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EFFECT OF PACLOBUTRAZOL ON GROWTH, YIELD AND QUALITY IN GRAPEVINES

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ABSTRACT

Effect of PBZ on growth, yield and quality parameters of grapevines in both seasons was evaluated. PBZ applied as a soil drench at 0.25, 0.50, 0.75, 1.00 and 1.25 g. a .i per vine (Treatment T_1 to T_5), however, PBZ was not applied in the treatment T_6 *i.e.* 7/5 (sub cane) and T_7 i.e. (Sub cane + 6 BA (10 ppm) + Uracil (50 ppm). Among all the treatments, application of 6 BA @ 10 ppm on 40th and Uracil @ 50 ppm on 50th day of back pruning effectively improved the yield in both seasons (20.80 and 22.25 t./ha. respectively) and yield attributing parameters such as average fruitful percentage, number and weight of bunches. While, in both the season's PBZ application reduced total pruning weight, average length of cane and average length of internodes but, the chlorophyll content was increased with higher PBZ concentration. PBZ application reduced vegetative growth that might have reflected in low yield by decreasing ability of the vine to supply sufficient photo-assimilates for berry development. There was no significant difference in quality parameters value and shelf life.

INTRODUCTION

Grapes (*Vitis vinifera* L.) belongs to family Vitaceae and is one of the most important fruit crops of temperate zone, which has acclimatized to sub-tropical and tropical agro climatic conditions prevailing in the Indian sub-continent. Grape is a good source of minerals like calcium, phosphorus, iron and vitamins like B_1, B_2 and C. Grape juice is mild, laxative and acts as stimulant (Basak, 2001). Its cultivation is believed to have originated in Armenia near the Caspian Sea in Russia from where it seems to have spread westward to Europe and eastward to Iran and Afghanistan. It was introduced into India in 1300 A.D by Muslim invaders from Iran and Afghanistan. World over it is grown mainly for wine making (82 % production), raisin making (10 % production) and rest for table purpose (8%). In India, bulk production is used for table purpose followed by raisin. Thus, India is growing mostly table varieties suiting to the taste of the local consumers. Among many varieties grown, Thompson Seedless occupies the prime place in Western and Southern parts of India's states like Maharashtra, Karnataka and Tamilnadu. It is multipurpose variety grown for both table purpose and raisin making due to its taste and seedlessness. The vine is a weak stem, grows continuously and delays the fruiting in tropical and subtropical regions of India. Intensive vegetative growth decreases the number of fruit buds and of the berries per cluster. Vegetative vigor of vine could be controlled through various approaches and different means. With respect to plant growth retardants, like CCC was earlier being used in majority of the garden. However, due to residue issue, this chemical is not permitted in export and also local market. Hence, the use of other growth retardant like Paclobutrazol comes into existence. Paclobutrazol retards vegetative growth Hunter and Proctor, (1990); Intrieri *et al*., (1986), Reynolds, (1988), by inhibiting gibberellins biosynthesis. Grapevine being grows continuously under tropical and subtropical conditions to accommodate the vigor and bring the vine into productivity, the vines are pruned twice in a year i.e. backward pruning after harvest of crop (April) and forward pruning for fruits (October). There are basic mechanisms by which tree height can be restricted. Inhibiting internodes elongation without disrupting apical meristematic functions, near specific inhibition of internodes elongation without concomitant disruption of apical meristematic function and loss of apical control is caused by paclobutrazol [{B(4-Chlorophenyl)2-(1,1,dimethyle)-1-11-1,1,2,4-triazol-i.ethanol]. It reduces gibberellins biosynthesis and retards the formation of *Kaurene-19-ol* from *Kaurene* to GA_{12}. The exact role of paclobutrazol in grapes for increasing or decreasing the growth, fruitfulness is not yet been well described. However, farmers are adapting this practice of application of Paclobutrazol on adhoc basis. The PBZ in other crops is being used regularly for effective fruitfulness particularly in mango. However, the flowering physiology of mango and that of grape is different.

This work was aimed to find out the role of Paclobutrazol (PBZ) in minimizing the growth and its effectiveness on fruiting, yield and quality.

