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Effect of paclobutrazol on fruit quality and yield in peach cv. July Elberta under high density planting systems

N.D. Negi and N. Sharma*
CSK Himachal Pradesh Krishi Vishvavidyalaya
Mountain Agricultural Resaerch and Extension Centre, Sangla,. Kinnaur-172 106, India.

Abstract

Paclobutrazol applied at 2000 ppm as foliar spray and at 2.0 ga.i. tree^{-1} as trunk soil line pour method (TSLP) to high density plantings of peach increased fruit yield, fruit size and weight and improved fruit quality during the year of its application and in the following year. Among the different planting systems, the square system of planting at 2x2m spacing registered higher yield per tree with better quality fruits. However, by further increasing the tree density, yield efficiency though increased, but the production of marketable fruits decreased. Therefore, it can be inferred that applications of paclobutrazol at 2000 ppm as foliar spray or at 2.0 g a.i. tree^{-1} as TSLP to the trees under the square system of planting (2x2m) can maintain the tree growth at desired space and optimize the production with good quality fruits.

Key words: Palcobutrazol, fruit quality, peach yield.

Introduction

Peach is an important stone fruit being grown in the mid hills of Himachal Pradesh. The main centre of peach production is confined to Rajgarh valley of district Sirmaor, because of highly congenial climatic conditions for its successful cultivation. A large number of peach cultivars are being grown in the state and out of these, July Elberta alone accounts for 75 per cent of total production as its fruits get premium price in the market. The total production of peaches in the country is about 1, 59,640 MT from an approximately area of 19,510 ha (F.A.O., 2005). In Himachal Pradesh, peaches occupy an area of about 5134 ha, which is scattered all over the state except Lahaul & Spiti, Kinnaur and Pangi or Bharmaur area of Chamba district, with an annual production of 9224 MT (Anonymous, 2008). Thus, the productivity of peach in the state is just over 1.5 MT/hectare in comparison to 145 MT per hectare elsewhere, under intensive cultivation (Ende and Chalmer, 1982).

High density planting system in apple has gained popularity in various developed countries but in India till date traditional system of planting is still practiced. In Himachal Pradesh, the high density orchards of apple and other fruits (peach and apricots) are not so common, but the initial results obtained are encouraging. Such trees under high density plantings have potential for early cropping with higher yields and more economic return per unit area (Loreti *et al.* 1993). Moreover, with the increasing pressure on land and reduction in average land holding, there has been a great scope to change over to more efficient system of planting and canopy management. Due to the non availability of size controlling rootstocks, the peaches when grown under high density planting system on seedling rootstocks have shown a tendency for excessive vegetative growth. The plant growth inhibitors can be used in such orchards to keep the trees within a limited space. Paclobutrazol is a potential growth retardant from triazole group, which can also improve fruit quality (Fletcher *et al.* 2000). Therefore, this study was carried out to see the effect of paclobutrazol application on fruit yield and quality of peach cultivar July elberta under different planting densities.

Material and Methods

This study was carried out in the Experimental Orchard of pomology Dpartment, Dr YS Parmar University of Horticulture and Furestry, Nauni, Solan in the years 2004 and 2005. The trees were planted at four planting distances (2x2m, 2.25x1m, 2x1.5m and 2x1m) accommodating 2500, 4444, 3333 and 5000 trees per hectare, respectively.

Foliar application

The paclobutrazol (2RS+ 3RS)-1-(4-chlorophenyl-4, 4-dimethyl-2- (1,2,4-triazol-1-yl) solutions were prepared by diluting the appropriate quantities of the commercial formulation, Cultar (Syngenta Crop production Ltd.) in water for foliar application at 500 ppm, 1000 ppm and 2000 ppm, respectively (T_1, T_2 and T_3). In order to decrease

* Department of Fruit Science, Dr YS Parmar University of Horticulture & Forestry, Nauni, Solan, HP-173 230.

