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Effect of Pre-Harvest Gibberellic Acid and Calcium Application on Post-Harvest Behaviour of Subtropical Peaches

SHASHI K. SHARMA[1]* and PREET PRATIMA[2]

[1]Department of Fruit Science, College of Horticulture and Forestry, Neri, Hamirpur (HP) India.
[2]Department of Fruit Science College of Horticulture, Dr Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP) India.

Abstract

Shorter shelf life and faster deterioration of fruits after harvest are the major constraints with the peach production in the subtropical regions. Pre-harvest application of GA_3 and chloride & nitrate of calcium were tried in a RBD experiment for enhancing peach fruit quality and reducing fruit deterioration during shelf life studies of five subtropical peach cultivars. At harvest fruit quality parameters viz. TSS, acidity, firmness etc. were influenced greatly by the treatments. Other physical properties of the fruit such as fruit weight, size and yield were not influenced much. Physiological weight loss during storage and the deterioration of other fruit characteristics were considerably lowered by calcium treatments. Foliar application of Calcium nitrate (1%) was found to be superior over calcium chloride (2%) for improving fruit quality and shelf life.

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Introduction

Peach is cultivated almost throughout the world and its production is about 24.97 million metric ton[22]. It ranks next only to apple (89.33 million metric ton) and pear (27.35 million metric ton) amongst the temperate fruits in the world production level. Though it has originated in the temperate region of China, the peach has very well adapted to the subtropical regions also. Today there is a wide array of peach varieties which have low chilling requirement and therefore flower and fruit very well in the subtropics. But despite of the good production levels, the subtropical peaches have very low proportion in international and domestic trade due to the high perishability of the fruits after harvest. To tackle this problem, the grower generally restore to early

CONTACT Shashi K. Sharma shashi_uhf@yahoo.com Department of Fruit Science, College of Horticulture and Forestry, Neri, Hamirpur (HP) India.

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harvest of the fruits when they are quite firm to withstand handling and transport. But it has been observed that the fruits so harvested, never reach their full flavor, aroma and consumer acceptance. Crisosto and Costa[3] have reported that recently most potential peach producing countries have lost considerable market share due to excessive early harvesting. The post harvest quality of peaches is largely a function of fruit physiological maturity at the time of harvest. They (peaches and Nectarines) undergo a rapid softening after harvest, which leads to dramatic losses in the marketing chain, soft fruits are easily bruised during handling and more susceptible to decay[10]. Therefore, it is necessary to pick them at early stage of ripening than at 'on tree physiological maturity'. But, this practice has certainly some repercussions related to fruit firmness and shelf life. Therefore, in order to succeed in domestic and international markets it is imperative to work over the issues of senescence reduction and fruit firmness and shelf life improvement of peaches.

Plant nutritional status is an important factor of fruit quality and post harvest life potential. The nutrient, calcium is involved in numerous biochemical and morphological processes in plants and has been implicated in many physiological disorders of considerable economic importance to production and post harvest quality. It plays a special role in maintaining the cell wall structure in fruits and other storage organs by interacting with pectic acid in cell walls to form calcium pectate[17]. The pre-harvest sufficiency of calcium determines the rate of deterioration of cellular membranes[12]. Being poor in translocation of calcium to the plant terminals, it has been generally observed suboptimal in the maturing fruits and therefore the pre-harvest foliar application of this nutrient element has been found to be beneficial in influencing the shelf life and fruit quality in many fruits. Apart from calcium plant growth regulators like gibberellins being anti –senescent in nature are also used in some fruit species for having extended harvesting and marketing seasons of the fruits[2]. Keeping in view the advantages of calcium and GA_3 applications in other fruits experiment was conducted to find out the effect of different calcium sources and GA_3 concentrations on the shelf life and storage behaviour of different low chill requiring peach cultivars.

