



EFFECT OF PACLOBUTRAZOL AND SUMMER PRUNING ON YIELD AND FRUIT QUALITY OF APPLE cv. 'RED DELICIOUS'

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ABSTRACT

The study was aimed to assess the effect of different levels of paclobutrazol and summer pruning on fruit quality of apple cv. 'Red Delicious'. The experiment was conducted at SKUAST-K, Shalimar (J&K) during 2012 and 2013 on apple trees of >15 years age, spaced at 5.49 × 5.49 m distance. The experiment was laid in a completely randomized block design with paclobutrazol spray tested at 3 concentrations (250, 500 and 750 ppm) and summer pruning at 2 timings (8 and 12 weeks after full bloom) and their combinations. Highest yield of 101.0 kg tree⁻¹ was obtained in treatment 750 ppm paclobutrazol + 2 summer prunings in comparison to control. In addition, it significantly improved fruit size (53.15 cm), weight (188.19 g), volume (188.12 cm³), colour change (3.40 score), firmness (11.98 kg cm⁻²), organoleptic rating in terms of taste (3.14 score), texture (3.24 score), flavour (3.12 score) and total soluble solids (14.47°B) whereas acidity (0.23%) was reduced in comparison to control and other treatments during both the years.

Key words: Apple, fruit quality, fruit firmness, paclobutrazol, summer pruning, yield

INTRODUCTION

Paclobutrazol is unique among the presently used growth regulators as it can either thin in the year of application or as a carryover effect can increase fruit set in the years following application. Paclobutrazol [PBZ; IUPAC name: (2RS, 3RS)-1-(4-chlorophenyl)-4, 4-dimethyl-2-(1H-1,2,4-triazol-1-yl) pentan-3-ol], is a triazol which inhibits GA biosynthesis in plants by inhibiting kaurene oxidase, a Cyt P-450 oxidase, thus blocks the oxidation of kaurene to kaurenoic acid (Dalziel and Lawrence, 1984). The inhibitory activity of paclobutrazol can be reversed by gibberellic acid (Steffens, 1985). Paclobutrazol treatment reportedly also increases fruit firmness in 'Delicious' apple at harvest (Greene, 1986). Paclobutrazol application in McIntosh apple trees shortly after full bloom affected fruit quality characteristics with respect to accelerated colour development, delayed and synchronized fruit maturation, control of pre-harvest fruit drop and maintenance of better fruit quality (Edgerton and Blanpied, 1970).

Several techniques are used to reduce or maintain tree canopy size, heading cuts are made through wood more than several years ago to shorten all stems and branches (Edward *et al.*, 2008). The pruning is done to restrict excessive vegetative growth and to maintain a balance between leaf/fruit ratio, fruit size, fruit colour and other quality attributes. Excessive tree vigour reduces flower bud formation and fruit set so results in reduced fruit quality. The woody tissues of a tree

compete with fruits for the products of leaves; and any excessive vegetative growth is made at the expense of fruits. The relationship between vegetative and reproductive growth influences the amount and quality of fruits produced by an apple tree. Removal of a large amount of leaf area may reduce canopy light interception and weaken canopy photosynthesis causing a potential shortage of carbohydrate supply that may limit fruit growth and fruit size which needs to be ascertained. In Kashmir the practice of summer pruning and paclobutrazol treatment are not followed perhaps due to the lack of knowledge or confirmatory research. Considering the above points and socio-economic importance of apple, the study was conducted to evaluate the effects of paclobutrazol and summer pruning on fruit quality of apple cv. 'Red Delicious' under temperate conditions of Kashmir.

MATERIALS AND METHODS

The present study was carried out during the years 2011 and 2012 on apple cv. 'Red Delicious'. The experimental site was located at Experimental Orchard of the Division of Fruit Science, SKUAST-Kashmir, Shalimar (Kashmir), situated between 34.01° N latitude and 79.89° E longitude at an elevation of 1685 m masl. The orchard had proper soil drainage and was on southern aspect with soil moderately deep having good fertility status. The trees of > 15 year age, spaced at 5.49 × 5.49 m, received uniform cultural treatments. The experiment was laid in a completely randomized block design with 3 trees representing a treatment. The treatments, replicated 3 times, comprised of 4 paclobutrazol (PP333) concentrations (0, 250, 500 and 750 ppm) and 2 summer prunings and their combinations. Paclobutrazol spray was given 4 weeks after full bloom while control plants were water-sprayed. First summer pruning was done 8 weeks after full bloom by thinning out water sprouts and unwanted branches while 2nd summer pruning was done 12 weeks after full bloom by heading back from upper, middle and lower canopy area to the extent of 25% of current season's growth.

