink (roots). This distribution of sugars is facilitated by boron. Hence, the treatment n_4 which involved the foliar application of magnesium and boron, might have helped in the production of significantly higher tuber yield per hectare. Among the treatment combinations, T_1n_4 and T_1n_3 produced significantly higher tuber yield with 21.81 t/ha and 21.07 t/ha respectively (Table 2). The tuber yield was found to increase by 280.63 percent in T_1n_4 compared to T_3n_1 asserting the dominance of reduced tillage and foliar nutrition to conventional tillage and recommended dose of nutrition.

Effect on Quality Attributes

Tuber quality of sweet potato was assessed in terms of starch, total sugars, vitamin C, carotene, crude protein and crude fibre. No significant effects were obtained in any of the treatments for starch percentage and total sugars

Table 2. Interaction effect of tillage and nutrient management on yield and yield attributes of sweet potato

Treatments	Number of tubers per vine	Number of marketable tubers per vine	Tuber yield (t/ha)
T_1n_1	3.45	3.20	18.60
T_1n_2	3.35	3.05	19.66
T_1n_3	3.50	3.40	21.07
T_1n_4	3.75	3.60	21.81
T_2n_1	3.10	2.95	16.46
T_2n_2	3.50	3.35	17.05
T_2n_3	3.45	3.40	17.30
T_2n_4	3.85	3.70	18.83
T_3n_1	1.25	1.20	5.73
T_3n_2	1.30	1.20	6.10
T_3n_3	1.35	1.25	5.93
T_3n_4	1.65	1.45	6.21
SE (m) A/B (±)	0.09	0.09	0.42
SE (m) B/A (±)	0.11	0.12	0.38
CD (0.05) A/B	NS	0.263	1.205
CD (0.05) B/A	NS	0.386	1.117

*NS – Not significant
* A/B – Factor (B) at same levels of Factor A
* B/A – Factor (A) at same levels of Factor B

(Table 3). Significantly higher vitamin C content was observed for reduced tillage (T_1- 20.60 mg/100g) and was found to be on a par with conventional tillage (T_3 - 19.99 mg /100g). Similar reports of significantly higher vitamin C was also reported in sweet potato raised in flat beds under irrigated conditions by Saqib *et al* (2017). No significant effects were observed for nutrient management and interaction. Significantly higher carotene content was observed for the treatment T_2 (ridge tillage) with 0.60 mg /100g (Table 5). There was significant difference in nutrient management for carotene content in sweet potato. Magnesium is crucial for photosynthesis and it also plays a role in synthesizing carotene. Boron is also attributed to increasing concentration of carotene and was confirmed by the study conducted by Younis *et al* (2024) who reported higher carotene content in sweet potato tubers when borax was sprayed. There was significance for interaction effects. Significantly higher carotene content was observed for the treatment T_2n_4 with 0.89 mg/100g. Crude fibre and crude protein were not significantly influenced by any of the treatments.

CONCLUSION

In *Onattukara* sandy loam soils of Kerala, higher number of tubers per vine, marketable tubers per vine, tuber yield per hectare and vitamin C can be obtained from sweet potato, when the vines are planted under reduced tillage (only one shallow primary tillage) and supplied with the recommended dose of fertilizers (FYM @ 10 t/ ha, N, P_2O5 and K_2O @ 75:50:75 kg/ ha) along with one foliar application of magnesium sulphate followed by borax (both @ 0.2%) at 30 days after planting.

Table 3. Effect of tillage and nutrient management on quality attributes of sweet potato

Treatments	Starch (%)	Total sugars (%)	Vitamin C (mg/100g)
Tillage			
T_1 – reduced tillage	21.01	4.86	20.60
T_2 – ridge tillage	20.51	4.90	18.54
T_3 – Conventional tillage	20.36	4.82	19.99
SEm (±)	0.22	0.07	0.21
CD (0.05)	NS	NS	0.722
Nutrient management			
n_1 – 100% RDF	20.55	4.90	20.13
n_2 – n_1 + MgSO4 @ 0.2% foliar spray	21.09	4.98	19.82
n_3 – n_1 + borax @ 0.2% foliar spray	20.49	4.80	19.60
n_4 – n_2 + borax @ 0.2% foliar spray	20.38	4.75	19.28
SEm (±)	0.16	0.65	0.66
CD (0.05)	NS	NS	NS

