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Yield and Morphological Characters as Affected by Chlormequat Chloride Application in Grape Cultivar Punjab MACS Purple

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ABSTRACT

The present investigation was carried out to evaluate the effect of growth retardant Chlormequat chloride (CCC) on morphological characters of grape cultivar Punjab MACS Purple. The foliar application of Chlormequat chloride (250, 500, 750 and 1000 ppm) was done at five leaf stage while the control vines were sprayed with water only. Observations on vegetative growth were recorded at different growth stages. Maximum dose of Chlormequat chloride was found to be most effective in reducing cane length and internodal length while the same dose resulted in maximum cane diameter. There was reduction in leaf area as well as size while the effect on time of anthesis and trunk girth was less significant. It has been reported that yield and bunch weight was maximum with the application of 1000 ppm Chlormequat chloride followed by 700 ppm Chlormequat chloride.

Key words: Grapes, Chlormequat Chloride, Vegetative Growth, Flowering, Yield.

INTRODUCTION

Grape cultivation is considered to be an economic venture for the farmers due to its high monetary returns. Grape belongs to the family Vitaceae which consists of 12 genera and 600 species. Among these, *Vitis vinifera* produces the highest quantity of grapes either as pure *vinifera* or in the form of hybrids. Grape cultivation occupies an area of 140 thousand hectares with the production of 3,125 thousand MT (Anonymous, 2020a).). In Punjab, area under grapes is 320 hectare with per annum production of 5,680 MT and productivity of 17,749 kg/ hectare. The recommended varieties of grapes by Punjab Agricultural University include Punjab Macs Purple, Superior Seedless, Flame Seedless, Beauty Seedless and Perlette (Anonymous, 2020b).

Under North Indian conditions, one of the reasons of barrenness of the vines is excessive vegetative growth of the vines. Moreover, presence of excessive shoot vigour is detrimental to the plant growth because plant metabolites are used for vegetative growth which results in reduction in yield. So, it is important to decrease the vigour of vegetative growth without reduction in the shoot number. The vigour of vines can be controlled with either judicious pruning of canes or with use of growth retardants or both. Plant growth regulators are now considered to be new generation agrochemicals after pesticides, fertilizers and herbicides as these improve the source sink relationship thereby enhancing the translocation of photo assimilates and helping in better fruit set (Anayat *et al* 2020). In horticulture, plant growth retardants are used for the reduction of unwanted shoot length without affecting the productivity of the plants. Use of growth retardants is also a good practice in viticulture for the improvement of quality and productivity in grapes (Kumber *et al* 2017). Out of all the growth retardants used, the application of quaternary ammonium salt– chlormequat chloride is most common (Polyvanyi *et al* 2020). Since excessive vegetative growth hampers the fruit production, fruiting and flowering is successfully enhanced by the use of growth retardants. Cycocel can be used on vines as it is non-toxic, as well as it reduces the internodal length without causing change in leaf number and emergence of lateral shoots (Chougule *et al* 2008). Plant growth retardant

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Chlormequat Chloride was discovered in 1950s. It was first described in Michigan State University at East Lansing in USA by N E Tolbert for the reduction of shoot length in many plant species (Rademacher 2016). Use of Chlormequat Chloride was done firstly in wheat crop for the production of shorter plants with thick stems. Chlormequat Chloride belongs to the onium compounds which blocks ent-kaurene synthase and copalyl-diphosphate synthase which are involved in the synthesis of Gibberellins (Koutroubas and Damalas 2016). In many fruit crops, Gibberellic Acid (GA) leads to inhibition of flower formation. Under such conditions use of growth retardants such as cycocel, paclobutrazol and SADH can be done to inhibit the biosynthesis of GA thus promoting flowering (Kumari *et al* 2018). Chlormequat chloride (CCC) is an inhibitor of biosynthesis of gibberellins and it is used to inhibit cell elongation and vegetative growth (Kulkarni *et al* 2018). Chlormequat chloride (CCC) is available commercially under the trade name of Cycocel. Its application on the foliage or fruit clusters one or three weeks before flowering leads to increased fruit set. The spray of chlormequat chloride (CCC) on the shoots also result in shortened internodes, dark green leaves, retarded tendrils and more number of inflorescence. Unlike daminozide, chlormequat chloride leads to inhibition of biosynthesis of Gibberellins early in the process. Chlormequat chloride has activity when application is done on leaves as well as roots. Usually, it is applied as foliar spray as more concentration is needed for its application as drench.