Materials and Methods

The studies were carried out from 2013 to 2015 at the college of Horticulture and Forestry (Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP), Neri, Hamirpur (HP) India. The experiment was set in the experimental orchard on low chilling peach varieties namely Pratap, Florda Prince, Early Grande, Prabhat, Shan-i-Punjab; which were planted during the year 2008 on wild peach rootstock and trained to a open vase system, planted in a alternate planting arrangement at a planting density of 1666 plant per hectare on sloppy terrain having soil pH 6.68 and organic carbon content 1.28% at the start of the experiment. The treatments consisted of two gibberellic acid (GA_3) treatments - 50 and 100 ppm and two calcium sources: Calcium chloride ($Cacl_2$) and Calcium nitrate ($Ca(NO_3)_2$), both applied at the rate of 1% and 2%. All the treatments were applied as foliar sprays one week prior to the expected physiological maturity. The experiment was laid out in randomized block design with a control of water spray and 4 replications of each treatment. Since ground cover may influence the nutrition level of the plant therefore all the trees kept mulched with orchard sod on a two meter wide terrace. Other orchard management practices including spray of fungicide, insecticide, fertilizer application etc. all were kept similar for all the varieties under study.

Twenty fruits, of uniform size and maturity level, per tree were randomly collected across the periphery of the tree at harvest time. These fruits were analysed for various physico-chemical characteristics like fruit size, weight, firmness, total soluble solids (^oBrix) and titrable acid content (*meq* of malic acid) as per standard procedure described by[1]. The shelf life observations were taken by placing the harvested fruits at room temperature. Physiological weight loss of the fruits was measured as the percent reduction in fruit weight. All these parameters were recorded at 0, 3, 6 and 9 days after harvest. All the statistical analyses were carried out as per procedure described by Gupta and Gupta[11] using SX statistical software.

Results and Discussion

The data pertaining to effect of GA_3 and calcium treatments on fruit quality and yield are presented in table 1. It is evident from the data that the effect of all the treatments was found to be superior over

the control as far as TSS, acidity and fruit firmness of different cultivars was concerned. Fruit size was influenced significantly incase of Early Grande and Shan-i- Punjab only. In other varieties no significant effect was obseved on fruit size. These findings were in close conformity with those of Farag *et al.,*[8] who reported no significant effect of calcium treatments on fruit physical parametrs. Similarly fruit weight has only been influenced significantly in case of pratap cultivar. Different treatments have not influenced total yield in any of the cultivars studied. From these results it can be inferred that GA_3 and calcium applications influenced only those fruit quality attributes which has certain correlation with fruit ripening processes which possess weak correlation with fruit ripening were raerly affected by gibberellin or calcium application[14,25]. The positive influence on fruit size of Early Grande and Shan-i-Punjab culitvars may be attributed to the fact that these cultivars are a bit late in maturity in comparison to other cultivars studied hence, the treatment applications just at the fag end of maturity might have resulted into marginal increase in fruit size of other due cellular expansion due to growth stimulating hormones or substances. It has been therefore inferred that significant influence of GA_3 and calcium applications was observed only in case of those varieties which have not attained their physiological maturity maxima. Sharma and Verma[21] have studied the maturity pattern of different subtropical peaches and reported that the cultivars Early Grande and Shan-i-Punjab are comparatively late in maturity than other cultivars under subtropical conditions of Himachal Pradesh. Fruit yield has not een influenced significantly by different treatments and this might have happended due to non significant effect of the treatments on the fruit physical parameters. Fruit ripening associated characteristics like TSS, acidity and firmness were influenced significantly by the application of different treatments. In most of the cultivars studied the highest TSS was recorded with calcium nitrate application. Calcium chloride ranked second and gibrrellic acid treatment was found to inluence TSS to the extent minimum. The higher doses reulted into higher TSS but, it was rarely found superior over the corresponding lower level of application. In case of Prabhat cultivar the effect of different treatments was found to be non-significant, may be due to the reason that it is a early maturing cultivar[21] and hence application of dfferent treatments could'nt influence this perticular fruit characteristic. Fruit acidity was also found to increase in the similar manner as the TSS increased with different chemical applications, highest value being recorded with calcium nitrate followed by calcium chloride and GA_3 applications. The increase in the acid content with 2% application was not statistically different from 1% application. Better results were obtained with calcium nitrate followed by calcium chloride and GA_3 aaplication which may be attributed to the fact that calcium treatments might have delayed the ripening process by preserving the cell wall integrity and delayed pectic substances solubilization[15]. Raja *et al.,*[18] also observed delayed ripening with calcium chloride application in peach. Improved fruit quality attributes with calcium nitrate over calcium chloride may be supported with the views of Crisosto and Costa[3] who explained that in peach fruit quality development the role of calcium application is not as important as that of nitrogen is. In peaches, the calcium mobility to the fruits is maintained throughout the fruit development period due to higher transpiration rates, if leaf calcium is under sufficiency. In addition to calcium, application of nitrogen in the form of calcium nitrate however might have results in better fruit quality development due to delayed fruit ripening and enhanced assimilation metabolism[7], apart from the above said advantages of calcium application. The effect of GA_3 application on different fruit quality attributes was superior over control but comparatively lesser than the calcium treatments may e attributed to the fact that GA_3 application is more effective when applied during early stages of fruit development. As the fruit advance toward maturity the influence of this hormone on fruit development fades away[6,20]. Better fruit quality attributes obtained with calcium treatments may be attributed to the fact that calcium plays an important role in maintaining cell wall structure by interaction with pectic acid in the cell walls to form calcium pectate[5]. Cell wall integrity is also preserved when de-esterified pectic acid residues form cross-bridges between negatively charged carboxylic groups and divalent cations such as calcium, thus minimizing pectic substance solubilization[15].