*RDF – Recommended dose of fertilizers
*NS – Not significant

Table 4. Interaction effect of tillage and nutrient management on quality attributes of sweet potato

Treatments	Starch (%)	Total sugars (%)	Vitamin C (mg/100g)
T_1n_1	20.74	4.95	20.42
T_1n_2	21.60	4.84	20.35
T_1n_3	20.94	4.69	20.42
T_1n_4	20.76	4.95	21.20
T_2n_1	20.26	4.96	19.55
T_2n_2	21.50	4.81	20.35
T_2n_3	20.66	4.86	17.97
T_2n_4	19.63	4.79	16.30
T_3n_1	20.65	5.03	20.42
T_3n_2	20.18	4.76	18.75
T_3n_3	19.88	4.70	20.42
T_3n_4	20.75	4.95	20.35
SE (m) A/B (±)	0.34	0.16	1.15
SE (m) B/A (±)	0.37	0.14	1.02
CD (0.05) A/B	NS	NS	NS
CD (0.05) B/A	NS	NS	NS

*NS – Not significant
* A/B – Factor (B) at same levels of Factor A
* B/A – Factor (A) at same levels of Factor B

Table 5. Effect of tillage and nutrient management on quality attributes of sweet potato (continued)

Treatments	Carotene (mg/100 g)	Crude fibre (%)	Crude protein (%)
Tillage			
T_1 – reduced tillage	0.48	2.15	5.51
T_2 – ridge tillage	0.60	2.19	5.47
T_3 – Conventional tillage	0.42	2.22	5.61
SEm (±)	0.02	0.05	0.10
CD (0.05)	0.057	NS	NS
Nutrient management			
n_1 – 100% RDF	0.39	2.16	5.50
n_2 – n_1 + MgSO4 @ 0.2% foliar spray	0.48	2.17	5.46
n_3 – n_1 + borax @ 0.2% foliar spray	0.47	2.16	5.51
n_4 – n_2 + borax @ 0.2% foliar spray	0.65	2.26	5.65
SEm (±)	0.03	0.05	0.16
CD (0.05)	0.098	NS	NS

*RDF – Recommended dose of fertilizers
*NS – Not significant

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Table 6. Interaction effect of tillage and nutrient management on quality attributes of sweet potato (continued)

Treatments	Carotene (mg/100g)	Crude fibre (%)	Crude protein (%)
T_1n_1	0.30	2.10	5.52
T_1n_2	0.56	2.19	5.51
T_1n_3	0.46	2.13	5.42
T_1n_4	0.49	2.17	5.60
T_2n_1	0.49	2.15	5.55
T_2n_2	0.45	2.12	5.16
T_2n_3	0.58	2.12	5.52
T_2n_4	0.89	2.33	5.64
T_3n_1	0.39	2.23	5.42
T_3n_2	0.44	2.21	5.71
T_3n_3	0.37	2.16	5.60
T_3n_4	0.48	2.28	5.71
SE (m) A/B (±)	0.05	0.08	0.27
SE (m) B/A (±)	0.046	0.08	0.26
CD (0.05) A/B	0.142	NS	NS
CD (0.05) B/A	0.135	NS	NS

*NS – Not significant
* A/B – Factor (B) at same levels of Factor A
* B/A – Factor (A) at same levels of Factor B

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Received on 30/9/2024 Accepted on 2/11/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 978-980

DOI : 10.5958/2349-4433.2024.00167.6

Short Communication

Effective Management of Rare Dystocia due to Diprosopus Monster with Cleft Palate in a Jersey Crossbred Cow under Field Condition

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ABSTRACT

A six years old jersey crossbred full-term pregnant cow was presented with a history of prolonged straining and dystocia. Vaginal examination revealed diprosopus monster calf with bilateral shoulder flexion. The monster calf was delivered per vaginum successfully by traction and the dam recovered uneventfully. The diprosopus fetal monster, characterized by a single neck, trunk, and normal limbs with craniofacial duplication and cleft in the palate was described in the current study.

