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Short communication

Effect of paclobutrazol treatments and planting density on photosynthetic efficiency and fruit production in peach cv. July Elberta

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The peach [*Prunus persica* (L.) Batch] is an important stone fruit with attractive appearance, delicious taste and nutritive values. In Himachal Pradesh, peaches occupy an area of about 6,000 ha, which is scattered all over the state except the dry and cold regions of Lahaul & Spiti, Kinnaur and Pangi or Bharmour areas of Chamba district, with an annual production of 8,004 MT (Anon, 1). However, these are commercially being grown under traditional low planting densities in India and as such are less productive and give low return per unit area. 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.

The control of tree size in peaches becomes a major problem when they are raised on seedling rootstock under high density orchard system, due to the non-availability of dwarfing rootstocks (Stan *et al*., 7). Therefore, this study was carried out see the effect of PP_{333}, a potential growth retardant (Fletcher *et al*., 2) and different systems of planting on photosynthetic activities and production of peaches.

The present study was carried out on 14-year-old July Elberta peach trees established on wild peach seedling rootstocks in four different planting systems, *viz*., square (2 m × 2 m), cluster (2.25 m × 1 m), paired row (2 m × 1.5 m) and single hedge row (2 m × 1 m) in the Departmental Orchard of Fruit Science, Univeristy of Horticulture and Forestry, Solan. For this study, 96 uniform trees (24 from each system) were selectd on the basis of their uniform growth and were given different treatments of paclobutrazol applied as foliar sprays at 500, 1000 and 2000 ppm at full bloom and as trunk soil line pour (TSLP) at 1.0 and 2.0 g a.i. tree^{-1} and trunk paste (TP) method at 0.5 and 1.0 g a.i. tree^{-1} before break. The treatments were replicated thrice and the experiment was laid down in randomized block design (RBD). These treatments were given during the first year and not repeated in following year, instead their residual effects were studied.

The leaf chlorophyll content was estimated by DMSO method as described by Hiscox and Isralistan (3). Rate of photosynthesis, stomatal conductance and internal CO_2 concentration were recorded with the help of LiCor-6200 portable photosynthesis system, when leaves were fully mature (last week of June). All these parameters were taken between 9:00 to 11:00 AM.

Paclobutrazol treatments and planting densities had a significant effect on leaf chlorophyll synthesis during the year of application and also in the following year. The maximum leaf chlorophyll content was recorded in the trees treated with PP_{333} at 2000 ppm as foliar spray, which was significantly higher than all other treatments. In the second year 2005, the carryover effect of different paclobutrazol treatments applied in 2004 was significant on leaf chlorophyll content, which was recorded significantly higher in trees treated with PP_{333} at 2.0 g a.i. tree^{-1} as TSLP, than the trees under other treatments. The increase in leaf chlorophyll content of paclobutrazol treated trees might either be due to the enhanced synthesis of chlorophyll or reduced catabolism (Fletcher *et al*., 2). Increased leaf chlorophyll content with application of paclobutrazol has also been reported earlier (Sharma and Joolka, 6) in different fruit crops. The planting systems also influenced the chlorophyll content of leaves, during both years of study. The trees planted in square system had maximum leaf chlorophyll content and minimum content of chlorophyll was observed in trees planted as single hedgerow. The higher planting density might have impaired the radiation regime in the tree canopy which lowered the synthesis of chlorophyll (Rana *et al*., 5).

Higher photosynthetic rate, stomatal conductance and internal CO_2 concentration were also significantly influenced with the paclobutrazol applications. The higher stomatal density (data not given) accompanied by stomatal conductance might have increased CO_2 fixation (Steffens and Zimmerman, 8) and increased photosynthesis, in PP_{333} treated trees. Planting systems also influenced the photosynthetic activities of the trees. The highest photosynthetic rate was observed in trees raised in square system and lowest in those established in single hedgerows. Similarly, the stomatal conductance and leaf internal CO_2 concentration were also recorded highest in trees

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Table 1. Effect of paclobutrazol and planting systems on leaf chlorophyll content (mg/g) in peach.

Treatment / Planting system (No. of trees/ha)	Mean of two years			
	Square (2,500)	Cluster (4,444)	Paired (3,333)	SHR* (5,000)
T_1 : PP_{333} 500 ppm	3.42	3.22	3.30	3.12
T_2 : PP_{333} 1000 ppm	3.46	3.27	3.38	3.17
T_3 : PP_{333} 2000 ppm	3.05	3.35	3.43	3.23
T_4 : PP_{333} 1.0 g a.i., TSLP	3.46	3.26	3.35	3.17
T_5 : PP_{333} 2 g.0 a.i., TSLP	3.52	3.30	3.40	3.22
T_6 : PP_{333} 0.5 g a.i., TP	3.46	3.25	3.34	3.16
T_7 : PP_{333} 1.0 g a.i., TP	3.43	3.27	3.37	3.19
T_8 : Control	3.39	3.19	3.27	3.10

*SHR : Single hedgerow

Table 2. Effect of paclobutrazol and planting systems on photosynthetic rate (μmole $m^{-2}s^{-1}$) in peach.

Treatment / Planting system (No. of trees/ha)	Mean of two years			
	Square (2,500)	Cluster (4,444)	Paired (3,333)	SHR* (5,000)
T_1 : PP_{333} 500 ppm	9.52	7.69	8.34	7.07
T_2 : PP_{333} 1000 ppm	9.56	7.74	8.40	7.12
T_3 : PP_{333} 2000 ppm	9.62	7.79	8.43	7.17
T_4 : PP_{333} 1.0 g a.i., TSLP	9.58	7.77	8.40	7.13
T_5 : PP_{333} 2 g.0 a.i., TSLP	9.61	7.79	8.43	7.16
T_6 : PP_{333} 0.5 g a.i., TP	9.54	7.72	8.36	7.09
T_7 : PP_{333} 1.0 g a.i., TP	9.56	7.74	8.39	7.12
T_8 : Control	9.49	7.67	8.31	7.04

*SHR : Single hedgerow

Table 3. Effect of paclobutrazol and planting systems on leaf stomatal conductance (mole $m^{-2}s^{-1}$) in peach.