Table 1. Effect of pre-harvest GA_3 and calcium sprays on fruit physico-chemical characteristics and yield of different subtropical peach cultivars

Variety	Treatment		Fruit	Fruit Size			TSS	Acidity	Firmness
	Chemical	Dose	wt.	Length	Diameter	Yield	(^{0}B)	(%)	(kg)
			(g)	(mm)	(mm)	(kg)			
Pratap	GA_3	50ppm	69.0	60.2	63.5	53.0	13.3	0.61	7.04
		100ppm	68.8	60.4	63.5	53.0	13.1	0.64	7.37
	$Ca(NO_3)_2$	1%	67.0	60.3	63.9	52.6	13.6	0.72	7.41
		2%	68.4	60.0	63.7	52.8	13.7	0.74	7.42
	$CaCl_2$	1%	71.6	60.2	63.2	53.6	13.0	0.67	7.45
		2%	68.3	59.9	63.0	52.6	13.1	0.68	7.47
	Control	--	65.8	51.2	53.3	46.8	12.1	0.56	6.42
	CD		5.65	NS	NS	NS	1.13	0.20	0.14
Florda Prince	GA_3	50ppm	65.2	61.3	65.5	52.8	14.2	0.67	6.81
		100ppm	67.5	60.8	65.4	53.3	14.6	0.69	6.88
	$Ca(NO_3)_2$	1%	60.8	60.1	64.9	51.1	14.8	0.69	7.12
		2%	60.6	59.1	66.8	51.3	14.2	0.71	7.22
	$CaCl_2$	1%	65.4	59.4	63.6	51.8	14.2	0.64	6.89
		2%	62.0	57.1	61.3	49.6	14.2	0.69	6.92
	Control	--	60.4	54.3	56.5	47.1	12.2	0.58	6.22
	CD		NS	NS	NS	NS	1.12	0.11	1.04
Early Grande	GA_3	50ppm	76.7	54.7	57.8	52.0	13.1	0.54	7.01
		100ppm	77.4	56.1	59.5	53.1	13.4	0.68	7.39
	$Ca(NO_3)_2$	1%	75.8	59.1	62.6	54.3	13.5	0.63	7.42
		2%	72.3	58.8	62.0	53.1	13.2	0.68	7.50
	$CaCl_2$	1%	74.8	59.6	62.7	54.2	13.1	0.51	7.14
		2%	74.4	61.2	65.1	55.2	13.9	0.52	7.43
	Control	--	73.3	55.1	57.0	51.0	11.9	0.49	7.00
	CD		NS	1.1	1.6	NS	NS	NS	0.31
Prabhat	GA_3	50ppm	59.9	58.4	62.5	49.7	14.1	0.59	6.05
		100ppm	65.8	61.4	65.6	53.0	14.2	0.62	6.23
	$Ca(NO_3)_2$	1%	59.5	57.0	61.9	49.1	14.9	0.61	6.28
		2%	59.2	56.5	60.8	48.5	14.3	0.68	6.32
	$CaCl_2$	1%	56.5	54.7	59.0	46.8	14.3	0.63	6.21
		2%	54.0	54.4	58.5	45.9	14.1	0.67	6.24
	Control	--	56.4	53.6	56.7	45.8	13.1	0.44	6.11
			NS	1.1	1.2	2.5	1.1	0.23	1.24
Shan-i-Punjab	GA_3	50ppm	71.2	57.1	60.6	51.9	13.5	0.66	7.14
		100ppm	74.5	52.5	55.7	50.2	13.2	0.68	7.23
	$Ca(NO_3)_2$	1%	69.1	55.9	59.2	50.7	13.3	0.65	7.15
		2%	72.9	56.3	59.7	51.9	13.4	0.71	7.31
	$CaCl_2$	1%	74.4	56.4	59.6	52.4	13.2	0.63	7.17
		2%	74.2	56.4	59.9	52.4	13.5	0.68	7.24
	Control	--	69.3	54.9	57.0	49.8	12.1	0.54	6.60
			NS	1.12	0.76	1.1	1.2	0.19	1.87