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the surface tension of droplets and to facilitate absorption, 0.1 % Teepol was added in the solution prior to spray. The spray solutions were applied to the aerial parts of the trees to run off with the help of foot sprayer. The spraying operation was performed during the morning hours on a clear and calm day.

Trunk Soil line Pour (TSLP)

The quantities of 4 ml (1 g a.i.) and 8 ml (2g a.i.) of cultar were diluted separately in one liter of water (T_4 and T_5), which were applied in the respective treatments to the soil around the tree trunk at a depth of 15 cm.

Trunk Paste (TP)

The trunks of trees were wetted with water and then painted with Cultar 2 ml (0.5g a.i. tree^{-1}) and 4ml (1.0 g a.i. tree^{-1}) per 500 ml of water under respective treatments (T_6 and T_7) without using any carrier material, with the help of a brush. The application area was extended from approximately 6 inches down the trunk to about 6 inches above the ground. The painted area was immediately wrapped with polythene to keep it moist for a period long enough to permit absorption of the chemical by the trunk bark. No treatment was given to control trees (T_8). These treatments were given during the year 2004 and not repeated in the following year (2005), instead their residual effects were studied.

Foliar spray was given at full bloom and TSLP and TP were applied before bud break. The treatments were replicated thrice and the experiment was laid on randomized block design (factorial).

The fruit firmness was determined by a pressure tester (Effegi Penetrometer-FT 327), which recorded the pressure necessary for the plunger to penetrate the peeled flesh of the fruit. The result was expressed in Newton (N).

Where;

Newton (N) = force in kg x 9.807

The total soluble solids in fruits were determined with Erma hand refractometer (0-32^0 Brix) by putting a few drops of fruit juice on its prism. Before use, it was calibrated with distilled water. The total soluble solids were expressed as percentage of fresh juice. The sugars and titratable acid content in the fruit was estimated as per procedure given in AOAC (1980) and expressed in percentage.

Results and Discussion

Fruit weight and size

The fruit weight, volume and size were significantly influenced by all the treatments of paclobutrazol during the year of application and in following year the residual effect paclobutrazol in affecting these parameters was still persistent, particularly at higher rates of application (Figures 1&2). Paclobutrazol applied at 2000 ppm as foliar spray produced heavier fruits in 2004, whereas in the year 2005, the trees under the soil applied paclobutrazol treatments produced heavier fruits, however, the trees given no paclobutrazol treatment produced smallest fruits, in both the years. Fruit quality is basically a function of light distribution within the canopy (Kom, 1990). Paclobutrazol treatments reduced shoot growth and improved light distribution and photosynthesis within the canopy (Negi, 2007) and thus translocation of more assimilates towards developing fruits as a result of their reduced competition with shoots having retarded rate of growth seems to have increased fruit size and weight in PP_{333} treated trees, in this study.

The planting systems also significantly influenced the physical parameters of fruits such as fruit size, weight and volume, during both the years of investigation. The fruits produced on the trees planted in square system were larger and heavier than those on trees planted in other systems, whereas fruits on the trees planted in single hedgerows were smallest in size. In this study, increased rate of photosynthesis in trees planted in square system as compared with those under other planting systems (data not given); explain for the increase in fruit size on these trees. Larger size of fruits on the trees planted in square system may be attributed to lower flower intensity (data not presented) and consequently the lower fruit density and higher leaf/ fruit ratio, which might have increased the carbohydrates and nutrients supply to the developing fruits in these plantations.

Fruit firmness

During the course of investigation, it was observed that paclobutrazol treatments and planting systems significantly influenced the fruit firmness (Figures 3 &4). The fruits on trees given paclobutrazol application as foliar sprays at 1000 or 2000 ppm had significantly increased flesh firmness in 2004, however, in the following year; the residual effects of paclobutrazol irrespective of method of application were significant at higher

concentrations. Paclobutrazol helped to increase Ca accumulation in fruits (Bhardwaj, 2005), which is essential to maintain structural integrity of membrane and cell wall, and as such might have maintained the fruit firmness even at maturity and ripening stages.