Key Words: Cleft palate, Cranio-facial duplication, Diprosopus, Double face and Dystocia.

INTRODUCTION

Dystocia is one of the most common obstetrical cases handled by veterinarians in the field and results in the loss of a fetus and dam if appropriate treatment is not given at the proper time. Dystocia may be caused by maternal or fetal origins (Roberts, 2004). Among the fetal origin of dystocia, fetal abnormalities were reported to be 5% of all the dystocias (Arthur *et al*, 2001), whereas the occurrence of fetal monstrosities in cattle was proclaimed to be 0.5% (Purohit *et al*, 2012). A fetal monster is a daunting abnormally large-sized fetus with a hereditary/congenital anomaly (Roberts, 2004). The most common fetal monster encountered was conjoined twins, which arise from partially or completely duplicated fertilized ovum at the mitotic stage. Partial duplication of the craniofacial region with or without the involvement of nasal or oral cavity is called diprosopus or double-faced fetus (Batra *et al*, 2015). Diprosopus fetal anomaly is rare among the fetal monsters reported across the world. So far, diprosopus monster fetus has been reported in cattle (Weber *et al*, 2017), sheep (Mazzullo *et al*, 2003), goat (Mukaratirwa and Sayi, 2006), cat (Sekeles *et al*, 2005) and dog (Mukaratirwa and Sayi, 2006). The current paper describes the dystocia due to craniofacial duplication (diprosopus) with cleft palate and bilateral shoulder dislocation and its successful obstetrical management.

CASE HISTORY

A six years old pluriparous (third parity) full-term pregnant cow, weighing around 300 kg was presented with the anamnesis of dystocia, ruptured water bag, prolonged straining for more than 8-9 hours.

OBSERVATION

The general clinical parameters unveiled normal temperature, pulse rate and respiration rate, edematous vulva with relaxed sacroschiatic ligaments and colostrum oozing from the enlarged mammary gland. Per vaginal examination revealed a fully dilated cervix, dry vaginal cavity, and craniofacially duplicated monster fetus (diprosopus) with no palpable fetal reflexes/movements (absence of suckling and withdrawal reflexes). Further examination revealed that the dead fetus was at the pelvic brim with the anterior-longitudinal presentation, dorso-sacral position and bilateral shoulder flexion. Thus, the case was diagnosed to be dystocia due to a diprosopus fetal monster with shoulder flexion.

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Fig 1: Amputated diprosopus monster calf head

Fig 2: Cleft palate in dead monster calf

CLINICAL MANAGEMENT

The jersey crossbred dam was restrained in such a way that the hindquarter of the animal was raised (by heaping sand and gunny bags) for easy handling of dystocia. Epidural anaesthesia with 5ml of 2% lignocaine hydrochloride was administered at sacro-coccygeal space. The vaginal cavity and fetus was lubricated with an ample amount of lubricant (castor oil). The fetus was repelled back and the shoulder flexion was corrected. Three men traction was applied with rope on both forelimbs and with william's long obstetrical hook on the inner canthus of the right head and the ribs. As the traction was unsuccessful, monster head and the left forelimb of the fetus were amputated and the traction was repeated. The dead calf was delivered successfully along with fetal membranes.

Following the delivery of diprosopus monster fetus, the dam was treated intravenously with Calcium borogluconate (450 ml total dose), 5% Dextrose Normal Saline (DNS-20ml/Kg), Oxytocin @ 30 IU total dose diluted in 500ml Normal saline. Then dam was administered with Flunixin meglumine @ 1.1 mg/Kg i.v. (Megludyne, Virbac Animal Health Ltd., Mumbai, India) Amoxycillin and Cloxacillin @ 10 mg/kg (Intamox, Intas Pharmaceuticals Ltd., Ahmedabad, India), Vitamin b-complex (Tribivet, Intas Pharmaceuticals Ltd., Ahmedabad, India), Chlorpheniramine maleate @ 0.5 mg/Kg i.m. (CPM-VET, Doctor's Life Science (India) Ltd) intramuscularly. The fluid therapy, antibiotics and analgesics were continued for 3 days. Due to the prompt obstetrical management, the dam recovered uneventfully and resumed feeding 7 hours after the treatment.

