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Effect of thinning time and fruit spacing on fruit maturity, yield, size, peel colour and quality attributes of peach cv. Flordasun

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ABSTRACT

In present study 12-year-old Flordasun peach trees were manual thinned at 10, 15 and 20 cm spacings along the shoot on whole tree canopy at an interval of 0, 10, 20, 30 and 40 days after full bloom (DAFB) to know the effect of thinning time and fruit spacing on fruit maturity, yield, fruit size, peel colour and quality attributes over two growing seasons. Earliest fruit maturity was recorded in thinning at 20 DAFB (67 days) compared to control (77 days) and linear increase in fruit spacing recorded delay in days to fruit maturity. The thinning treatments decreased the yield significantly, while and least reduction was attributed at 20 DAFB (28.82 kg/tree). The fruits thinned at 20 DAFB and spaced at 20 cm recorded enhanced fruit weight (58.09 g), fruit length and diameter (4.79 and 4.56 cm) followed by 30 DAFB with spaced at 20 cm. The fruit skin colour (*L, *a** and *b**) value, improved in different thinning treatments, however, fruit thinned at 20 DAFB and spaced at 20 cm followed by 15 cm were found more effective. In fruit quality, highest TSS (12.10°B); TSS: acid ratio (20.17), ascorbic acid 6.52 mg/100 g) and lowest titratable acidity (0.60%) were recorded in fruits thinned at 20 DAFS and spaced at 20 cm followed by 15 cm with maximum total sugars (6.22%) content. The best results were dedicated to thinning of Flordasun peach at 20 DAFB with fruits spaced 20 to 15 cm apart.**

Key words: Fruit size, fruit quality, peach, thinning time, maturity.

INTRODUCTION

In India, low chilling peaches (*Prunus persica* L. Batsch.) are grown in sub-mountainous region of the Himalayas extend up to the north eastern region of India at an altitude of 1,000-2,000 m. Among them cultivars, *viz*., Flordasun and Partap are found suitable for commercial production under mid-hill of NE India (Babu *et al*., 1). Generally, peaches produce a large number of fruits and thinning is required to set an acceptable yield and maximum returns (Southwick and Glozer, 14). The fruit thinning in stage-I (early fruit development period) stimulates cell division and expansion, produced larger fruit size. Another advantage could be early ripening of fruits, however, blossom thinning reduces both fruit set and yield (Greene *et al*., 6).

Profuse bearing in cv. Flordasun was observed, which resulted in to excessive crop load of undersized fruits with impaired fruit quality and limb breakage. Further ripening of this cultivar coincided with rains in late April hampering fruit quality and marketability under humid tropical climate of NE India. Fruit thinning by hand improved the fruit size and advanced its maturity (Chanana *et al*., 3). However, intensity and fruit load must be well adapted for balanced fruit production (Bussi *et al*., 2). Distance between fruits and thinning time has been reported to have positive effect on fruit size and quality (Drogoudi *et al*., 5) of peaches, however its response is closely related to thinning intensity, cultivar and tree size (Jimenez and Royo Diaz, 7); climatic conditions and cultural practices *etc*. (Da Silva Linge *et al*., 4). Even though response of thinning was studied in past, the information is lacking on low chilling peach cv. Flordasun grown in north east India. Thus, the present study was undertaken.

MATERIALS AND METHODS

Experiment was carried out during two successive seasons of 2014 and 2015 on 12-year-old trees of peach cv. Flordasun planted at a spacing of 4.5 m × 4.5 m and trained to open centre system at Horticultural Research Farm, ICAR Research Complex for NEH Region, Umiam, Meghalaya. The experimental site is situated at an elevation of 1010 m and lies between 25°40' to 25°21'N latitude and 90°55'15 to 91°55'16 E longitude. The mean rainfall, mean maximum and minimum temperature recorded during 2014 was 2217 mm, 30.1° and 6.5°C and during 2015 were 2551 mm, 29.01° and 5.1°C, respectively. Three trees were selected for their uniformity in shape and vigour under one treatment and replicated thrice and given uniform cultural practices during study. The experiment was randomized block design with a factorial arrangement

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consist of manual thinning of flowers/ fruitlets at 10, 15 and 20 cm on whole tree canopy at an interval of 0 days (when 80% of blossom opened), 10, 20, 30 and 40 days after full bloom (DAFB) and control (un-thinned).

