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Influence of Growth Retardants on Vegetative Growth of Apple (*Malus* × *domestica* Borkh.) Cultivars under High Density Planting System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation entitled "Regulation of growth, fruiting and biochemical characteristics in Fuji Zehn Aztec and Red Braeburn apple cultivars through application of growth retardants under high density planting system" was conducted in the Experimental Block of the Division of Fruit Science at Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar

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campus, Srinagar (J&K) during the years 2020 and 2021. Four-year-old apple cultivars Fuji Zehn Aztec and Red Braeburn on M9-T337 planted at a distance of 3×1 meter of uniform age, vigor and girth were used for the study. The experiment comprising of seven treatments viz., control, prohexadione-calcium @125 ppm, prohexadione-calcium @250 ppm, prohexadione-calcium @500 ppm, paclobutrazol @200 ppm, paclobutrazol @400 and paclobutrazol@600 ppm was laid out in randomized complete design with three replications. The chemicals were sprayed one week after petal fall, three weeks after 1st spray and three weeks after 2nd spray. Paclobutrazol@600 ppm resulted in maximum reduction in vegetative growth parameters in both the apple cultivars under study.

Keywords: Rootstocks; yield; fruit quality.

1. INTRODUCTION

With the introduction of size controlling rootstocks and spur type varieties in apple, there is a shift from low density to high density planting system for better yield and quality but yet the size and quality of the produce is not met to the desirable level. Under high density orcharding, a delicate balance exists between vegetative growth and cropping in apple trees and the successful balance of vegetative vigor and fruiting results in 'calm' trees that produce regular crops and require only a light annual pruning. Frequently, management mistakes or abnormal weather conditions disrupt this balance, resulting in excessive vegetative growth that can negatively influence fruit quality, productivity, pest control, and profitability [1]. Successful management of such orchards mainly depends on maintaining the balance between vegetative and reproductive growth, to increase spur number, improving fruiting size and quality production. A number of growth controlling techniques are available, with merits and demerits. A new approach to maintain the delicate balance between vegetative and reproductive growth and to enhance fruit quality is the use of plant growth regulators (PGRs). The plant growth regulators or phytohormones are organic substances produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its place of production and active in minute amounts [2]. Plant growth retardants (PGRs), like anti-gibberellins, have been used for decades to improve the quality and quantity of horticultural crops [3]. Gibberellin biosynthesis inhibitors have received the most attention because of their key role in cell elongation [4,5]. Paclobutrazol is a triazole-type PGR that inhibits the oxidative steps from ent-kaurene to ent-kaurenoic acid in the gibberellin biosynthesis pathway (Hedden and Graebe, 1985); [5]. Recently Prohexadione-calcium (Pro-Ca; Apogee® BASF Corp., Research Triangle Park, NC, USA), another GA biosynthesis inhibitor with low toxicity and limited persistence, has been effectively used for controlling the vegetative growth on apples [6].

2. MATERIALS AND METHODS

The present investigation entitled "Regulation of growth, fruiting and biochemical characteristics in Fuji Zehn Aztec and Red Braeburn apple cultivars through application of growth retardants under high density planting system" was conducted in the Experimental Block of the Division of Fruit Science at Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar campus, Srinagar (J&K) during the years 2020 and 2021. Four-year-old apple cultivars Fuji Zehn Aztec and Red Braeburn on M9-T337 planted at a distance of 3×1 meter of uniform age, vigor and girth were used for the study. The experiment comprising of seven treatments viz., control, prohexadione-calcium @125 ppm, prohexadione-calcium @250 ppm, prohexadione-calcium@500 ppm, paclobutrazol@200 ppm, paclobutrazol@400 and paclobutrazol@600 ppm was laid out in randomized complete design with three replications. The chemicals were sprayed one week after petal fall, three weeks after 1st spray and three weeks after 2nd spray. In order to determine the effect of these growth retardants on apple cultivars following vegetative parameters were recorded.

a) Incremental tree height (cm)

The initial and final height of selected trees was measured from the bud union to the top of tree in meters with the help of measuring tape and average value was recorded.

b) Tree trunk cross sectional area (cm^2)

Tree trunk cross sectional area of each experimental unit was measured 15 cm above

bud union and expressed as cm^2 using following formula:

$$\text{Area} = \frac{(\text{girth})^2}{4}$$

c) Plant spread (m)

Spread of each experimental tree was measured with the help of measuring tape in two directions i.e. East-West and North-South at the end of growing season. The average of both the directions was taken as spread of tree and expressed in metres (m).

3. RESULTS

The data presented in Table 1 and Figs. 1 & 2 reveals that plant height of both the cultivars was significantly influenced by the foliar spray of growth retardants. In Fuji Zehn Aztec the highest increment in tree height (42.05 cm and 44.82) was recorded in control whereas, the lowest increment in tree height (29.21 cm 26.33 cm) was found in PBZ @ 600ppm trees followed by (30.98 cm and 28.96 cm) in PBZ@400 ppm during the first and second year of investigation, respectively. Similarly, in case of Red Braeburn, the highest increment in tree height (37.35 cm and 39.75cm) was recorded in control whereas the lowest increment in tree height (23.85 cm 21.93 cm) was found in PBZ @ 600ppm trees followed by (25.18 cm and 23.80 cm) in PBZ@400 ppm during the first and second year of investigation, respectively.