DISCUSSION

The craniofacial duplication (diprosopus) is a rare fetal monster case reported in buiatric practice. The gross examination of the fetus in the present case, revealed craniofacial duplication, one neck (monauchenos), two eyes each on two faces (tetraophthalmus), duplicated oral and nasal cavity with cleft palate, two tongue, two mandible, two maxilla, two ears on the lateral aspect of the face (no ears on the medial aspect of both faces), single trunk and normal limbs. The thoracic cavity viscera of the monster fetus was found to be exposed due to the traction applied to the ribs by an obstetrical hook. Similar cases were reported in cattle by Pratheepa *et al* (2021), Weber *et al* (2017) and Ozcan *et al* (2005).

In this diprosopus monster fetus, there was a hindrance at the frontal bone development during monozygotic twinning, thus resulting in craniofacial duplication (Long *et al*, 2009). Fetotomy and caesarian section were generally performed to deliver the monster calf dystocias (Sharma *et al*, 1992; Purohit *et al*, 2012). Similarly, amputation and simple traction with rope and the obstetrical hook were applied to deliver the fetus because the dystocia was handled without any complication (no para vet mishandling) and was also attempted as early as possible. In the present case, an added advantage

is the occurrence of dystocia in a pluriparous cow than primiparous, which resulted in the successful management of dystocia.

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Received on 20/10/2024 Accepted on 10/11/2024

ISSN 2319-6432 (Print)
ISSN 2349-6433 (Online)

J Krishi Vigyan 2024, 12(4) : 981-985

DOI : 10.5958/2349-4433.2024.00168.2

Short Communication

Management Module for Banana Pseudostem Weevil *Odoiporus longicollis* Oliver

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ABSTRACT

Banana crop is affected by the pseudostem weevil (*Odoiporus longicollis*), which damages the pseudostem and causes the plant to collapse. This weevil causes yield losses of between 10% and 90%. The study was conducted on the evaluation of various management modules for pseudo stem weevil in banana (var. Red Banana) in farmer's fields with four treatments and seven replications in an RBD design. Treatments were imposed on 5th ,6th and 7th month after planting which includes spraying of cassava leaf based biopesticides (Nanma) in the pseudostem, filling the leaf axil with Heterorhabditis (EPN), spraying of Chlorpyriphos 20EC in the pseudo stem. Percentage of plants affected and extent of pseudostem borer infestation, individual bunch weight were measured. In plants treated with the biopesticide based on cassava leaves (Nanma), crop damage was found to be 2.0%; in contrast, EPN showed 13.0% damage, Chlorophyriphos showed 15.2% damage, and untreated control plants showed 35.5% damage. The Weevil infestation was 2.4 % in cassava leaf based biopesticides (Nanma) treatment followed by 8.60% in EPN treatment and 14.60 per cent in Chlorophyriphos treatment and 36.60 per cent in untreated control. The average increase in bunch weight was 26.16 percent for plants treated with the cassava leaf-based biopesticides (Nanma), 21.52 percent for EPN, and 18.60 percent for Chlorophyriphos when compared to untreated control plants. The study revealed that the spraying of cassava leaf based biopesticides reduced the incidence of pseudostem weevil with higher yield.

Key Words: Banana, Pseudostem Weevil, Cassava leaf based biopesticide, Nanma, Entomo pathogenic nematode, *Heterorhabditis*