The fruit yield was calculated by weighing the total fruits harvested from each tree (Westwood, 1993). The fruits were harvested at proper maturity and only firm uniform sized fruits were selected for further analysis. Fruit size in terms of fruit length and diameter of each harvested fruit was measured at the longest and widest positions, respectively, with the help of a digital Vernier Calliper. Fruit size was obtained by multiplying fruit length by fruit breadth. Fruits from each sample were weighed on a sensitive mono-pan balance and fruit volume of selected fruits was measured by water displacement method. The fruit flesh firmness was determined with the help of a digital Effegi pressure tester plunger. In each treatment, representative fruit samples were punched at 3 different places on its surfaces after removing about 2.5 cm² peel. Fruit was held against a hard surface (table top) and plunger pressed in with force. Fruit colour on each harvest date was determined by visual score using 1-4 scale (Blanpied *et al.*, 1975). The fruits were rated by a panel of four judges for taste, flavour, texture, crispness and juiciness and a rating of 1-4 point scale was used. The total soluble solids were determined from fresh strained thoroughly stirred fruit juice on each sampling date with the help of a digital hand refractometer and readings corrected at 20°C (AOAC, 1980). The acidity in terms of malic acid was determined by diluting the known volume of apple juice and titrating it against 1N NaOH solution using phenolphthalein as indicator. The data was analyzed using one way analysis of variance as per the method of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Fruit yield and quality

The highest yield of 101.0 kg tree⁻¹ was observed in treatment 750 ppm paclobutrazol + two summer

Table 1: Effect of paclobutrazol and summer pruning on yield of apple cv. Red Delicious

Treatments	Fruit weight (g)			Yield (kg tree ⁻¹)		
	2011	2012	Mean	2011	2012	Mean
Control	159.9	159.9	159.9	81.73	81.65	81.69
paclobutrazol (P333) @ 250 ppm	162.7	163.6	163.1	83.22	90.69	86.95
P333 @500 ppm	164.2	165.0	164.6	83.82	92.05	87.93
P333 @750 ppm	165.0	165.60	165.5	84.32	93.50	88.91
1 st summer pruning (SP I)	163.9	164.8	164.3	85.76	91.98	88.87
250 ppm PP333+ SP I	164.9	166.3	165.6	85.12	94.89	90.00
500 ppm PP333 + SP I	165.7	168.1	166.9	89.11	97.06	93.08
750 ppm PP333 + SP I	170.0	175.6	172.8	92.52	99.09	95.80
2 nd summer pruning (SP II)	164.6	165.6	165.1	86.93	93.44	90.18
250 ppm PP333 + SP II	165.0	166.9	166.0	87.91	96.71	92.31
500 ppm PP333 + SP II	168.0	170.5	169.3	91.11	98.15	94.63
750 ppm PP333 + SP II	172.1	177.2	174.7	93.11	100.06	96.58
Two summer prunings	167.1	171.0	169.1	84.22	97.67	90.94
250 ppm PP333 + SP I + SP II	178.0	180.5	179.2	94.80	101.02	97.91
500 ppm PP333 + SP I + SP II	180.5	187.1	183.8	96.56	103.04	99.80
750 ppm PP333 + SP I + SP II	182.7	193.6	188.2	97.89	104.14	101.01
CD _{0.05}	2.20	2.28	2.24	0.83	1.01	1.04

Two summer prunings = SP I + SP II

prunings, followed by 99.8 kg tree⁻¹ in 500 ppm paclobutrazol + two summer pruning treatment and the lowest yield of 81.73 kg tree⁻¹ was in control (Table 1). Our findings are in conformity with Pant and Ratan (2004) and Mohamed *et al.* (2011) in case of apple and plum. Paclobutrazol is effective in enhancing the yield of several horticultural crops as it inhibits gibberellic acid (GA) biosynthesis which changes the sink-source relationship by reallocating carbohydrate to other organs (Yadav *et al.*, 2005). The increase in yield by pruning is due to the fact that pruning performed on growing shoots removed apical dominance, released lateral buds from correlative inhibition and changed tree form and architecture which, in turn, increased flower bud initiation from lateral buds and increased yield (Jankiewicz and Stecki, 1976). The mean data revealed significantly highest fruit weight of 188.2 g in 750 ppm paclobutrazol + two summer pruning treatment and lowest fruit weight of 159.9 g in control. The results are in agreement with Rather (2006) in apple.