MATERIALS AND METHODS

The experimental trial was conducted in year 2021 at Punjab Agricultural University, Ludhiana. The experimental plot is located at 30° 40′ N and 75°48′ E with an altitude of 247 m above the mean sea level. The present investigation was carried out on own rooted grape vines of Punjab MACS Purple at the spacing of 5x5 feet and trained on bower system of training. All the vines were provided with uniform cultural practices, manure and fertilizers during the research.

Foliar application of Chlormequat chloride was done in morning hours using knap sack sprayer when vines reach 5 leaf stage after sprouting. At the same time, untreated grape vine were sprayed with water. There were five treatments (T_1: Chlormequat Chloride @ 250 ppm, T_2: Chlormequat Chloride @ 500 ppm, T_3: Chlormequat Chloride @ 750 ppm, T_4: Chlormequat Chloride @ 1000 ppm, T_5: Control). The experiment was conducted in Randomized Block Design (RBD) and the data was analyzed using statistical software CPCS1.

The length of the cane was measured from the base to the tip with the help of a measuring tape and was expressed in centimetres. The diameter of the mature cane was measured at the middle of the first internode with the help of vernier caliper and was expressed in centimetres. For internodal length, measurement of third internode (between second and third node) was done using measuring tape.
Leaf area of ten leaves per treatment was measured, with the help of Leaf Area meter (Delta-T digital image Analysis System). Trunk girth was measured at 15 cm from ground level with the help of measuring tape. Time of anthesis was considered when more than 90% of the flowers on a panicle were opened. From the harvest data, the yield per vine from each treatment was calculated. It was expressed as kg/vine by multiplying the number of bunches per vine with average bunch weight.

RESULTS AND DISCUSSION

Cane Length (cm)

Application of chlormequat chloride had a clear effect on reduction of cane length. The perusal of the data in Fig. 1 reveals that the cane length was higher in control in comparison to other treatments. The length of canes reduced drastically with increase in dose of chlormequat chloride. Towards the end of growth period (at 69 days interval), the maximum cane length was recorded in T_1 (94.2 cm) which was

closely followed by T_5 (92.8 cm). It is clear from the data that the treatments had shown remarkable effect in inhibiting the vegetative growth in terms of cane length as it was found to be lowest in T_3 and T_4 (84.2 cm each).

Chlormequat chloride, a growth retardant has been used traditionally for reduction in vegetative growth of the plants. The decrease in cane length as recorded in the present study results due to inhibition of gibberellins biosynthesis. The role of gibberellic acid in cell elongation thereby decreasing the vegetative growth is well known. Chlormequat chloride decreases the same by acting as an anti-gibberellin compound. Reduced concentration of gibberellic acid in the cells affects the movement of solutes between the cells as plasticity and cell wall relaxation is decreased while the stiffness of the cell wall increases. This increase in stiffness results in reduced cell elongation and replication (Abdel-Mohsen 2015).The results of the current study are in accordance with Bahar *et al* (2009) who observed that there was reduction in cane length in grape cultivars Sauvignon Blanc and Semillon with the application of chlormequat chloride. Similarly, Taili *et al* (2011) found that in grape cultivar Kyoho the growth of new shoots was inhibited after 3 weeks of treatment with chlormequat chloride with more pronounced effect at the 4th week after treatment. Also, the branch length in Kyoho cultivar of grapes was reduced due to the application of 300, 500 and 750 ppm cycocel (HongYan *et al* 2013). The decrease in cane length in grape cultivar Thompson Seedless was also observed by Kulkarni *et al* (2018). In this study the length of shoots was reduced significantly by the application of chlormequat chloride @ 1000ppm at 5 leaf stage, 1500 ppm at 7 leaf and 2000 ppm at 12 leaf stage.

Cane Diameter (cm)

As presented in Fig. 2, the cane diameter was maximum (0.51 cm) in the vines with the highest dose of cycocel. The cane diameter in all other treatments was nearly same with the least value in T_2 (0.45 cm). After 60 days, the cane diameter in T_3 increased substantially and was the highest (0.61 cm) among all the treatments. This was followed by both T_1 and T_2 (0.59 cm each). The lowest cane diameter was recorded under controlled conditions (0.57 cm).