Perusual of data presented in Table 2 reveals that the influence of foliar spray of growth retardants on TCSA of both the apple cultivars viz. Fuji Zehn Aztec and Red Braeburn was non-significant during both the years of investigation.

Table 1. Effect of growth retardants on incremental plant height (cm) of Fuji Zehn Aztec and Red Braeburn apple cultivars under high density planting system

Varieties / Treatments	Fuji Zehn Aztec			Red Braeburn		
	2020	2021	Pooled	2020	2021	Pooled
T_0 : Control	42.05	44.82	43.43	37.35	39.75	38.55
T_1 : PCa@ 125ppm	35.62	35.97	35.79	30.29	30.91	30.60
T_2 : PCa@ 250ppm	34.15	34.56	34.35	28.07	28.39	28.23
T_3 : PCa@ 500ppm	31.04	31.45	31.24	25.94	26.06	26.00
T_4 : PBZ@ 200ppm	33.48	32.29	32.88	27.80	26.68	27.24
T_5 : PBZ@ 400ppm	30.98	28.96	29.97	25.18	23.80	24.49
T_6 : PBZ@ 600ppm	29.21	26.33	27.77	23.85	21.93	22.89
C.D ($p<0.05$)	1.45	1.36	1.30	1.60	1.48	1.53

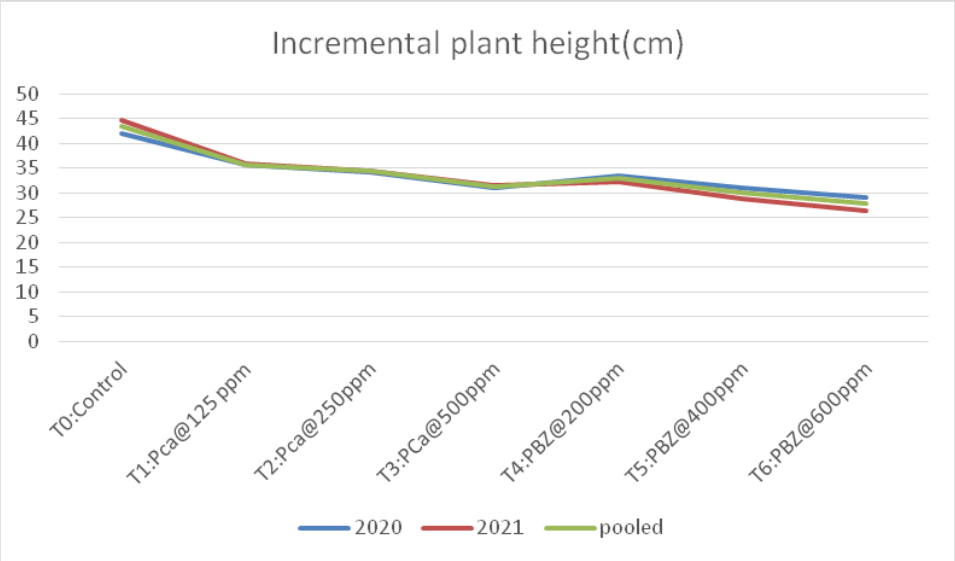

Fig. 1. Effect of growth retardants on incremental plant height (cm) of Fuji Zehn Aztec under HDP

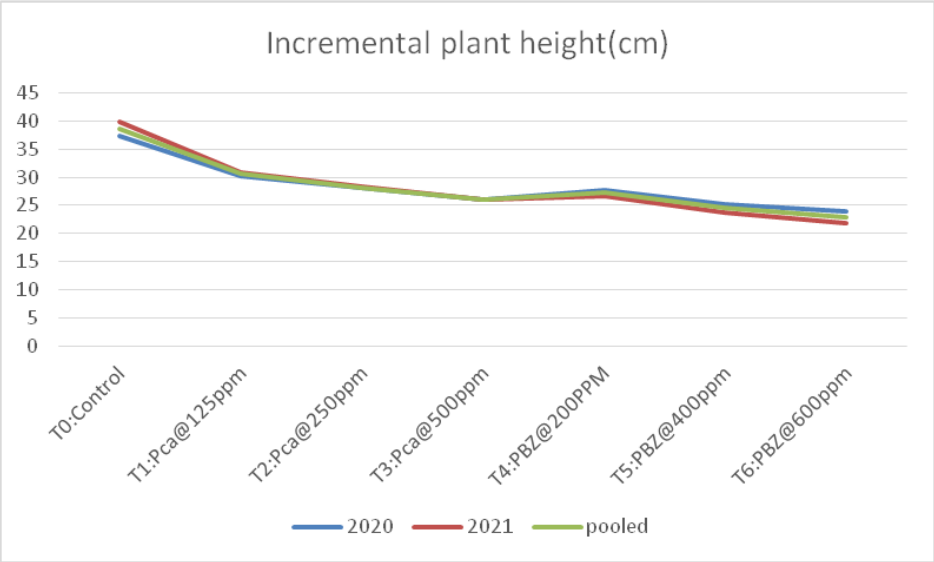

Fig. 2. Effect of growth retardants on incremental plant height (cm) of Red Braeburn under HDP