Two year mean data revealed highest fruit length of 7.17 cm and breadth of 7.86 cm in 750 ppm paclobutrazol + two summer pruning treatment, followed by the respective value of 7.11 and 7.83 cm in 500 ppm paclobutrazol + two summer pruning treatment; whereas lowest fruit length of 5.87 cm and breadth of 5.91 cm was observed in control (Table 2). Our observations are in conformity with Pant and Ratan (2004). The increase in fruit length and breadth may be attributed to the fact that paclobutrazol spray reduced the vegetative growth (sinks) which, in turn, increased the partitioning of nutrients and dry matter towards fruits and thereby enhanced fruit size and weight (Wolstenholme *et al.*, 1990). Fruit size in our study was significantly highest (55.71 cm) in 500 ppm paclobutrazol + two summer pruning treatment followed by 54.52 and 53.15 cm in 250 and 750 ppm paclobutrazol (+ two summer prunings) treatments, respectively; while lowest fruit size of 34.72 cm was in control. Pruning decreased fruit load and it appeared that since the fruit number was less, the available food material reached the individual fruit in sufficient quantity which thereby enhanced fruit size. These findings are in line with Myriam *et al.* (2005) and Bussi *et al.* (2005) in peach.

Highest fruit volume of 186.37, 189.87 and 188.12 cm³ was noticed in 750 ppm paclobutrazol + two summer pruning treatment in 2011, 2012 and their mean, respectively (Table 3). The lowest fruit volume 161.08, 160.06 and 160.57 cm³ in the year 2011, 2012 and their mean, respectively, was observed in control which was significantly lower than all other treatments. The results are in line with Mohamed *et al.* (2011) in plum and Pescie *et al.* (2011) in blueberry.

Table 2: Effect of paclobutrazol and summer pruning on physical characteristics of apple cv. Red Delicious

Treatments	Fruit length (cm)			Fruit breadth (cm)			Fruit size (cm ³)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
Control	5.86	5.88	5.87	5.91	5.92	5.91	34.63	34.81	34.72
Paclobutrazol (P333) @ 250 ppm	6.20	6.35	6.27	6.79	6.83	6.81	42.10	43.37	42.73
P333 @500 ppm	6.28	6.44	6.36	6.98	7.00	6.99	43.83	45.08	44.45
P333 @750 ppm	6.35	6.62	6.48	7.06	7.09	7.07	44.83	46.94	45.88
1 st summer pruning (SP I)	6.31	6.71	6.51	7.23	7.05	7.14	45.62	47.31	46.46
250 ppm PP333+ SP I	6.53	6.77	6.65	7.31	7.25	7.28	47.73	49.08	48.40
500 ppm PP333 + SP I	6.41	6.82	6.61	7.50	7.31	7.40	48.08	49.85	48.96
750 ppm PP333 + SP I	6.60	6.9	6.75	7.08	7.40	7.24	46.73	51.06	48.89
2 nd summer pruning (SP II)	6.47	7.01	6.74	7.28	7.12	7.20	47.10	49.91	48.50
250 ppm PP333 + SP II	6.65	7.09	6.87	7.47	7.28	7.37	49.68	51.62	50.65
500 ppm PP333 + SP II	6.50	7.13	6.81	7.56	7.34	7.45	49.14	52.33	50.73
750 ppm PP333 + SP II	6.69	7.17	6.93	7.43	7.64	7.53	49.71	54.78	52.24
Two summer prunings	6.60	7.21	6.90	7.66	7.33	7.49	50.56	52.85	51.70
250 ppm PP333 + SP I + SP II	6.79	7.26	7.02	7.70	7.82	7.76	52.28	56.77	54.52
500 ppm PP333 + SP I + SP II	6.94	7.29	7.11	7.81	7.85	7.83	54.20	57.23	55.71
750 ppm PP333 + SP I + SP II	7.03	7.32	7.17	7.86	7.87	7.86	51.04	55.27	53.15
CD _{0.05}	0.11	0.13	0.12	0.04	0.01	0.02	0.20	0.26	0.23

The significantly high fruit firmness of 11.98 kg cm⁻² was observed in 750 ppm paclobutrazol + two summer pruning treatment and lowest of 8.48 kg cm⁻² in control (Table 3). This may be attributed to the reduction in ethylene evolution during storage which induced delay in respiratory climacteric after harvest and storage; thereby showing the loss in firmness (Luo *et al.*, 1987). Summer pruning increased fruit firmness as calcium content in fruits was increased due to increased partitioning of nutrients and dry matter towards the fruits. These results are in accordance with Rather (2006) in apple and Mohamed *et al.* (2011) in plum.