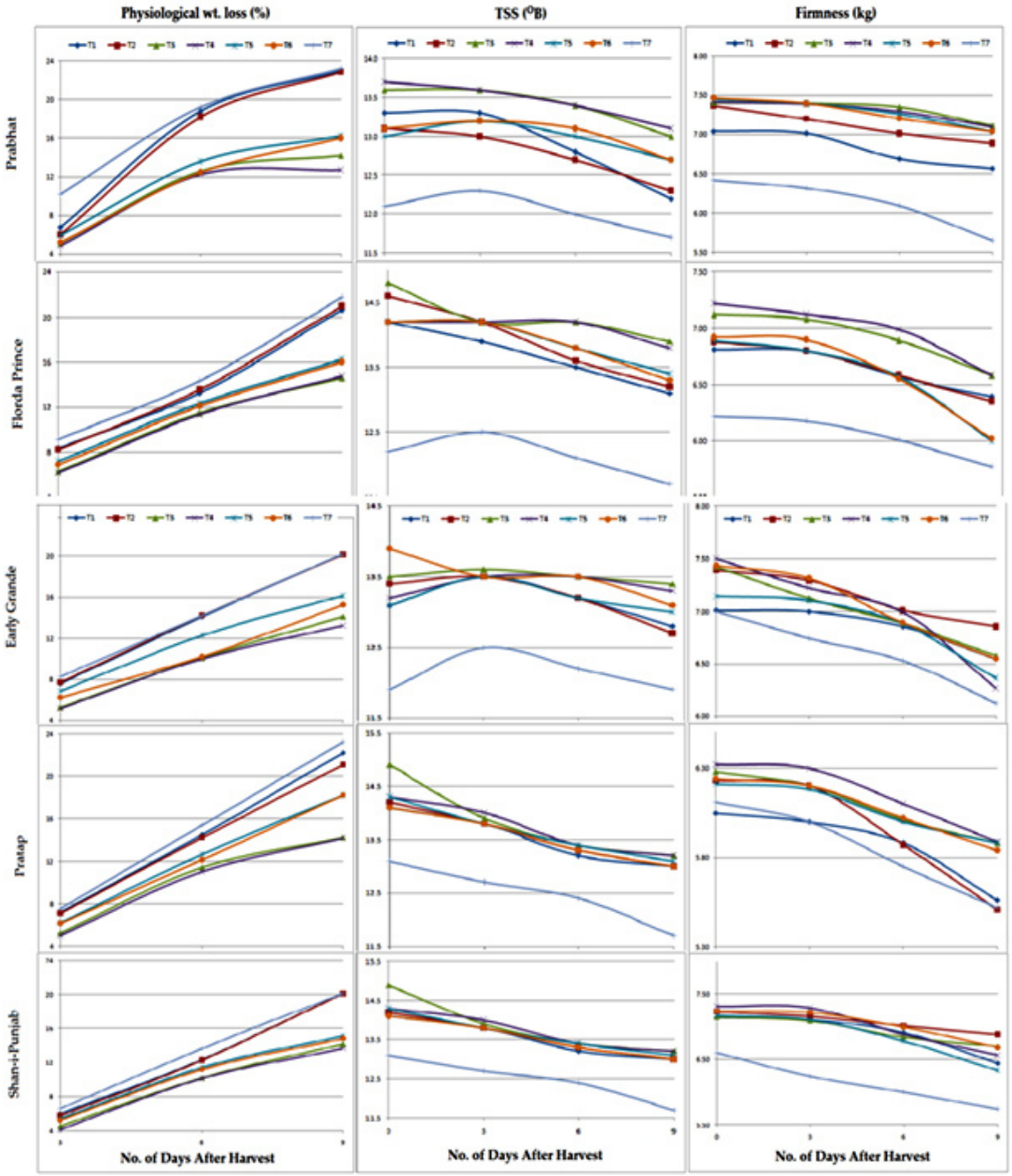

Fig. 1: Effect pf pre-harvest GA_3 and Calcium Sprays on physiological wt. loss, TSS and firmness of different peach cultivators during post-harvest shelf life

After harvest, the fruit weight loss percent and the corresponding changes in TSS and fruit firmness has been presented in the Fig 1 (a and b). With the increase in time after harvest there has been observed steady gain in weight loss percent of different peach cultivars studied. The loss observed under the control has been found to be considerably high than that observed under the different treatments applied. The slope of the curves of different treatments indicates that the rate of physiological weight loss was higher during first three days of observation and lower during the subsequent period of observation. In all most all the varieties studied the physiological weight loss of the fruits treated with GA_3 weather 10 or 20 ppm was not statistically lower than the untreated control though the loss observed with different calcium treatments was considerably lower than control and GA_3 treatments. T4 i.e.foliar application on of calcium nitrate 2% resulted into lowest phsysiological fruit weight percent in all the cultivars but statistically it has been found to be at par with 1% dose of this chemical. In some cases it was also at par with 2% calcium chloride treatment. Overall it has been inferred that T4 i.e. foliar application of 1% calcium nitrate resulted into best reduction in phsysiological weight loss percent of the fruits of different peach varieties. In all the varieties studied except Prabhat there has been observed slight increase in the total soluble solids content upto 3 days after harvest in case of untreated control but incase of treated