INTRODUCTION

Banana (*Musa* sp.) is the second most important fruit crop in India and contributes 29.19% of the world's 145 million tons (Mt) of banana production (Ploetz, 2015). Numerous pests and non-pests have been associated to Musa spp., that significantly damage fruit, leaves, pseudostems, and rhizomes. It has been found that banana cultivars are infested by 19 different species of insects (Padmanaban *et al*, 2001). According to Padmanaban *et al* (2020a, b) *Odoiporus longicollis* and *Cosmopolites sordidus* are the two weevil pests that primarily impede banana production. In the Asia Pacific banana-growing region, pseudostem weevil *Odoiporus longicollis*, causes severe assault and production loss (Justin *et al*, 2008). The grub nibbles from the collar region near the rhizome till peduncle, which reduces nutrition intake and weakens the stem. (Padmanaban and Sathiamoorthy, 2001). Pseudostem weevil infestations cause severe damage, which decreased bunch weight and yield. Bunch size decreases significantly as the infection progresses and the infected pseudostem that supports the bunch break off and topples due to wind. Depending on the banana cultivar's growth stage and the effectiveness of management, the pseudostem weevil could result in a yield loss of 10–90% (Padmanaban *et al,* 2020a). Farmers use very toxic synthetic insecticides for spray or

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Grade	Symptom
0	Plants with no symptoms
1	Plants with 1 to 5 bore holes on the pseudostem
2	Plants with 6 to 10 bore holes on the pseudostem
3	Plants with more than 10 bore holes on the pseudostem
4	Plants with pseudo stem about to break or already broken

pseudo stem injection, despite there is no satisfactory control which triggers high levels of pesticide pollution and residue problem in the fruits. Globally there is a drive to shift from synthetic insecticides to eco-friendly formulations in pest management strategies.

The most prevalent way for managing banana stem weevil in India is to use synthetic chemical insecticides (Tippaiah *et al,* 2011). Safer methods of management are needed as bananas serve as a food crop. Biological management with entomopathogenic fungi (EPF) is a safe and effective alternative since these fungi can naturally develop in soil and infect a variety of insects (Sharmila and Mohan, 2015). *O. longicollis* is controlled by the use of entomopathogenic fungi (Velavan *et al*, 2021). When treated early in the crop cycle, endophytic isolates of *B. bassiana* are effective for *O. longicollis*. (Alagesan *et al*, 2019). Padmanaban *et al,* (2019) isolated of endophytic Entomopathogenic fungi (EPF) from cultivars of Musa germplasm that provided protection against pests of banana. The effect of EPN *Heterorhabditis indica* against banana stem weevil under *in vitro* was studied by Padamanaban *et al* (2002). A biopesticide based on cassava leaf extract effectively controls the pseudostem weevil in banana plants (Pushparaj and Shinoj, 2022).The purpose of the field study was to document the effectiveness of several management modules in controlling the banana pseudostem weevil.

MATERIALS AND METHODS

The experimental trial was conducted at Muthalakurichi of Thuckalay block, Kanyakumari during the *Kharif* season. The texture of the soil was sandy loam, with a moderate capacity to hold water. It had a low to medium level of organic carbon (0.31-0.63%), low levels of available nitrogen (175-273 kg/ha), phosphorus (5.4-9.9 kg/ha), and potassium (76-154 kg/ha), as well as a slightly acidic to neutral pH (6.0-6.7). . For all treatments, the typical integrated nutrient management schedule of 150:90:300 g NPK per plant/year was adhered with, along with the use of 20 g of *Azospirillum* and *Phosphobacteria* per plant. The crop with 2.1 x 2.1 m spacing was planted. The management of pseudo stem weevil in the banana variety Red banana involved the application of the following four treatments with seven replications in an RBD design.

T1: Spraying of cassava leaf based biopesticides (Nanma) in the pseudostem @ 5 ml on 5^{th} ,6^{th} and 7^{th} month after planting

T2: Filling the leaf axil with Heterorhabditis, (EPN) @ four cadavers per plant on 5^{th} ,6^{th} and 7^{th} month after planting

T3: Spraying of Chlorpyriphos 20EC @ 0. 25% in the pseudo stem at monthly interval on 5^{th} , 6^{th} and 7^{th} month after planting

T4: Untreated control

During the crucial stages of the crop, fields were irrigated; the crop was harvested, and the yield was recorded. The symptoms, which included tiny pinhead-sized holes, fibrous extrusions, sticky substance exudation, and adult weevil presence, were observed. Percentage of plants affected and extent of pseudostem borer infestation were determined. The weevil infestation was calculated using the damage grade index described by Thippiah *et al* (2010). The number of plants that fell as a result of a pest attack was divided by the total number of plants to determine the extent of crop damage. Individual bunch weight was determined by randomly selecting harvested bunches.

