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Influence of pre-harvest treatments of paclobutrazol, calcium chloride and summer pruning on shelf-life of peach (*Prunus persica* Batsch.)

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Abstract

The study was undertaken on 9-year-old trees of peach cv. July Elberta established on Behmi (*Prunus mira* L.) rootstocks at 2.5x2.5 m spacing in the Department of Fruit Science, University of Horticulture and Forestry, Solan. Experimental trees were given different treatments of PP_{333} at 250 and 500ppm applied at 3 or 6 week after full bloom (WAFB), $CaCl_2$ at 0.5% and 1.0% at 6 or 8 WAFB and summer pruning at 6 or 8 or 10 WAFB. Higher increase in Ca-pectate content of fruits was observed with the application of 1% $CaCl_2$ at 8 WAFB, PP_{333} at 500ppm at 3 WAFB and early summer pruning. Pre-harvest application of $CaCl_2$ at 0.5 and 1.0% applied at different stages after full bloom and early summer pruning decreased the physiological fruit weight loss and maintained higher fruit firmness during storage. Treatment of PP_{333} when applied 6 WAFB maintained higher fruit TSS and sugar contents during storage. Fruits from trees sprayed with 1.0% $CaCl_2$ at 8 WAFB or given early summer pruning (6 WAFB) showed least decline in fruit acidity and ascorbic acid contents during ambient storage.

Key words: PP_{333}, $CaCl_2$, summer pruning, storage, TSS, Ca-pectate.

Introduction

The Peach (*Prunus persica* Batsch.) has wide range of climatic adaptation and grown commercially around the world between 24° and 45° latitude both north and south of the equator. In India, it is being cultivated from northern plains to an elevation of 2000m amsl and its production is estimated to be about 1, 14, 000 MT (FAO, 2012). In Himachal Pradesh, peach cultivation is scattered all over the state except dry and cold regions of Lahaul & Spiti, Kinnaur and Pangi or Bharmaur areas of Chamba district.

July Elberta is a leading variety of peach in the state, which is greatly prized for its juicy, sweet and much flavoured table fruits; besides it can be canned. However, like other stone fruits, it can not endure long storage after harvest as they are highly perishable at normal storage conditions. The modifications of ripening and senescence process of fruits without hampering its quality and shelf life have created attention of researchers in recent years. Though proper postharvest handling and retention at cooler temperature prolong the shelf life, yet pre-harvest application of various chemicals have been reported to improve shelf life of various commodities. The quality and storage life of fruits can be enhanced with the pre-harvest application of calcium (Mahajan and Sharma, 2000) and certain growth retardants like paclobutrazol (Singh, 2000). Cultural practices like summer pruning also have potential to enhance quality and storage life of fruits (Hughes, 1998). These treatments are known to play an important role in modulating the maturation and ripening processes by affecting changes in fruit firmness especially by changes in cellular contents. Keeping above observations in view the present study was aimed to evaluate the influence of paclobutrazol, calcium chloride and summer pruning on storage life of peach cv. July Elberta.

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Materials and Methods

The study was undertaken in the experimental orchard of the Department of Fruit Science, Nauni on 9-year-old trees of peach cv. July Elberta established on Behmi (*Prunus mira* L.) rootstocks at 2.5x2.5 m spacing. The treatments consisting of PP_{333} at 250 and 500 ppm at 3 and 6 weeks after full bloom (WAFB), $CaCl_2$ at 0.5 and 1.0 % at 6 and 8 WAFB, summer pruning at 6, 8 and 10 WAFB were applied. The experiment was conducted in a simple randomized block design with three replications. The treatments of PP_{333} and $CaCl_2$ were applied through spray of 12 liter solution (4 l $tree^{-1}$) of the respective treatment to the aerial part of the trees with addition of 0.1 % Tween-20. In summer pruning treatment, heading back of the shoots was done with a secateurs to 4-6 mature leaves, while in control no treatment was given. The fruits were harvested at colour break stage (26th June) and 20 fruits from each replication were stored in well aerated place at temperature ranging between 18.5 to 29.5 °C and relative humidity between 50 to 94 %. Carre and Hayne's method as describe by Ranganna (1986) was used for the estimation of pectin content (Ca-pectate). The observation on physiological weight loss was taken at periodic intervals of five days (at 0, 5, 10 and 15 days from harvest) and loss in weight was expressed as per cent of initial weight on each sampling date. The other parameters of fruits were also analyzed at periodic intervals of five days. The fruit firmness was determined by a pressure tester (Effegi Penetrometer-FT 327 and expressed in Newton [Newton (N) = Force in kg x 9.807]. The total soluble solids content in fruits were determined with Erma hand refractometer (0-32° Brix) and expressed as percentage of fresh juice. Total, reducing and non-reducing sugars, total titratable acidity and ascorbic acid contents of fruits were determined as per A.O.A.C. (2005) method. The data generated during studies were analyzed as per procedure described by Cochran and Cox (1963).