Structurally, cycocel is closely related to Choline which takes part in methylation reaction and lipid methabolism. Both these processes result in thicker and shorter shoots (Tolbert 1960). Kulkarni *et al* (2018) found that in grape cultivar Thompson Seedless, the use of chlormequat chloride at various concentrations lead to increased cane diameter. In the past studies, it has been revealed that chlormequat chloride reduces the internodal length by its inhibitory effect on the growth promoting hormones. The impact of growth retardants in the plant takes place in the sub-apical region of the tip of the shoot. At sub-apical region of the shoot, cell division as well as elongation is inhibited. Therefore the internodes of the treated plants are shorter because of lesser number of cells. Chlormequat chloride application at 5 leaf stage has been proved to be more effective than other treatments in reduction of internodal length between 5th and 6th; 10th and 11th and 15th and 16th internode in grapes (Wani *et al* 2020). Coombe (1967) observed the decrease in internodal length with the application of 1000 ppm cycocel. Similar findings were obtained by Umar and Sharma (2008) who concluded that the application of chlormequat chloride at 5 leaf stage resulted in reduced internodal length. In grape cv. Ciliegiolo application of 500 and 1000 ppm of chlormequat chloride resulted in minimum internodal growth among all the treatments (Loreti 1974).

Internodal Length (cm)

The effect of spray on reducing the internodal length was significant in open conditions. The internodal length was highest in control at all the intervals (Fig 3). At 15 days interval, the length of internodes was maximum (8.50 cm) in control and minimum in T_4 (7.16 cm). At 75 days interval, the internodal length was maximum in T_5 (11.34 cm)

Table 1: Effect of chlormequat chloride application on leaf characteristics in grape cv. Punjab Purple

Treatment	Leaf Length (cm)	Leaf Breadth (cm)	Leaf Area (cm^2)
T_1 Chlormequat Chloride @ 250 ppm	11.98	14.26	183.95
T_2 Chlormequat Chloride @ 500 ppm	12.45	13.39	151.82
T_3 Chlormequat Chloride @ 750 ppm	11.71	13.43	143.74
T_4 Chlormequat Chloride @ 1000 ppm	11.3	12.38	112.08
T_5 Control	14.41	15.84	221.72
CD (5%)	0.66	0.30	1.33

and least in T_4 (10.48 cm) which was at par with T_2 (10.74 cm) and T_3 (10.58 cm).

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Trunk Girth (cm)

The data pertaining to effect of chlormequat chloride on trunk girth of grape cv. Punjab Purple shows that trunk girth did not vary significantly among the treatments. As depicted in Fig. 4, the trunk girth under open field conditions was at par in all the treatments.

Leaf Characters (cm and cm^2)

Data presented in Table 1 shows the effect of cycocel application on leaf characters of Punjab Purple cv. of grapes. It was observed that the spray had significant influence on all three characteristics with the maximum values being obtained in control under both environmental conditions. Under open field conditions, leaf length, breadth and area decreased substantially in the higher doses of chlormequat chloride with the least values being recorded in T_4 which were 11.3 cm, 12.38 cm and 112.08 cm^2 for leaf length, breadth and area, respectively. The leaf length (14.41 cm), breadth (15.84 cm) and area (221.72cm^2) was maximum in untreated vines.

Gibberellic Acid stimulates leaf expansion, stem and root elongation in the plants (Hedden and Sponsel 2015). Expansion of the leaves is inhibited due to cycocel due to inhibition of biosynthesis of gibberellins in the epidermal cells of leaves (Li *et al* 2011). Cycocel application results in reduction of cane length and leaf area along with increasing fruit set and improving the quality of bunches (Kumar *et al* 1998). In grape cv. Thompson Seedless there was decrease in leaf area from , 177.27 cm^2, 184.50 cm^2, 190.76 cm^2 in control to 166.00 cm^2, 132.20 cm^2, 177.86 cm^2, 182.00 cm^2 by the application of chlormequat chloride (CCC) @ 1500 mg/l at 5 leaf, 2000 mg/l at 7 leaf and 2500 mg/l at 12 leaf stage (Kulkarni *et al* 2018). Similarly, in grape cv. Thompson Seedless, the leaves in the vines with the treatment of growth retardant paclobutrazol were thicker, darker and smaller in comparison to untreated vines (Sable 2016). In strawberry, the application of GA resulted in maximum number of leaves per plant while the number of leaves were decreased significantly with the application of 700 and 500 ppm of chlormequat chloride (Kumar *et al* 2012).