MATERIALS AND METHODS

The present investigation was carried out at AICRP on Fruit, Department of Horticulture, MPKV., Rahuri during 2013-2015. For this study ten years old vines of grape cultivar Thompson Seedless is grafted on rootstock Dogridge with spacing 3.0 x 1.5 m and trained on bower system were selected. Paclobutrazol was applied as soil drench at 0.25, 0.50, 0.75, 1.00 and 1.25 g. a .i per vine (Treatment T_1 to T_5), however, Paclobutrazol was not applied in the treatment T_6 i.e. 7/5 (sub cane) and treatment T_7 i.e. Sub cane + 6 BA (10 ppm) + Uracil (50 ppm). The Paclobutrazol was applied at April pruning of both season's at 60 to 120 cm from the main trunk. The experiment was carried out in Randomized Block Design statistical analysis with seven treatments, each treatment including 6 grapevines and each treatment replicated thrice.

Treatment details

Treat.	Treatments (after April pruning)
T_1	Paclobutrazol 0.25 g a.i. per vine
T_2	Paclobutrazol 0.50g a.i. per vine
T_3	Paclobutrazol 0.75 g a.i. per vine
T_4	Paclobutrazol 1.0 g a.i. per vine
T_5	Paclobutrazol 1.25 g a.i. per vine
T_6	Sub cane (7 /5)
T_7	Sub cane + 6 BA (10 ppm) + Uracil (50 ppm)

Measured parameters

Pruning weight was recorded on six experimental vines in each treatment and replication at the time of backward and forward pruning during both the seasons. The total pruning weight per vine of a season was computed by adding pruning weight of backward pruning with forward pruning of particular season. Pruned canes were weighted using electronic weight balance and are expressed in Kilograms. Ten canes per experimental vine were selected randomly from every treatment and replication in both the seasons. The cane length was recorded at monthly intervals throughout the course of this experiment i.e. during vegetative stage (April to October) and fruiting stage (October to April) and average length of cane was computed. Average internodes length was computed from the earlier selected canes used to measure the cane length and internodes per cane from experimental vine. The average length of internodes was calculated as per the formula given below.

$$\text{Average internodes length} = - \frac{\text{Average cane length}}{\text{Number of internodes per cane}}$$

For chlorophyll estimation fifth leaf from the base of the fruiting shoot was sampled for estimation of chlorophyll. Total fifty leaves were collected from each replication and treatment. Known weight (0.25g) of fresh leaf was taken and then it was crushed finely in acetone. The solution was fed to spectrophotometer at 652 nm and percent transmission was noted. The total chlorophyll was estimated according to standard procedure as suggested by Yoshida *et al.,* (1976).

Fruitful cane (%) The cane on which bunch was observed, was considered as a fruitful cane. The percentage was calculated as per the formula given below.

$$\text{Fruitful cane (\%)} = \frac{\text{Number of fruitful canes}}{\text{Total number of canes}} \times 100$$

Average number of bunches per vine at each harvest was counted from the experimental vines of each treatment and replication and were summed up and average bunch was computed in first season. In second season, offseason bearing was observed. The average number of bunches of offseason as well as for regular bearing was computed. The total number of bunches for the second season was computed by adding bunches of offseason and regular bearing and average was computed. Yield per vine was calculated by taking weight of all bunches harvested per vine by using weighing balance and expressed as kg/vine. Yield per hectare was calculated as per the formula given below:

$$\text{Yield / ha. (t)} = \frac{\text{Yield / vine (Kg) x number of vines /ha.}}{1000}$$

The quantity of cultar (commercial product) required for each vine (ml) was calculated by using the formula given below.

$$\text{Amount of commercial product} = \frac{\text{Treatment dose}}{\text{a.i}} 100$$

During the period of fruit bud differentiation 6 BA was sprayed @ 10 ppm on 40th day while, Uracil @ 50 ppm was sprayed on 50th day after backward pruning.

RESULTS AND DISCUSSION

Growth Parameters

Table 1: Effect of treatments on pruning weight in grape vine

Treat.	Pruning weight per vine (Kg)					
	Oct. 2013 Apr. - Oct. 2013	Apr.2014 Oct. 2013- Apr. 2014	Oct. 2014 Apr. – Oct. 2014	Apr.2015 Oct. 2014 - Apr. 2015	Total 2013-14	Total 2014-15
T_1	1.544	3.312	0.900	3.162	4.856	4.062
T_2	1.100	2.231	0.970	2.031	3.331	3.001
T_3	0.803	1.174	0.511	1.024	1.976	1.535
T_4	0.650	0.989	0.430	0.739	1.639	1.169
T_5	0.618	1.001	0.435	0.801	1.618	1.236
T_6	1.200	2.113	0.999	2.108	3.313	3.107
T_7	1.287	2.374	1.033	2.364	3.661	3.397
S.Em ±	0.04	0.06	0.02	0.07	0.18	0.1
CD at 5 %	0.13	0.19	0.07	0.24	0.56	0.31