The maximum fruit colour score of 3.14 and 3.67 was noticed in 750 ppm paclobutrazol + two

Table 3: Effect of paclobutrazol and summer pruning on physical characteristics of apple cv. Red Delicious

Treatments	Fruit volume (cm ³)			Fruit firmness (kg cm ⁻²)			Fruit colour (score)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
Control	161.1	160.1	160.6	8.53	8.44	8.48	2.22	2.19	2.20
Paclobutrazol (P333) @ 250 ppm	163.7	165.2	164.4	9.41	10.84	10.12	2.68	2.81	2.74
P333 @500 ppm	166.6	168.8	167.7	9.50	11.03	10.26	2.72	2.94	2.83
P333 @750 ppm	169.4	170.2	169.8	9.74	11.25	10.49	2.79	3.02	2.90
1 st summer pruning (SP I)	164.9	166.0	165.5	9.46	11.17	10.31	2.69	2.99	2.84
250 ppm PP333+ SP I	170.2	171.1	170.6	9.98	11.35	10.66	2.87	3.17	3.02
500 ppm PP333 + SP I	171.3	172.4	171.8	10.28	11.70	10.99	2.96	3.29	3.12
750 ppm PP333 + SP I	176.3	177.0	176.7	10.50	12.16	11.33	3.03	3.33	3.18
2 nd summer pruning (SP II)	169.1	169.1	169.1	9.69	11.21	10.45	2.77	3.09	2.93
250 ppm PP333 + SP II	170.8	172.0	171.4	10.16	11.55	10.85	2.91	3.24	3.07
500 ppm PP333 + SP II	172.3	173.0	172.7	10.42	11.85	11.13	2.99	3.31	3.15
750 ppm PP333 + SP II	181.9	182.2	182.1	10.62	12.22	11.42	3.05	3.35	3.20
Two summer prunings	171.1	172.9	172.0	10.34	11.85	11.09	2.94	3.30	3.12
250 ppm PP333 + SP I + SP II	182.6	185.2	183.9	10.82	12.34	11.58	3.08	3.37	3.22
500 ppm PP333 + SP I + SP II	183.6	187.4	185.5	10.98	12.53	11.75	3.10	3.55	3.32
750 ppm PP333 + SP I + SP II	186.4	189.9	188.1	11.14	12.82	11.98	3.14	3.67	3.40
CD _{0.05}	2.23	2.26	2.24	0.21	0.19	0.20	0.02	0.05	0.04

summer pruning treatment and minimum fruit colour score of 2.22 and 2.19 in control during the years 2011 and 2012, respectively. Mean highest fruit colour score of 3.40 was observed in 750 ppm paclobutrazol + two summer pruning treatment which was significantly higher than other treatments whereas minimum fruit colour was in control. The paclobutrazol spray significantly reduced vegetative growth characters of trees, thereby exposed fruits to direct sunlight which may have significantly imparted red colour to fruits. The results are in line with Wani (2004) in sweet cherry and Rather (2006) in apple. Also, by summer pruning, the canopy size was controlled and light availability to fruits for red colour development improved without undesirable post-pruning re-growth by summer pruning (Dusi *et al.*, 2004).

More tasty fruits (3.14 score) were observed in 750 ppm paclobutrazol + two summer pruning treatment and less tasty fruits (2.31 score) in control (Table 4). Highest fruit texture (2.98, 3.51 and 3.24 score) was noticed in 750 ppm paclobutrazol + two summer pruning treatment and lowest fruit texture (2.38, 2.62 and 2.50 score) was in control in 2011, 2012 and mean values, respectively. Maximum flavour score of 3.12 was observed in 750 ppm paclobutrazol + two summer pruning treatment which was significantly superior over all other treatments; whereas minimum flavour score of 2.43 was noticed in control. The improvement in organoleptic rating of fruits may be attributed to the fact that more metabolites were translocated to the fruits in treated trees with paclobutrazol (Wolstenholme *et al.*, 1990) which, in turn, appeared to have improved fruit taste, flavour and texture. High organoleptic rating by summer pruning appears due to better quality fruits which were sweeter and less acidic. Our findings are in conformity with Wani (2004) and Rather (2006) in apple and Wani *et al.* (2007) in sweet cherry.