Results and Discussion

Calcium pectate

Pectin content (Ca-pectate) of fruits was significantly increased by different treatments (Table 1). Treatments with 1.0% $CaCl_2$ applied 8 WAFB, PP_{333} at 500ppm applied at 3 WAFB and early summer pruning (6 WAFB) caused higher increase in fruit pectin content over the control (Table 1). These results are in agreement with the findings that pre-harvest application of calcium chloride and PP_{333} (Hu and Huang, 1992) increase fruit calcium contents. In this study, removal of actively growing shoots by summer pruning may have increased fruit calcium content by channelizing its translocation into the developing fruits.

Physiological loss in weight

It was observed that the physiological loss in fruit weight during storage increased gradually under different treatments with advancement of storage period (Table 1). However, fruit weight loss was lowest (6.88 %) in the treatment of 1 per cent $CaCl_2$ applied 8 weeks after full bloom, closely followed by the treatments of summer pruning and 0.5 per cent $CaCl_2$ applied at 6 and 8 weeks after full bloom respectively. Other treatments except, the late summer pruning (10 WAFB) also reduced the per cent loss in fruit weight during storage. The physiological loss in weight during storage is generally due to the depletion of moisture and respiratory losses occurring in the commodity. Calcium is known to act as an anti-senescent agent as it prevents cellular disintegration by maintaining protein and nucleic acid synthesis and thus elevated fruit calcium contents under different treatments (Table 1) seems to have decreased the fruit weight loss in storage by slowing down the physiological process responsible for causing the weight loss.

Fruit firmness

Different pre harvest treatments significantly influenced the firmness of fruits at harvest, as well as during 15 days of ambient storage (Table 1). Fruit from trees treated with 1 per cent $CaCl_2$, 8 weeks after full bloom recorded maximum flesh firmness (75.98 N) at harvest and also maintained significantly higher firmness during 15 days of storage as compared to control. Other treatments of $CaCl_2$ maintained significantly higher flesh firmness during storage than control. Furthermore, fruits from paclobutrazol treated and early summer pruned (6 WAFB) tree maintained higher firmness during storage in comparison to

Table 1. Effect of paclobutrazol, calcium chloride and summer pruning on physiological loss in weight (%), flesh firmness (N), TSS (%) and acidity in peach cv. July Elberta during storage