Treatments: (Application of paclobutrazol after April pruning); T_1: Paclobutrazol 0.25 g a.i. per vine; T_2: Paclobutrazol 0.50 g a.i. per vine; T_3: Paclobutrazol 0.75 g a.i. per vine; T_4: Paclobutrazol 1.00 g a.i. per vine; T_5: Paclobutrazol 1.25 g a.i. per vine; T_6: Sub cane (7 / 5); T_7: Sub cane + 6 BA (10 ppm) + Uracil (50 ppm)

Table 2: Effect of treatments on vegetative growth in grape vine

Treat.	Length of cane (cm)				No. of internodes per cane				Average length of internode (cm)			
	Apr. - Oct. 2013	Oct. 2013- Apr.14	Apr.-Oct. 2014	Oct. 2014 - Apr. 15	Apr.-Oct. 2013	Oct. 2013 -Apr. 14	Apr. -Oct. 2014	Oct. 2014 -Apr. 15	Apr. - Oct. 2013	Oct. 2013 -Apr. 14	Apr. -Oct. 2014	Oct. 2014 -Apr.15
T_1	86.86	79.23	74.70	67.51	19	19	20	20	4.66	4.10	3.74	3.38
T_2	61.77	58.68	53.12	50.32	15	16	18	19	4.03	3.59	2.95	2.65
T_3	51.68	46.51	42.38	37.67	15	16	17	15	3.56	2.94	2.49	2.51
T_4	51.44	43.73	41.16	33.89	14	15	16	15	3.75	2.85	2.57	2.26
T_5	44.44	37.78	35.56	22.91	12	14	15	13	3.56	2.67	2.37	1.76
T_6	71.62	67.32	67.33	63.03	15	16	17	19	4.70	4.24	3.96	3.32
T_7	61.92	60.68	60.67	59.43	13	13	14	15	4.91	4.60	4.33	3.96
S.Em±	1.85	1.83	1.55	2.18	0.52	0.68	0.54	0.72	0.18	0.10	0.11	0.09
CD at5 %	5.69	5.63	4.78	6.72	1.62	2.09	1.67	2.23	0.56	0.32	0.33	0.27

Treatments: (Application of paclobutrazol after April pruning)
T_1: Paclobutrazol 0.25 g a.i. per vine; $_2$: Paclobutrazol 0.50 g a.i. per vine; T_3: Paclobutrazol 0.75 g a.i. per vine ; T_4: Paclobutrazol 1.00 g a.i. per vine; T_5: Paclobutrazol 1.25 g a.i. per vine; T_6: Sub cane (7 / 5); T_7: Sub cane + 6 BA (10 ppm) + Uracil (50 ppm)

Table 3: Effect of treatments on yield and yield parameters in grape vine

	Fruitful canes (%)						Average number of bunches per vine			Yield / ha. (t)		
Treat.	Ist season	IInd season (Offseason bearing)(a)	IInd season (Regular bearing)(b)	Total (a + b)	Ist season	IInd season (Offseason bearing)(a)	IInd season (Regular bearing)(b)	Total (a + b)	Ist season	Second season's off season bearing (a)	Second season regular bearing(b)	Total (a + b)
15	2013-14	2014	2014-15	2014-15	2013-14	2014	2014-14	2014-15	2014-15	2014	2013-14	2014-
T_1	100	4.84	85.71	90.55	35	1.69	30	31.69	18.66	0.68	11.07	11.74
T_2	100	13.44	82.86	96.3	36	4.7	29	33.7	19.36	1.72	12.95	14.68
T_3	85.71	42	53.71	95.71	30	14.11	18.8	32.91	12.67	4.7	7.12	11.83
T_4	82.86	41	54	95	29	14.11	18.9	33.01	12.89	4.55	6.36	10.91
T_5	82.86	39.62	50.86	90.47	29	13.87	17.8	31.67	12.37	4.62	3.97	8.59
T_6	85.71	0	85.71	85.71	30	0	30	30	17.46	0	16.29	16.29
T_7	100	0	97.14	97.14	36	0	34	34	24.8	0	22.55	22.55
S.Em±	3.27	0.62	2.33	3.11	1.07	0.61	1.19	1.02	1.04	0.18	0.73	0.73
CD at 5%	8.38	1.92	7.2	NS	2.75	1.89	3.67	NS	3.2	0.58	2.25	2.25