The highest total soluble solids (TSS = 14.47°B) were recorded in 750 ppm paclobutrazol + two summer pruning treatment, whereas the control trees had lowest mean TSS values (11.85°B) (Table 5). The increase in TSS was due to increase in sucrose, starch and sugar levels due to reduced vegetative growth and absence of other potentially competitive actively growing sinks which resulted in more nutrients partitioning to fruits (Abdel Rahim *et al.*, 2011). Our findings are in conformity with Wani *et al.* (2007) in apple. The increased rate of photosynthesis led by more light penetration into the interior tree canopy increased the soluble solids in fruits harvested from pruned trees (Ibrahim *et al.*, 1983). These findings are supported by Hassani and Rezaee (2007) in peach.

Table 4: Effect of paclobutrazol and summer pruning on organoleptic rating (score) of apple cv. Red Delicious

Treatments	Taste			Texture			Flavour		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
Control	2.32	2.30	2.31	2.38	2.62	2.50	2.37	2.49	2.43
Paclobutrazol (P333) @ 250 ppm	2.44	2.53	2.48	2.49	2.80	2.64	2.46	2.61	2.53
P333 @500 ppm	2.49	2.57	2.53	2.52	2.84	2.68	2.50	2.66	2.58
P333 @750 ppm	2.49	2.59	2.54	2.57	2.89	2.73	2.55	2.72	2.63
1 st summer pruning (SP I)	2.53	2.55	2.54	2.50	2.82	2.66	2.48	2.64	2.56
250 ppm PP333+ SP I	2.47	2.61	2.54	2.59	2.94	2.76	2.57	2.83	2.70
500 ppm PP333 + SP I	2.58	2.72	2.65	2.68	3.07	2.87	2.63	2.94	2.78
750 ppm PP333 + SP I	2.67	2.86	2.76	2.77	3.24	3.00	2.68	3.08	2.88
2 nd summer pruning (SP II)	2.75	2.58	2.66	2.55	2.87	2.71	2.53	2.70	2.61
250 ppm PP333 + SP II	2.51	2.66	2.58	2.62	2.99	2.80	2.60	2.89	2.74
500 ppm PP333 + SP II	2.63	2.80	2.71	2.73	3.12	2.92	2.65	2.99	2.82
750 ppm PP333 + SP II	2.72	2.92	2.82	2.86	3.29	3.07	2.70	3.17	2.93
Two summer prunings	2.78	2.78	2.78	2.71	3.10	2.90	2.64	2.96	2.80
250 ppm PP333 + SP I + SP II	2.69	3.09	2.89	2.89	3.32	3.10	2.72	3.21	2.96
500 ppm PP333 + SP I + SP II	2.84	3.27	3.05	2.94	3.47	3.20	2.76	3.34	3.05
750 ppm PP333 + SP I + SP II	2.93	3.36	3.14	2.98	3.51	3.24	2.82	3.42	3.12
CD _{0.05}	0.10	0.10	0.12	0.01	0.09	0.02	0.07	0.04	0.05

Two summer prunings = SP I + SP II

Table 5: Effect of paclobutrazol and summer pruning on chemical characteristics of apple cv. Red Delicious