Treatments (T)	Pectin content (%Ca-pectate)	Storage interval in days (I) Physiological weight loss (%)			Mean	Storage interval in days (I) Flesh firmness (N)				Mean	Storage interval in days (I) TSS (%)				Mean	Storage interval in days (I) Acidity (%)				Mean
		5	10	15		0	5	10	15		0	5	10	15		0	5	10	15	
PP_{333} 250ppm (3WAFB)	3.31	5.89 (2.42)	10.08 (3.17)	19.48 (4.41)	11.82 (3.33)	73.24	62.55	35.92	9.98	45.42	10.86	11.85	12.54	11.45	11.68	0.65	0.53	0.44	0.25	0.47
PP_{333} 500ppm (3WAFB)	3.75	3.93 (1.98)	6.09 (2.46)	14.68 (3.83)	8.23 (2.76)	75.33	63.28	37.45	12.86	47.23	10.58	11.83	12.50	11.41	11.58	0.68	0.59	0.43	0.36	0.52
PP_{333} 250ppm (6WAFB)	3.38	5.58 (2.36)	9.44 (3.07)	15.36 (3.91)	10.13 (3.11)	73.56	61.94	36.10	10.24	45.46	11.26	12.36	12.95	11.92	12.12	0.62	0.50	0.40	0.24	0.44
PP_{333} 500ppm (6WAFB)	3.46	5.46 (2.34)	8.37 (2.89)	15.08 (3.88)	9.64 (3.04)	73.95	62.02	36.53	10.76	45.83	11.45	12.49	13.08	12.13	12.29	0.59	0.47	0.38	0.21	0.41
$CaCl_2$ 0.5% (6WAFB)	3.35	5.62 (2.37)	9.12 (3.02)	15.22 (3.90)	9.99 (3.10)	73.32	62.68	36.08	10.22	45.58	11.12	12.28	12.56	11.88	11.96	0.61	0.51	0.43	0.29	0.46
$CaCl_2$ 1.0% (6WAFB)	3.47	5.43 (2.33)	8.32 (2.88)	14.76 (3.84)	9.50 (3.02)	73.98	62.45	36.55	11.22	46.05	10.93	12.20	12.54	11.98	11.91	0.63	0.53	0.45	0.34	0.49
$CaCl_2$ 0.5% (8WAFB)	3.58	4.15 (2.03)	5.99 (2.44)	11.02 (3.32)	7.05 (2.60)	74.18	64.73	38.58	13.96	47.86	10.73	12.00	12.51	12.13	11.84	0.65	0.56	0.47	0.33	0.50
$CaCl_2$ 1.0% (8WAFB)	3.87	3.87 (1.96)	5.95 (2.43)	10.89 (3.29)	6.88 (2.56)	75.98	65.14	41.59	14.96	49.35	10.53	11.77	12.50	12.28	11.77	0.68	0.59	0.48	0.38	0.53
Summer pruning (6WAFB)	3.75	4.09 (2.02)	6.01 (2.41)	10.98 (3.31)	7.03 (2.59)	74.24	62.65	40.75	13.94	47.90	9.95	11.66	12.12	11.74	11.37	0.69	0.60	0.47	0.34	0.53
Summer pruning (6WAFB)	3.29	6.17 (2.48)	12.05 (3.47)	20.85 (4.56)	13.02 (3.50)	72.93	59.97	36.34	10.05	44.82	10.52	12.08	12.55	11.55	11.68	0.66	0.57	0.46	0.30	0.50
Summer pruning (8WAFB)	3.02	7.01 (2.65)	13.26 (3.64)	23.56 (4.85)	14.60 (3.71)	70.23	59.25	35.45	9.38	43.58	10.65	12.23	12.02	10.95	11.46	0.64	0.54	0.37	0.19	0.55
Control	3.04	6.98 (2.64)	13.20 (3.63)	23.47 (4.84)	14.55 (3.70)	70.52	59.48	35.72	9.62	43.84	10.64	12.22	11.99	10.93	11.55	0.65	0.54	0.38	0.19	0.44
Mean	0.10	5.35 (2.30)	8.99 (2.96)	16.28 (3.99)		73.46	62.18	37.26	11.41		10.77	12.08	12.49	11.70		0.65	0.54	0.43	0.29	

CD (P=0.05)				
Treatment (T)	0.09	0.60	0.08	0.02
Interval (I)	0.04	0.34	0.04	0.01
TxI	0.11	0.85	0.11	0.02

Values in parentheses are square root transformed.

control. In this study, the increase in fruit firmness under different treatments may be attributed to increased accumulation of calcium pectate (Table 1), which directly influences the fruit firmness. Pre-harvest application of calcium delayed softening of the fruit during storage (Plisch *et al.*, 2002). The increase in the firmness by PP_{333} treatments may also be due to the inhibition of autocatalytic production of ethylene (Hu and Ding, 1993).

Total soluble solids, acidity, sugars and ascorbic acid contents

Present investigations revealed a significant influence of different pre-harvest treatments on TSS, acid, sugars and ascorbic acid content of fruits (Tables 1 & 2). During storage, TSS content generally increased up to 10 days except, in the treatments of late summer pruning (10 WAFB) and control, which subsequently declined during the remaining storage period (Table 1). After 15 days of storage, the highest TSS content (12.29 %) in fruits was observed in treatment of PP_{333} when applied 6 weeks after full bloom. A gradual decline in the acid content of fruit was observed with the advancement of storage period (Table 1). Treatments of 1 per cent $CaCl_2$ applied at 8 WAFB and early summer pruning (6 WAFB) retained higher acid in fruits even at 15 days of storage. Regarding reducing, non-reducing and total sugars content of fruits, it was observed that there was a gradual increase in their contents up to 10 days except, in fruits from late summer pruning treatment (Table 2). Thereafter, the sugars content declined during the remaining storage period, under all the treatments. A gradual decline in the ascorbic acid content of the fruits (Table 2) was observed under all the treatments with the advancement of storage period. However, fruits treated with 1 per cent $CaCl_2$ 8 weeks after full bloom retained significantly higher ascorbic acid content (4.06 mg/100 g) than control (3.81 mg/100g) after 15 days of storage. These findings confirm earlier report (Gupta *et al.* 1987) that pre-harvest calcium reduced the breakdown of sugar and other chemical constituents of fruits during storage.