fruits there was not observed such type of rise in TSS after harvest, thereafter there has been recorded sharp decline in the TSS of all the varieties studied. This indicates that GA_3 and calcium treatments have supressed the after harvest climacteric rise and resulted into controled ripening process with decreased rate of TSS decline. In case of peaches this view has also been supported by a number of workers worldwide[4,13,16]. Thomas *et al.,*[24] noticed that gibberellins induce hydrolytic cell wall enzymes and enhance polysaccharide solubilization, favoring cell expansion. GA_3 can also regulate genes involved in its own biosynthetic pathway or play a role in the protection of the endo-membrane system, and cell wall loosening[14]. In other cases, GA_3 delays the onset of climacteric respiration[2] and ripening cycle[9]. Similar influence of calcium has also been demonstrated by[17,3,23].

Conclusion

Fruit physico-chemical characteristics viz. TSS, acidity and firmness have been found to be influenced greatly by the pre-harvest sprays of GA_3 and calcium. The rate of physiological weight loss and deterioration of other fruit characteristics like TSS and firmness was also reduced significantly by these treatments. The post harvest deterioration of fruit quality as found to be less in calcium treated samples than gibberellic acid treated ones. Overall effect of 1% calcium nitrate foliar spray one week prior to expected physiological maturity has been found to be best treatment for maintaining fruit quality attributes and making long distance transportation of peaches, possible. Further, research on the impact of this treatment on nutritional status of the fruits may further strengthen the findings.

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