Table 4: Effect of treatments on quality parameters in grape vine

Treat.	TSS (⁰Brix)			Acidity (%)			TSS: Acidity		
	Ist season	IInd season (Offbearing)	IInd season (Regular bearing)	Ist season	IInd season (Offbearing)	IInd season (Regular bearing)	Ist season	IInd season (Offbearing)	IInd season (Regular bearing)
T_1	19.09	17.22	18.99	0.59	0.67	0.52	32.36	25.58	36.52
T_2	19.12	18.94	19.02	0.61	0.67	0.54	31.34	28.27	35.23
T_3	19.17	18.17	19.07	0.61	0.67	0.53	31.43	27.00	35.98
T_4	19.23	18.04	19.13	0.61	0.68	0.54	31.52	26.54	35.43
T_5	19.23	18.17	19.13	0.61	0.67	0.56	31.52	26.99	34.16
T_6	19.10	-	19.00	0.61	-	0.55	31.31	-	34.55
T_7	19.17	-	19.07	0.61	-	0.54	31.43	-	35.32
S.Em ±	0.56	0.97	0.56	0.02	0.02	0.01	0.92	1.24	0.56
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatments: (Application of paclobutrazol after April pruning); T_1: Paclobutrazol 0.25 g a.i. per vine; T_2: Paclobutrazol 0.50 g a.i. per vine ; T_3: Paclobutrazol 0.75 g a.i. per vine ; T_4: Paclobutrazol 1.00 g a.i. per vine; T_5: Paclobutrazol 1.25 g a.i. per vine ; T_6: Sub cane (7 / 5); T_7: Sub cane + 6 BA (10 ppm) + Uracil (50 ppm)

Pruning Weight (Kg. / vine)

Grape vines were drenched with PBZ, after April pruning in both season's showed a strong reduction in vegetative growth as compared to treatment control as shown in Table 1. PBZ @ 1.25 g a.i. per vine (T_5) significantly reduced total pruning weight of vine in both the seasons (1.618 kg, 1.236 kg, respectively) and which was statistically on par with PBZ @ 1.00 g a.i. per vine (T_4). The total pruning weight deceased in both the seasons, indicating lesser vegetative growth of vine. The seasonal study clearly indicated that the growth of vine was more hampered in the second season than in the first one. This could be due to residual effect of PBZ which might have reflected in less initial growth for the second season and consequent application of PBZ in the second season. As the PBZ was applied through drenching and could have remained in the soil for a longer time might have resulted in continuous supply of PBZ and which could have been taken up by the roots and translocated acropetally, thus maintaining the concentration of PBZ above the threshold level for inhibition of gibberellins biosynthesis. The role of gibberellic acid in growth is well documented. It helps in increasing cell elongation and thereby of shoot etc. Paclobutrazol acts as anti-gibberellins. The increased concentrations of PBZ reduced the pruning weight as by reducing internodes length thereby cane length. Similar results were reported by Hunter and Proctor (1990), Intrieri *et al* (1986), Fisher *et al* (1977) and

Table 5: Effect of treatments on shelf life (PLW %) of grape vine

Treat.	Physiological loss in weight (PLW %)											
	2013-14 After 2nd day	2014-15 After 2nd day	mean After 2nd day	2013-14 After 4th day	2014-15 After 4th day	mean After 4th day	2013-14 After 6th day	2014-15 After 6th day	mean After 6th day	2013-14 After 8th day	2014-15 After 8th day	mean After 8th day
T_1	3.17	3.21	3.19	4.92	5.22	5.07	7.87	7.80	7.84	15.27	17.00	16.14
T_2	3.92	3.77	3.85	4.99	4.30	4.65	8.01	8.30	8.16	16.12	17.21	16.67
T_3	3.27	3.19	3.23	4.77	4.24	4.51	8.19	8.00	8.10	15.98	16.30	16.14
T_4	3.47	3.55	3.51	5.01	5.00	5.01	8.33	8.50	8.42	16.07	17.00	16.54
T_5	3.74	3.00	3.81	4.67	4.78	4.73	7.89	7.00	7.45	15.77	16.50	16.14
T_6	3.29	3.12	3.21	4.88	5.00	4.94	8.38	8.70	8.54	16.01	16.00	16.01
T_7	3.09	3.00	3.05	4.77	4.20	4.49	7.89	7.00	7.45	15.91	15.88	15.90
S.Em±	0.22	0.38	0.2	0.27	0.37	0.25	0.36	0.47	0.33	0.48	0.48	0.97
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatments: (Application of paclobutrazol after April pruning) ; T_1: Paclobutrazol 0.25 g a.i. per vine; T_2: Paclobutrazol 0.50 g a.i. per vine; T_3: Paclobutrazol 0.75 g a.i. per vine; T_4: Paclobutrazol 1.00 g a.i. per vine ;T_5: Paclobutrazol 1.25 g a.i. per vine; T_6: Sub cane (7 / 5); T_7: Sub cane + 6 BA (10 ppm) + Uracil (50 ppm)

Kaps and Cahoon (1989).