Pre-harvest spray of $CaCl_2$ increased Ca-pectate in fruits, reduced storage spoilage and maintained high flesh firmness of fruits during storage when applied at 1.0 % (8 WAFB).

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Table 2. Effect of paclobutrazol, calcium chloride and summer pruning on sugar and ascorbic acid in peach cv. July Elberta during storage

Treatments (T)	Storage interval in days (I) Reducing sugar (%)				Mean	Storage interval in days (I) Non-reducing sugar (%)				Mean	Storage interval in days (I) Total sugar (%)				Mean	Storage interval in days (I) Ascorbic acid (mg/100g)				Mean
	0	5	10	15		0	5	10	15		0	5	10	15		0	5	10	15	
PP_{333} 250ppm (3WAFB)	1.79	2.10	2.28	1.98	2.04	3.51	4.37	4.71	4.40	4.25	5.48	6.70	7.24	6.61	6.51	4.80	4.02	3.74	2.81	3.84
PP_{333} 500ppm (3WAFB)	1.71	1.93	2.10	1.82	1.89	3.44	4.29	4.78	4.38	4.22	5.33	6.45	7.17	6.43	6.35	4.92	4.27	3.88	3.10	4.04
PP_{333} 250ppm (6WAFB)	1.85	2.21	2.37	2.02	2.12	4.62	4.77	4.89	4.61	4.72	6.71	7.23	7.52	6.90	7.09	4.88	4.17	3.71	2.88	3.91
PP_{333} 500ppm (6WAFB)	1.90	2.27	2.43	2.13	2.18	4.72	4.89	4.99	4.62	4.81	6.87	7.42	7.68	6.99	7.24	4.93	4.29	3.87	3.08	4.04
$CaCl_2$ 0.5% (6WAFB)	1.85	2.19	2.24	1.99	2.07	4.44	4.76	4.81	4.46	4.62	6.52	7.20	7.30	6.68	6.93	4.83	4.07	3.78	2.86	3.89
$CaCl_2$ 1.0% (6WAFB)	1.79	2.08	2.19	2.08	2.04	4.46	4.80	4.83	4.47	4.64	6.48	7.13	7.27	6.79	6.92	4.86	4.16	3.88	2.95	3.96
$CaCl_2$ 0.5% (8WAFB)	1.76	1.99	2.18	2.13	2.02	3.70	4.77	4.83	4.48	4.45	5.65	7.01	7.25	6.85	6.69	4.84	4.12	3.86	2.95	3.94
$CaCl_2$ 1.0% (8WAFB)	1.73	1.96	2.16	2.15	2.00	3.41	4.47	4.78	4.62	4.32	5.32	6.57	7.20	7.01	6.55	4.89	4.29	3.95	3.11	4.06
Summer pruning (6WAFB)	1.67	1.92	2.14	2.09	1.96	3.19	4.16	4.66	4.49	4.13	5.03	6.30	7.01	6.82	6.29	4.87	4.25	3.87	3.08	4.02
Summer pruning (6WAFB)	1.85	2.01	2.22	2.02	2.03	3.28	4.51	4.80	4.37	4.24	5.30	6.76	7.27	6.63	6.49	4.83	4.13	3.75	2.83	3.89
Summer pruning (8WAFB)	1.89	2.27	2.25	1.82	2.06	3.34	4.65	4.61	4.04	4.16	5.41	7.16	7.10	6.07	6.44	4.79	3.98	3.69	2.79	3.81
Control	1.88	2.28	2.26	1.80	2.06	3.33	4.64	4.58	4.05	4.15	5.39	7.16	7.08	6.06	6.42	4.82	3.95	3.71	2.78	3.82
Mean	1.81	2.10	2.24	2.01		3.79	4.59	4.77	4.42		5.79	6.93	7.26	6.65		4.86	4.14	3.81	2.94	
CD (P=0.05)																				
Treatment (T)			0.02					0.07					0.10					0.09		
Interval (I)			0.01					0.04					0.06					0.05		
TxI			0.02					0.10					0.14					NS		