The planting systems also significantly influenced the flesh firmness of fruits. The trees planted in higher density (cluster & single hedgerow) produced fruits with more flesh firmness, however, as the planting density decreased, the firmness also decreased considerably. In this study, the fruits in these plantations were smaller in size. The flesh firmness is related to fruit size, as the size decreases the flesh firmness often increases, possibly as a concentrating effect of calcium in smaller fruits.

Total soluble solids, sugars and titratable acidity

The total soluble solids, sugars content of fruits remained unaffected with the application of paclobutrazol. However, the titratable acidity increased significantly by different treatments of paclobutrazol during both the years of study (Figures 5 to 10). As per earlier reports, the effect of paclobutrazol on fruit quality in peaches is inconsistent. Xu and Cao (1987) reported that paclobutrazol had no effect on fruit quality in peach; however, some reports suggest that its application improved the fruit quality in plum (Lurie *et al.*, 1987) and peaches (Li *et al.*, 1989).

The planting systems however, significantly influenced these parameters of fruits. The fruit TSS contents were highest (9.99 % and 10.02 % during 2004 and 2005, respectively) in trees planted in square system, which were however, statistically at par with the treatments of cluster and paired row systems. Fruits from trees under single hedgerow planting had significantly lowest acid contents than other planting systems during both the years. The maximum total sugar content (7.24% in 2004 and 7.26 % in 2005) was recorded in trees raised in square system of planting which was significantly higher than other planting system except paired row system in 2004. The minimum total sugar content of fruit (6.67 % and 6.79 % in 2004 and 2005, respectively) was observed in trees planted in single hedgerows. The titratable acidity in fruits was significantly higher in square and paired systems than the trees planted in cluster and single hedgerow systems. These results can be explained on the basis of higher rates of photosynthesis in trees planted in lower density, resulting in more synthesis of carbohydrates and possibly their enhanced translocation to the storage organs like fruits in these plantations.

Yield and yield efficiency

The fruit yield (kg tree^{-1}) was more in the trees under different paclobutrazol treatments in both the years (Table 1). The maximum fruit yield (5.09 kg tree^{-1}) was observed under the treatment of PP_{333} at 2000 ppm when applied as foliar spray, during 2004 and subsequently in 2005. The increase in these production parameters was greater in those trees, which were treated with PP_{333} at 2.0 g a.i. tree^{-1} in the previous year. This increase might be due to increased fruit retention (data not presented) and fruit weight (Fig. 1 & 2) under different paclobutrazol treatments. The increase in fruit yield following the application of paclobutrazol has also been reported earlier by different workers (Stan *et al.*, 1989; Chen *et al.*, 1997 and Eliwa and Ashour, 2004). Similarly, the productivity in terms of MT/ha was also higher in trees given PP_{333} treatments as compared to untreated control trees. The maximum yield efficiency in terms of MT/ha (19.36 and 20.22 MT) was observed in trees treated with PP_{333} at 2000 ppm as foliar spray and at 2.0 g a.i./tree as TSLP method in the years 2004 and 2005, respectively.

Different planting systems also significantly influenced fruit yield and productivity (Tables 1 & 2). The maximum fruit yield (kg tree^{-1}) was recorded in trees under square system, having the lowest planting density and the yield deceased linearly with the increase in planting density and thus it was recorded minimum in trees planted under single hedgerow system having the highest tree density (Table 1). However, the yield efficiency when worked out on hectare basis, the trend was just reverse. It was recorded maximum in single hedgerow system and minimum in square system, in both the years of investigation. Similar results were also reported by Szewczuk and Licznar (2004), who observed higher yield efficiency on per hectare basis when peach trees were planted at higher density.