Time of anthesis

In grape cv., Punjab Purple (Table 4.2), earliest anthesis was observed in T_2 and T_3 (04

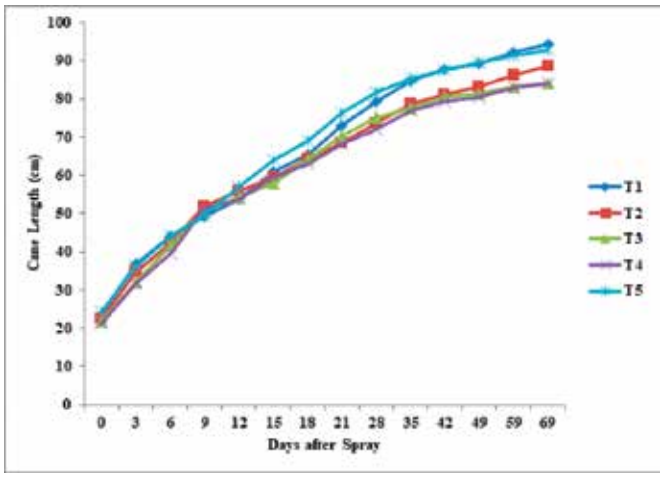

Fig. 1: Effect of chlormequat chloride application on cane length (cm) in grape cv. Punjab Purple

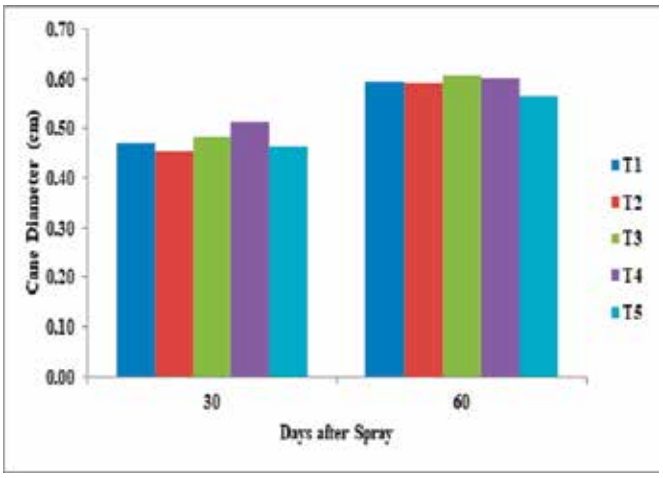

Fig. 2: Effect of chlormequat chloride application on cane diameter (cm) in grape cv. Punjab Purple

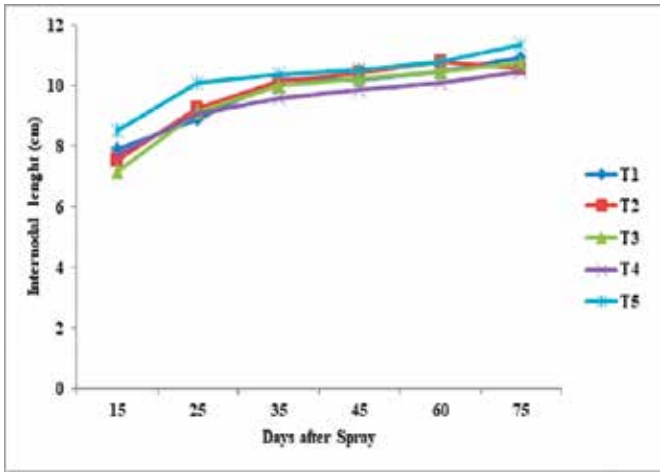

Fig. 3: Effect of chlormequat chloride application on internodal length (cm) in grape cv. Punjab MACS Purple under open field conditions