Treatments	Total soluble solids ($^{\circ}$ Brix)			Acidity (%)		
	2011	2012	Pooled	2011	2012	Pooled
Control	11.85	11.86	11.85	0.39	0.40	0.39
Paclobutrazol (P333) @ 250 ppm	13.21	12.83	13.02	0.36	0.35	0.35
P333 @500 ppm	13.28	12.60	12.94	0.35	0.34	0.34
P333 @750 ppm	13.31	13.40	13.35	0.33	0.32	0.32
1 st summer pruning (SP I)	13.27	13.40	13.33	0.36	0.35	0.35
250 ppm PP333+ SP I	13.39	13.34	13.36	0.32	0.31	0.31
500 ppm PP333 + SP I	13.46	13.49	13.47	0.30	0.28	0.29
750 ppm PP333 + SP I	13.53	13.66	13.59	0.28	0.26	0.27
2 nd summer pruning (SP II)	13.34	13.42	13.38	0.34	0.32	0.33
250 ppm PP333 + SP II	13.44	13.52	13.48	0.31	0.30	0.30
500 ppm PP333 + SP II	13.49	13.65	13.57	0.29	0.27	0.28
750 ppm PP333 + SP II	13.75	13.78	13.76	0.27	0.25	0.26
Two summer prunings (SP I + SP II)	13.75	13.94	13.84	0.30	0.28	0.29
250 ppm PP333 + SP I + SP II	13.93	14.18	14.05	0.27	0.25	0.26
500 ppm PP333 + SP I + SP II	14.25	14.32	14.28	0.26	0.23	0.24
750 ppm PP333 + SP I + SP II	14.43	14.51	14.47	0.24	0.22	0.23
CD _{0.05}	0.17	0.13	0.15	0.02	0.01	0.01

Mean data revealed lowest acidity of 0.23% in 750 ppm paclobutrazol + two summer pruning treatment; whereas highest acidity of 0.39% was in control which was significantly higher than all other treatments (Table 5). Our results support the findings of Wani (2004) in sweet cherry and Wani *et al.* (2007) in apples. Andres *et al.* (2008) observed that the acidity of fruits diminished as a result of ripening process in mango by paclobutrazol application. Fruit acidity was reduced by summer pruning which may be attributed to the fact that fruit maturation was accelerated in summer pruned trees which resulted in higher TSS content. The findings are in agreement with Hossain *et al.* (2006) in peach and Rather (2006) in apple.

Conclusion: The study revealed that the spray of paclobutrazol at 3 concentrations (250, 500 and 750 ppm), 2 timings of summer pruning (8 and 12 weeks after full bloom) and their combinations significantly improved fruit quality of 'Red Delicious' apple. Fruit yield, size, weight, volume, colour, firmness and organoleptic rating in terms of taste, texture, flavour and TSS was significantly improved by combined application of paclobutrazol and summer prunings whereas acidity was reduced by this treatment in comparison to control and other treatments.

REFERENCES

- A.O.A.C. 1980. *Official Methods of Analysis of the Analytical Chemists* (13th edn.). [ed. W. Horwitz]. Association of Official Analytical Chemists, Washington, USA.
- Abdel Rahim, A.O.S., Elamin, O.M. and Bangerth, F.K. 2011. Effects of growth retardants, paclobutrazol (pbz) and prohexadione-Ca on floral induction of regular bearing mango *Mangifera indica* L.) cultivars during off-season. *Journal of Agricultural and Biological Science*, **6**(2):18-26.
- Blanpied, G.D., Forshey, C.G., Styles, W.C., Green, D.W., Lord, W.J. and Ramledge, W.J. 1975. Use of ethephon to stimulate red colour without hastening ripening of McIntosh apples.