Table 1. Effect of paclobutrazol and planting systems on fruit yield (kg/tree) in peach cv. July Elberta

Treatment \ Planting system (No. of trees/ha)	2004 Square (2500) **	Cluster (4444)	Paired (3333)	SHR* (5000)	Mean	2005 Square (2500)	Cluster (4444)	Paired (3333)	SHR* (5000)	Mean
T_1: PP_{333} 500 ppm	5.56	4.37	5.11	4.11	4.78	5.65	4.45	5.16	4.16	4.85
T_2: PP_{333} 1000 ppm	5.80	4.60	5.39	4.33	5.09	5.78	4.51	5.35	4.23	4.97
T_3: PP_{333} 2000 ppm	5.97	4.75	5.67	4.53	5.23	5.90	4.72	5.52	4.30	5.11
T_4: PP_{333} 1.0 g a.i., TSLP	5.63	4.45	5.23	4.17	4.87	6.10	4.88	5.65	4.44	5.26
T_5: PP_{333} 2.0 g a.i., TSLP	5.78	4.55	5.37	4.19	4.97	6.22	5.02	5.92	4.66	5.45
T_6: PP_{333} 0.5 g a.i., TP	5.46	4.32	5.10	4.07	4.73	5.5	4.36	5.37	4.10	4.84
T_7: PP_{333} 1.0 g a.i., TP	5.54	4.47	5.20	4.13	4.83	5.64	4.52	5.25	4.16	4.89
T_8: Control	5.42	4.11	4.99	4.00	4.63	5.44	4.14	5.02	4.04	4.66
Mean	5.65	4.46	5.28	4.19		5.78	4.57	5.40	4.26	

CD (P=0.05)
a. Treatment (T) 0.23 0.21 b. Planting System (S) 0.18 0.15 c. TxS 0.52 NS

Table 2. Effect of paclobutrazol and planting systems on yield efficiency (MT/ha) in peach cv. July Elberta

Treatment \ Planting system (No. of trees/ha)	2004 Square (2500) **	Cluster (4444)	Paired (3333)	SHR* (5000)	Mean	2005 Square (2500)	Cluster (4444)	Paired (3333)	SHR* (5000)	Mean
T_1: PP_{333} 500 ppm	13.90	19.40	17.03	20.57	17.72	14.13	19.80	17.20	20.82	17.98
T_2: PP_{333} 1000 ppm	14.50	20.44	17.96	21.65	18.63	14.46	20.06	17.85	20.83	18.30
T_3: PP_{333} 2000 ppm	14.91	21.01	18.89	22.65	19.36	14.76	20.96	18.39	21.52	18.90
T_4: PP_{333} 1.0 g a.i., TSLP	14.07	19.77	17.43	20.85	18.03	15.25	21.70	18.83	22.18	19.49
T_5: PP_{333} 2.0 g a.i., TSLP	14.45	20.22	17.89	20.95	18.37	15.54	22.32	19.73	23.30	20.22
T_6: PP_{333} 0.5 g a.i., TP	13.66	19.18	16.99	20.37	17.55	13.80	19.39	17.92	20.52	17.90
T_7: PP_{333} 1.0 g a.i., TP	13.86	19.88	17.33	20.65	17.93	14.11	20.10	17.49	20.82	18.13
T_8: Control	13.55	18.26	16.65	20.02	17.12	13.61	18.43	16.73	20.22	17.38
Mean	14.11	19.77	17.52	20.96		14.45	20.34	15.75	21.27	

*SHR; Single hedgerow
**Number of trees/ha.
CD (P=0.05)
a. Treatment (T) 0.35 0.26 b. Planting System (S) 0.24 0.18 c. TxS 1.86 0.52

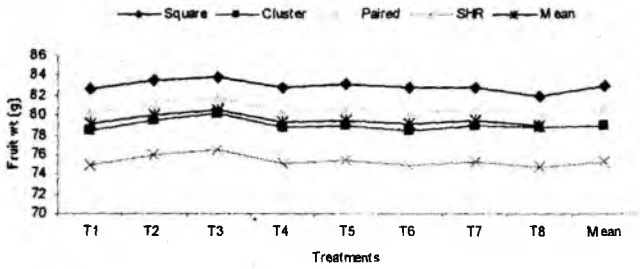


Figure 1: Effect of paclobutrazol and planting systems on fruit weight (g) of peach cv. July Elberta (2004).