Treatment / Planting system (No. of trees/ha)	Mean of two years			
	Square (2,500)	Cluster (4,444)	Paired (3,333)	SHR* (5,000)
T_1 : PP_{333} 500 ppm	0.65	0.54	0.59	0.50
T_2 : PP_{333} 1000 ppm	0.69	0.59	0.62	0.54
T_3 : PP_{333} 2000 ppm	0.72	0.65	0.69	0.59
T_4 : PP_{333} 1.0 g a.i., TSLP	0.69	0.62	0.66	0.56
T_5 : PP_{333} 2.0 g a.i., TSLP	0.73	0.64	0.69	0.56
T_6 : PP_{333} 0.5 g a.i., TP	0.69	0.57	0.62	0.51
T_7 : PP_{333} 1.0 g a.i., TP	0.70	0.60	0.64	0.54
T_8 : Control	0.54	0.52	0.57	0.46

*SHR : Single hedgerow

Table 4. Effect of paclobutrazol and planting systems on internal CO_2 level (ppm) in peach.

Treatment / Planting system (No. of trees/ha)	Mean of two years			
	Square (2,500)	Cluster (4,444)	Paired (3,333)	SHR* (5,000)
T_1 : PP_{333} 500 ppm	283.4	257.5	272.0	253.1
T_2 : PP_{333} 1000 ppm	288.4	263.0	276.6	239.7
T_3 : PP_{333} 2000 ppm	293.3	267.8	281.4	244.5
T_4 : PP_{333} 1.0 g a.i., TSLP	290.9	265.3	279.0	242.3
T_5 : PP_{333} 2.0 g a.i., TSLP	293.5	267.1	281.1	244.0
T_6 : PP_{333} 0.5 g a.i., TP	285.6	260.5	274.0	237.1
T_7 : PP_{333} 1.0 g a.i., TP	288.2	263.0	276.4	239.9
T_8 : Control	280.7	255.3	269.0	232.5

*SHR : Single hedgerow

planted in square system, when compared with those planted in paired, cluster and single hedgerow systems. The photosynthetic activities are the function of light and in the present investigation the photosynthetic activities might have decreased with the increase tree density as a result of impaired radiation regime in the crown of densely planted trees. Testolin and Costa (10) also reported that mature leaves of peach when subjected to better light exposure showed enhanced photosynthetic activities.

The fruit yield (kg/tree) was significantly high on trees treated with paclobutrazol (Table 5). The highest production of fruit was recorded on trees given foliar sprays of PP_{333} at 2000 ppm and in the following year it was highest on trees given PP_{333} at 2.0 g a.i. tree^{-1}. The increase in fruit set and fruit retention (data not presented) by the PP_{333} treatment explains the high yield on treated trees. The increase in fruit yield by the PP_{333} application has also been reported earlier by Stan *et al.* (7) in peach. The planting systems also exerted the significant influence on fruit yield (5.75 & 5.78 kg tree^{-1}, respectively) was recorded in trees under square system, having the lowest planting density and the yield decreased 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 5). On the contrary, the yield efficiency (Table 6) increased with the increase in planting density and thus recorded highest in hedgerow plantation (20.96 & 21.27 t ha^{-1}, respectively). The present findings are in line with those of Loreti *et al.* (4), who observed that the yield per tree was positively related to the planting distance in peach. The results are also in congruence with the findings of Szewdzuk and Licznar (9), who observed higher yield efficiency on per hectare basis when peach trees were planted at higher density.

Thus it may be concluded from present findings that paclobutrazol applied at 2000 ppm as foliar application and at 2.0 g a.i. as TSLP methods increased photosynthetic efficiency and fruit yield in peach with planting distance of 2 m × 2 m, but further increasing the planting density caused reduction in production of fruits as well as the photosynthetic efficiency.

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Table 5. Effect of paclobutrazol and planting systems on fruit yield (kg/tree) in peach cv. July Elberta.

Treatment / Planting system (No. of trees/ha)	1st year					2nd year				
	Square (2,500)	Cluster (4,444)	Paired (3,333)	SHR* (5,000)	Mean	Square (2,500)	Cluster (4,444)	Paired (3,333)	SHR* (5,000)	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	

*SHR : Single hedgerow

$CD_{0.05}$	1st year	2nd year
a) Treatment (T)	0.23	0.21
b) Planting System (S)	0.18	0.15
c) T × S	0.52	NS

Table 6. Effect of paclobutrazol and planting systems on yield efficiency (MT/ha) in peach cv. July Elberta.

Treatment / Planting system (No. of trees/ha)	1st year					2nd year				
	Square (2,500)	Cluster (4,444)	Paired (3,333)	SHR* (5,000)	Mean	Square (2,500)	Cluster (4,444)	Paired (3,333)	SHR* (5,000)	Mean
T_1 : PP_{333} 500ppm	13.90	19.40	17.03	20.57	17.72	14.13	19.80	17.20	20.82	17.98
T_2 : PP_{333} 1000ppm	14.50	20.44	17.96	21.65	18.63	14.46	20.06	17.85	20.83	18.30
T_3 : PP_{333} 2000ppm	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	

Values in parenthesis are number of plants per hectare

$CD_{0.05}$	1st year	2nd year
a) Treatment (T)	0.35	0.26
b) Planting System (S)	0.24	0.18
c) T × S	1.86	0.52

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