Table 2. Effect of growth retardants on TCSA (cm^2) of Fuji Zehn Aztec and Red Braeburn apple cultivars under high density planting system

Varieties / Treatments	Fuji Zehn Aztec			Red Braeburn		
	2020	2021	Pooled	2020	2021	Pooled
T_0 : Control	31.48	31.97	31.72	27.56	27.78	27.67
T_1 : PCa@ 125ppm	31.33	31.74	31..53	27.45	27.57	27.51
T_2 : PCa@ 250ppm	31.24	31.69	31.46	27.37	27.51	27.44
T_3 : PCa@ 500ppm	31.16	31.58	31.37	27.25	27.38	27.31
T_4 : PBZ@ 200ppm	31.20	31.65	31.42	27.33	27.45	27.39
T_5 : PBZ@ 400ppm	30.97	31.24	31.10	27.12	27.31	27.21
T_6 : PBZ@ 600ppm	30.85	31.29	31.07	26.97	27.23	27.10
C.D ($p<0.05$)	NS	NS	NS	NS	NS	NS

Table 3. Effect of growth retardants on plant spread (m) of Fuji Zehn Aztec and Red Braeburn apple cultivars under high density planting system

Varieties / Treatments	Fuji Zehn Aztec			Red Braeburn		
	2020	2021	Pooled	2020	2021	Pooled
T_0 : Control	1.59	1.64	1.61	1.46	1.51	1.48
T_1 : PCa@ 125ppm	1.53	1.58	1.55	1.36	1.42	1.39
T_2 : PCa@ 250ppm	1.50	1.54	1.52	1.32	1.37	1.34
T_3 : PCa@ 500ppm	1.43	1.46	1.44	1.22	1.26	1.24
T_4 : PBZ@ 200ppm	1.48	1.52	1.50	1.30	1.35	1.32
T_5 : PBZ@ 400ppm	1.38	1.42	1.40	1.20	1.24	1.22
T_6 : PBZ@ 600ppm	1.34	1.38	1.36	1.16	1.20	1.18
C.D ($p<0.05$)	0.03	0.03	0.04	0.05	0.03	0.03

Table 3 shows that in apple cultivar Fuji Zehn Aztec, the lowest plant spread (1.34 m and 1.38 m) was recorded at the highest level (PBZ @ 600 ppm) whereas the highest plant spread (1.59 m and 1.64 m) was recorded in control during both the years of investigation, respectively. Similarly, in apple cultivar Red Braeburn, the lowest plant spread (1.16 m and 1.20 m) was recorded at the highest level (PBZ @ 600 ppm) whereas the highest spread (1.46 m and 1.51 m) was recorded in control during both the years of investigation, respectively.

4. DISCUSSION

The present studies revealed that plant growth retardant sprays exhibited a significant influence on the vegetative growth parameters. Significantly maximum reduction in growth characteristics in terms of incremental plant height (cm) and plant spread (cm) was found in T_6 (paclobutrazol@600 ppm) and minimum in the control plants. The reduction in vegetative growth characteristics in response to growth retardants is because both paclobutrazol and prohexadione calcium act as antigiberllins as they block the enzymes involved in GA biosynthesis, thus inhibiting the cell elongation phase. Since GA stimulates the elongation of cells and thus is intimately involved in vegetative growth of plants. These results are in agreement with the findings of Kumar et al. [7] who reported that cultar @ 1500 ppm was most effective in reducing the plant height, extension growth and shoot internode length in peach trees under high density planting system. Similar results have been confirmed by Basak [8] in Jonagold apple trees and Miller [9] in Red Chief Delicious apple trees. Jacyna and Lipa [10] also found that application of prohexadione-calcium resulted in reduction of internode length, total growth per branch unit and shoot extension growth in apple and sweet cherry trees. Our results confirmed that the effect of paclobutrazol was stronger than prohexadione calcium on apple cultivars Fuji Zehn Aztec and Red Braeburn under high density planting system. Similar findings have been reported by Lordan et al. [11] in pear and Mouco et al. [12] reported better growth control of paclobutrazol than ProCa in mango (*Magnifera indica* L.).

5. CONCLUSION

Frequently, vegetative growth is excessive and if not appropriately controlled, it could influence many aspects of fruit production, including flower bud formation, fruit set, fruit quality, physiological disorders, pest management, and postharvest fruit life. In the present study the foliar spray of paclobutrazol and prohexadione-calcium proved to be beneficial in maintaining a proper balance between vegetative growth and fruiting, thereby improving fruit yield, quality and return bloom during the next year. Paclobutrazol@600 ppm resulted in maximum reduction in vegetative growth parameters in both the apple cultivars under study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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