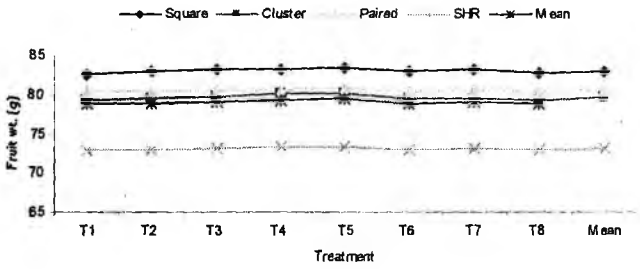


Figure 2: Effect of paclobutrazol and planting systems on fruit weight (g) of peach cv. July Elberta (2005).

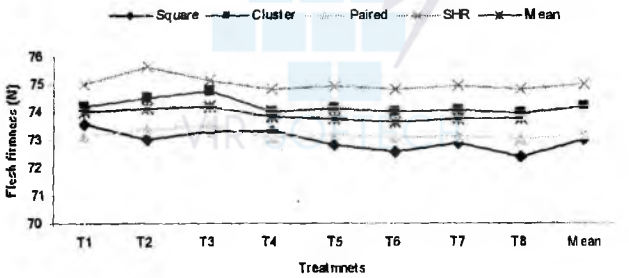


Figure 3: Effect of paclobutrazol and planting systems on flesh firmness of peach fruit (N) cv. July Elberta (2004).

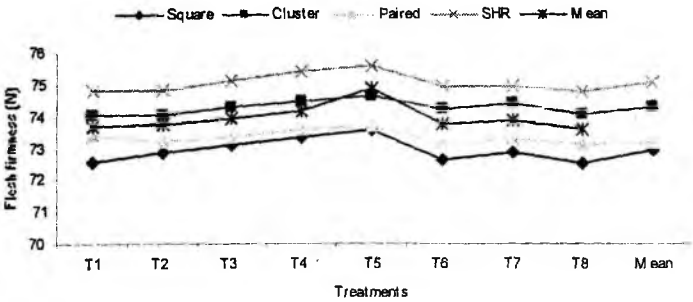


Figure 4: Effect of paclobutrazol and planting systems on flesh firmness of peach fruit (N) cv. July Elberta (2005).

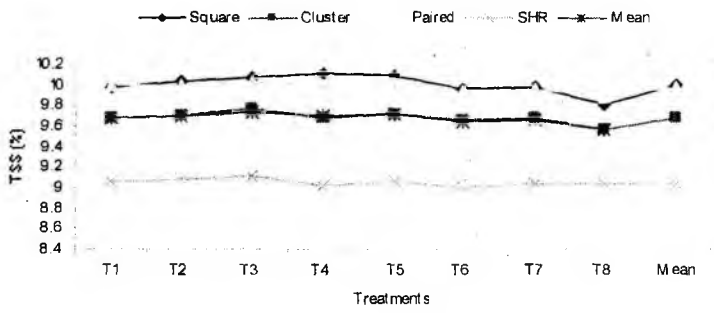


Figure 5: Effect of paclobutrazol and planting systems on total soluble solid (%) of peach fruit cv. July Elberta (2004).

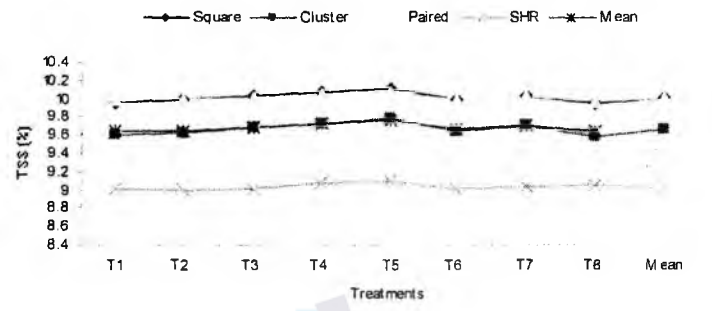


Figure 6: Effect of paclobutrazol and planting systems on total soluble solid (%) of peach fruit cv. July Elberta (2005).