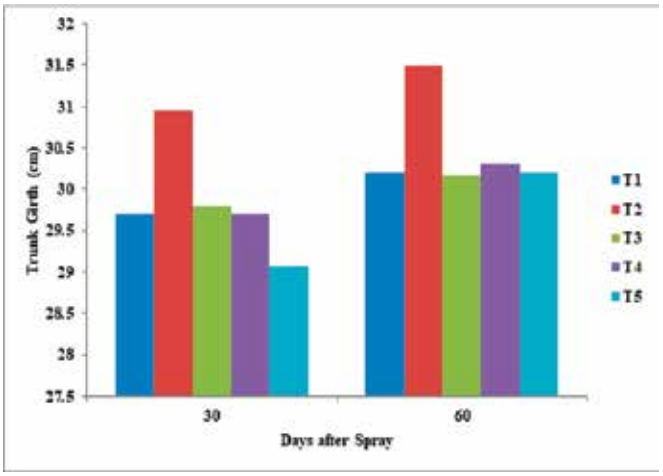

Fig. 4: Effect of chlormequat chloride application on trunk girth (cm) in grape cv. Punjab Purple

April) followed by T_5 (05 April) and T_1 (07 April). However, the time of flower opening in T_4 was late among all treatments (14 April).

In cycocel treated plants, the earlier flowering may be attributed to ita inhibitory effect on the vegetative growth of the vines resulting in favourable C: N ratio in the terminal buds for the floral initiation to occur at the earliest (Akshay 2020). Higher levels of gibberellic acids inhibit the flowering in plants as the more levels of GA_3 are antagonistic to the formation of flower primordia. The lower levels of endogenous Gibberellic Acid due to application of Chlormequat Chloride must have resulted in the earlier and profuse flowering in treated vines.

Number of bunches

Application of Chlormequat chloride resulted in increase in the bunch number with the maximum being obtained in T_4 (107.33) while minimum number of bunches (96.33) were recorded in the vines sprayed with lowest dose of Chlormequat chloride (Table 2).

In vines with the treatment of cycocel, number of bunches increases due to increased fruitfulness of the vines. Also, the increase in number of bunches

Table 2: Effect of chlormequat chloride application on time of anthesis, number of bunches and yield in grape cv. Punjab Purple

Treatment	Date of anthesis	Number of Bunches	Yield (kg/ vine)
T_1 Chlormequat Chloride @ 250 ppm	07 April	96.33	17.39
T_2 Chlormequat Chloride @ 500 ppm	04 April	97.33	19.35
T_3 Chlormequat Chloride @ 750 ppm	04 April	105.66	20.82
T_4 Chlormequat Chloride @ 1000 ppm	04 April	107.33	21.38
T_5 Control	05 April	101.00	18.86
CD (5%)	-	2.44	0.56

per tree might be due to the fact that chlormequat chloride reduces the vegetative growth of the plants and thus leads to decrease in abortion of fruitlets, therefore increasing the fruit set and consequently the number of fruits.

Yield

As indicated in Table 2, yield recorded was maximum in T_4 (21.38 kg/vine) followed by T_4 (20.82 kg/vine) while minimum yield was recorded in T_1 (17.39 kg/vine).

When treated with chlormequat chloride, the plants carry 20 times more cytokinins concentration in comparison to control treatments. Therefore, the increase in fruit set in the plants treated with cycocel may be due to increased cytokinins production in the plants (Skene 1969). Albuquerque *et al* (2000) reported that with the application of cycocel @ 500 ppm at 5 leaf stage, cane density of 35/ vine and leaf density of 16/ cane, highest yield per vine (15.96 kg) and highest per hectare yield (35.44 MT) was recorded in grape vines. Similarly, Sherawat *et al* (1998) observed that the application of 1500 ppm cycocel lead to increase in yield and bunch size in grapes. Also, yield per vine was increased by the use of chlormequat chloride @ 1500 ppm at 15 leaf stage in grapes due to more number of clusters per vine (Shikhamany and Reddy, 1989). Likewise, Shikhamany and Reddy (1989) reported the maximum yield with the treatment of chlormequat chloride@ 3000ppm at 15 leaf stage. Higher number of fertile buds in grapes due to cycocel application was also reported by Motoike *et al* (1996).

CONCLUSION

From present investigations, it is concluded that Chlormequat Chloride (CCC) @ 1000ppm followed by 750 ppm proved to be most effective in reduction of vegetative growth of vines in terms of shoot length, internodal length and leaf area and size. Also the application of chlormequat chloride @ 1000ppm resulted in significant improvement in the yield and number of bunches.

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