STATISTICAL ANALYSIS

All the experiments were analyzed independently. The OP STAT software was used to analyze the data statistically. The treatment means were compared by Duncan's Multiple Range-Test

Table 1. Effect of different management modules on Pseudostem weevil incidence, yield, economics in Banana.

Treatment	Crop Damage (%)	Infestation percentage of Pseudostem weevil (%)	Bunch weight (Kg)	Yield (q/ha)	BCR
T1	2.0 (8.11)	2.40 (8.91)	21.55	474.0	2.33
T2	13.0 (21.13)	8.60 (17.07)	20.27	446.0	2.06
T3	15.2 (22.95)	14.60 (22.48)	19.55	408.0	2.09
T4	35.5 (36.57)	25.30 (30.21)	15.91	250.0	1.57
SED	0.085	0.361	4.0	175.0	
CD(P=0.05)	0.33	0.68	2.25	14.86	

Figures in parentheses are arc sine transformed values

(DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The effect of different management modules against pseudostem weevil is presented in Table 1. Treatment of plants based on cassava leaves (Nanma) biopesticide) recorded crop damage of 2.0%, in contrast, EPN (13.0%), Chlorophyriphos (15.2%), and untreated control plants recorded 35.5% damage. The Weevil infestation was 2.4 % in cassava leaf based biopesticides (Nanma) treatment followed by 8.60% in EPN treatment and 14.60 per cent in Chlorophyriphos treatment and 36.60 per cent in untreated control. The outcomes align with the research conducted by Jithu *et al* (2017) and Pushparaj and Shinoj (2022), which demonstrated the effectiveness of cassava leaf extract based biopesticide against banana stem weevil. The application of a cassava leaf extract based biopesticide formulation effectively suppressed banana weevil (Hali, 2016). Kannan *et al* (2021) reported that Nimbicidine and cassava based Nanma significantly reduced the infestation of Banana Stem Weevil similar to positive control chlorpyriphos.

On comparing treated vs untreated control plants, the average increase in bunch weight was 26.16 percent for plants treated with the cassava leaf-based biopesticides (Nanma), 21.52 percent for EPN, and 18.60 percent for Chlorophyriphos. The yield of banana is 474.0q/ha with BCR of 2.33 in plants treated with the cassava leaf based biopesticides (Nanma) followed by 446.0q/ha with BCR of 2.06 in plants treated with EPN and plants treated with Chlorophyriphos recorded yield of 408q/ha with BCR of 2.09. The untreated control recorded yield of 250q/ha with BCR of 2.06. The decrease in crop damage was the reason of the increased banana output. Earlier studies by Pushparaj and Shinoj (2022) and Irulandi *et al* (2012) have reported similar results. In conclusion, results of this study revealed that the spraying of cassava leaf based biopesticides reduced the incidence of pseudostem weevil with higher yield. Cassava leaf extract contains secondary metabolites such cyanogenic glycosides, flavonoid glycosides, and hydroxycoumarins that function as chemical defenses and insecticidal qualities, and functions as a natural insecticide by altering the physiology of insects and causing behavioral changes (Joseph *et al,* 2021). Ethyl acetate extract of Cassava leaf extract is a possible grain protector against *Sitophilus oryzae* adult (Mity and Tom 2015). Cyanogens, the primary active ingredients in cassava that effectively combats key stored grain pests like *Rhyzopertha dominica* and *Tribolium castaneum* (Ajesh *et al*, 2018).

CONCLUSION

Using botanical ingredients as pesticides will help crops from pest infestation. In addition to being inexpensive, they pose no insecticidal risks to the environment. The results of the current studies provide compelling evidence for the application and investigation of botanicals in pest management techniques. This formulation's popularity will result in a cleaner environment and more revenue for farmers. The implementation

Integrated pest control techniques could significantly lower the occurrence of pests incidence, boost revenue, and enhance the standard of living for the agricultural community when combined with other enhanced production techniques in the banana

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Received on 6/8/2024 Accepted on 7/10/2024