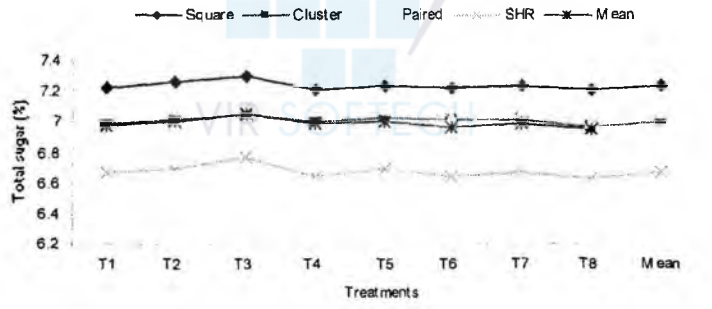


Figure 7: Effect of paclobutrazol and planting systems on total sugar (%) of peach fruit cv. July Elberta (2004).

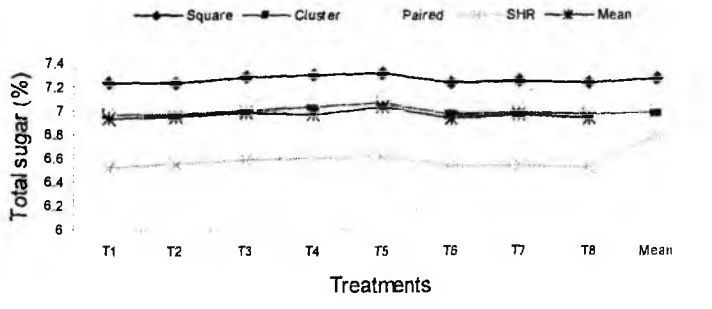


Figure 8: Effect of paclobutrazol and planting systems on total sugar (%) of peach fruit cv. July Elberta (2005).

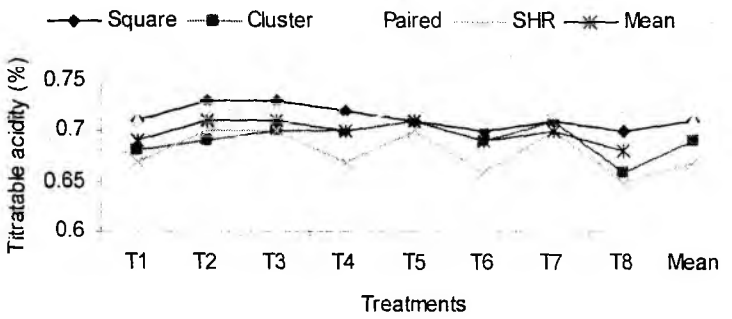


Figure 9: Effect of paclobutrazol and planting systems on titratable acidity (%) of peach fruit cv. July Elberta (2004).

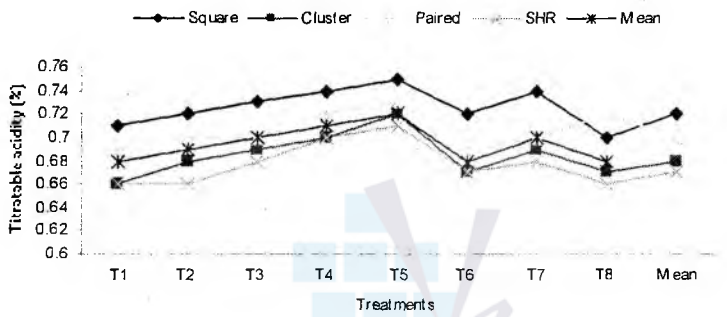


Figure 10: Effect of paclobutrazol and planting systems on titratable acidity (%) of peach fruit cv. July Elberta (2005).

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