- Journal of American Society for Horticultural Science*, **100**: 379-381.
- Bussi, C., Lescourret, J., Genard, M. and Habib, R. 2005. Pruning intensity and fruit load influence on vegetative and fruit growth in an early maturing peach tree cv. Alexandra. *Fruits*, **60**: 133-142.
- Dalziel, J. and Lawrence, D.K. 1984. Biochemical and biological effects of kaurene oxidase inhibitors such as paclobutrazol. pp. 43-57. In *Biochemical Aspects of Synthetic and Naturally Occurring Plant Growth Regulators Monograph* (eds. R. Menhenett and D.K. Lawrence). British Plant Growth Regulation Group, Wantage, England.
- Dussi, M.C., Sosa, D., Junyent, G. and Giardina, G. 2004. Summer pruning in Red Delicious apple tree and its effect on fruit and spur leaf quality. *Revista de la Facultad de Ciencias Agrarias Universidad Nacional de Cuyo*, **36**(2): 15-22.
- Edgerton, L.J. and Blanpied, G.D. 1970. Interaction of succinic acid 2, 2-dimethylhydrazide, 2-chloro-ethylphosphoric acid and auxins on maturity, quality and abscission of apples. *Journal of American Society for Horticultural Science*, **95**: 664-666.
- Edward, F.G., Knox, G.W. and Patricia, V. 2008. Pruning method affects flowering and sprouting on crape-myrtle. *Journal of Environmental Horticulture*, **26**: 164-170.
- Gomez, K.A. and Gomez, A.A. 1983. *Statistical Procedures for Agricultural Research* (2nd edn.). John Wiley and Sons, New York, USA.
- Greene, D.W. 1986. Effect of paclobutrazol and analogous on growth, yield, fruit quality and storage potential of Delicious apples. *Journal of American Society for Horticultural Science*, **11**: 328-332.
- Hassani, G. and Rezaee, R. 2007. Effect of training system and rate of pruning on yield and quality of peach fruit. *Agriculture Science Tabriz*, **17**: 31-38.
- Hossain, A.B.M.S., Mizutani, F., Onguso, J.M. and Ali, E.S.R. 2006. Effect of summer pruning on shoot growth and fruit quality in peach trees trained as slender spindle bush type. *Bulletin of the Faculty of Agriculture, Ehime University, Japan*, **51**: 9-13.
- Ibrahim, A.K.A., Mika, A.A. and Piatkowski, M. 1983. Fruit quality and storage ability of two apple cultivars as affected by rootstocks, planting systems, irrigation and growth retardants: Effects of orchard treatments on fruit quality and mineral content of apple. *Fruit Science Reporter*, **10**: 161-172.
- Jankiewicz, L.S. and Stecki, Z.J. 1976. Some mechanism responsible for differences in tree form. pp. 157-172. In: *Tree Physiology and Yield Improvement* (eds. Cannel and Last). Academic Press, London, UK.
- Luo, Y., Wainwright, H. and Moore, K.G. 1987. Effects of orchard application of paclobutrazol on the post harvest ripening of apples. *Journal of Horticultural Science*, **62**: 295-301.
- Mohamed, S.M., Fayed, T.A., El-Shrief, H.M. and Mokhtar, O.S. 2011. Effect of heading cut levels, bending and NAA on spurs formation, yield and fruit quality of sun gold plum cultivar. *Journal of Horticultural Science and Ornamental Plants*, **3**: 232-243.
- Myriam, S., Bussi, C., Lescourret, F., Genard, M., Habib, R. and Gilreath, J. 2005. Pruning intensity and fruit load influence on vegetative and fruit growth in 'Alexandra' peach. *Proceedings of the Florida State Horticultural Society*, **118**: 266-269.
- Pant, N. and Kumar, R. 2004. Effect of paclobutrazol and chloromequat on growth, flowering, yield and quality of 'Red Delicious apple'. *Progressive Horticulture*, **36**: 167-170.
- Pescie, M., Borda, M., Fedyszak, P. and Lopez, C. 2011. Effect of time and intensity of pruning on the yield and fruit quality of southern high bush blueberries (*Vaccinium corymbosum*) var. O'neal in Buenos Aires province. *Argentina*, **37**(3): 1-5.
- Rather, G.H. 2006. *Combined Influence of Pruning Regimes and Fertilizer Application on Production and Quality of Apple (Malus x domestica Borkh.) cv. Red Delicious*. Ph.D. thesis, S.K. University of Agricultural Sciences and Technology of Kashmir, Srinagar, India.
- Steffens, G.L., Byun, J.K. and Wang, S.Y. 1985. Controlling plant growth via the gibberellins biosynthesis system. I. Growth parameter alterations in apple seedlings. *Physiologia*

- Plantarum*, **63**: 163-168.
- Wani, A.M., Peer, F.A. and Lone, I.A. 2007. Effect of paclobutrazol on growth, picking maturity and storage behaviour of Red Delicious apples. *The Asian Journal of Horticulture*, **2**: 171-175.
- Wani, W.M. 2004. *Influence of Growth Retardant (Paclobutrazol) and Gibberellic Acid on Growth and Production of Sweet Cherry*. Ph.D. thesis, S.K. University of Agricultural Sciences and Technology of Kashmir, Srinagar, India.
- Westwood, M.N. 1993. *Temperate Zone Pomology: Physiology and Culture* (3rd edn.). Timber Press, Portland, Oregon, USA.
- Wolstenholme, N., Whaley, W. and Saranah, J.B. 1990. Manipulating vegetative and reproductive growth in avocado (*Persea americana* Mill.) with paclobutrazol foliar sprays. *Scientia Horticulturae*, **41**: 315-327.
- Yadav, R.K., Rai, N., Yadav, D.S. and Asati, B.S. 2005. Use of paclobutrazol in horticultural crops – A review. *Agricultural Reviews*, **26**: 124-132.