Average cane length and internodal length (cm): Average cane lengths in both seasons, were recorded at monthly intervals throughout the investigation. Season, consisting April pruning *i.e.* (April to October) and October pruning *i.e.*(October to April). In both the seasons, proportional reduction in cane length of grapevine have been recorded by PBZ @ 1.25 g a.i. per vine (T_5) which was followed by PBZ @ 1.00 g a.i. per vine (T_4) and attributed to the reduction in cane growth to an effect on internodal elongation i.e. cane length (cm) as compared to the PBZ @ 0.25 g a.i. per vine (T_1) and treatments (T_6 and T_7) without PBZ application. Similar results were reported by Hunter and Proctor (1992), Hale and Weaver (1962). The translocation of PBZ through xylem in grapevine which is exclusively apical and thus, Paclobutrazol active compound reaching the sub-apical meristems might have inhibited gibberellins production. Inhibited gibberellins production turns to reduced rate of cell division in apical meristem and ultimately reduced cane and internodal length. Similarly reports were reported by Hedden and Graebe (1985), Davis *et al.* (1988) and Winkler *et al.* (1974).

Quality attributes and Shelf life

The data on quality parameters *viz.* TSS, titratable acidity and TSS: Acidity in both the seasons revealed differences non-significant. Similar results were reported by Zoecklein *et al* (1991)**.** The application of paclobutrazol at various concentrations did not significantly influenced the physiological loss in weight (PLW %) at ambient temperature after 2nd ,4th ,6th and 8th days of storage for both the seasons.

Yield

The higher fruitful cane percentage (85.71 % each) in the both season were recorded in treatment T_7 (Sub cane + 6 BA (10 ppm) + Uracil (50 ppm) which was followed by PBZ @ 0.25 g a.i. per vine (T_1) while, it was lower in PBZ @ 1.25 g a.i. per vine (T_5). This more fruitful cane percentage was due to the role of hormones like 6 BA and Uracil increasing fruit bud differentiation and thereby fruitful cane percentage. This also indicates the soil application of PBZ @ 0.25 g a.i. per vine at the time of backward pruning has a role in increasing fruit bud differentiation which normally takes place with a period of 45 to 60 days after backward pruning as also reported by Hedden and Graebe (1985).

The hypothecated retained PBZ and consequent application of it, in second season at the time of backward pruning might have reflected in offseason bearing. The offseason bearing was not observed in the treatments (T_6 and T_7) i.e. without PBZ application. In offseason bearing, the maximum fruitful canes were recorded in treatment PBZ @ 0.75 g. a. i (T_3) and it were minimum in the treatment PBZ @ 0.25 g. a. i (T_1). The role of PBZ in inhibiting gibberelic acid biosynthesis could be one of the reasons for offseason bearing and thus increases fruitful canes percentage. Higher concentration of PBZ in two consecutive years led to decreased yield in regular bearing. The yield at harvest in first season, offseason and regular bearing of second season are presented in table 3. The yield at offseason and regular bearing was summed up to receive total yield of second season. The significantly higher yield in both the seasons (24.80, 22.55 t./ha. respectively) was recorded with treatment Sub cane + 6 BA 10 ppm + Uracil 50 ppm (T_7) and it was the minimum in treatment PBZ @ 1.25 g a.i. per vine (T_5). Higher yield might have been due to well proportionate leaf area and therby the ability of the vine to supply sufficient photoassimilates for berry development. Hunter and Proctor (1992). The more yield in both the seasons also might be due to higher fruit set, increased bunch and berry weight and proper nutritional supply to the developing bunches, higher photosynthetic rate and less fruit drop with application of 6 BA (10 ppm). These results are supported with the findings of Tambe (2001), Usha *et al.* (2005), Meena *et al.* (2012), Khot *et al.* (2015), Ramteke and Khot (2015) and T. Kranti Kumar and M. K. Sharama (2016). The PBZ @ 1.25 g a.i. per vine (T_5) reduced the growth of vine which affected leaf area thereby synthesis of food materials requited for bunch development and might have reflected in to low yields.

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