Observations on days to fruit maturity and fruit yield were recorded. Fruit yield per tree was calculated by multiplying the number of fruits with mean fruit weight and expressed in kg/ tree. Physico-chemical parameters were recorded on the basis 10 fruits per replication. Fruits weight was recorded with the help of electronic pan balance. Fruit size (length and breadth) was measured with the help of digital Vernier calipers. Firmness of fresh five fruits was measured using a Stable Micro System TA-XT-plus texture analyzer (Texture Technologies Corp., UK) fitted with needle. The studies were conducted at a pre-test speed of 1 mm/s, test speed of 2 mm/ s, distance of 5 mm and load cell of 50 kg. The fruit peel colour was determined with Huntor colour values (L^*, a^* & b^*) by Hunter Lab (Colour Quest XE). Where L^* (lightness) varies from '0' (black) to 100 (pure white); a^* and b^* values represent the levels of tonality and saturation; with +a (indicating red); -*a* (indicating green); +b (indicating yellow) and -*b* (indicating blue) colours. Total soluble solids (TSS) of the fruits were recorded by using a digital refractometer and expressed in °Brix and TSS: acid ratio was work out. Titratable acidity (%), ascorbic acid (mg/100 g) and total sugars (%) were determined as per method suggested by Ranganna (10). The average data of two years were subjected to analysis of variance (ANOVA) using statistical software SPSS version 17.0 and differences were considered statistically significant at p= 0.05.

RESULTS AND DISCUSSION

Time of thinning altered days to fruit maturity (Table 1) when conducted at 20 DAFB (67 days), while maximum days to fruit maturity were recorded in control (77 days). Results related to fruit spacing was significant, the linear increased in fruit spacing from 10 cm (74 days) to 20 cm (69 days) recorded decrease in days to fruit maturity. However, interaction between thinning time and fruit spacing (T × S) was found non-significant. However, minimum days to fruit maturity were recorded in T3 × S3 (64 days), the faster accumulation of minerals and metabolites might help in early development of thinned fruits. These results are in line with Chanana *et al.* (3) who also reported that thinning advanced the fruit maturity in peaches. In present study, mean fruit yield of Flordasun peach (Table 1) was reduced significantly on all the considered thinning treatments compared with control. The least reduction was attributed to T3 (28.82 kg/tree) at par with T1 (28.46 kg/tree). While, highest fruit yield was recorded in T6 (38.66 kg/tree). In spacing effect fruit yield was decreased significantly with increasing fruit spacing. Interaction (T × S) showed that treatments T1 × S1 followed by T2 × S1 and T3 × S1 produced higher yield but significantly lower than control. In present study, the least reduction was credited to thinning done at 20 DAFB (T3). In similar findings, Jimenez and Royo Diaz (7) reported that thinning of peach fruit between bloom and 30 DAFB with four to five fruits per shoot had positive effect on fruit production. The highest fruit weight (Table 1) was recorded at T3 (55.02 g) followed by T4, while lowest in control (37.22 g). In comparison with spacing, the highest fruit weight was recorded

Table 1. Effect of thinning time and fruit spacing on days to fruit maturity, fruit yield and fruit weight in peach cv. Flordasun.

Thinning time (DAFB*) fruit spacing (cm)	Days to fruit maturity				Fruit yield (kg/ plant)				Fruit weight (g)			
	10	15	20	Mean (T)	10	15	20	Mean (T)	10	15	20	Mean (T)
T1 (0 DAFB)	74	75	71	73	32.89	27.88	24.61	28.46	37.37	39.00	46.67	41.01
T2 (10 DAFB)	72	72	69	71	31.12	26.18	22.92	26.74	45.02	53.72	51.73	50.16
T3 (20 DAFB)	70	68	64	67	31.10	29.00	26.37	28.82	51.73	55.23	58.09	55.02
T4 (30 DAFB)	75	70	68	71	30.00	26.92	22.14	26.35	52.13	53.03	56.14	53.77
T5 (40 DAFB)	73	71	67	70	24.80	20.14	17.69	20.88	44.23	47.02	49.10	46.78
T6 (unthinned)	78	76	77	77	38.64	39.00	38.34	38.66	37.68	38.00	37.22	37.55
Mean (S)	74	72	69		31.43	28.19	25.35		44.69	47.67	49.83	
LSD (P ≤ 0.05)												
Thinning time (T)		2.46				2.5				1.72		
Fruit spacing (S)		1.90				1.94				1.33		
T × S		NS				4.33				2.97		

*DAFB = days after full bloom; NS = non-significant

at 20 cm (49.83 g). The interaction results clarify that, heaviest fruit were produced in T3 × S3 (58.09 g) at par with T4 × S3 and T3 × S2. Fruit is the most important assimilate sink in the trees and increased in fruit weight in different treatments possibly due to increased supply of resources (carbohydrates) to individual fruits from source organs due to reduced crop load. Similar results were reported in other studies (Rathi *et al*., 11; Bussi *et al*., 2; Da Silva Linge *et al*., 4).

Fruit size is an important external quality attributes because it influences consumer acceptance and postharvest handling of fruits. The time of thinning and fruit spacing significantly improved the fruit size (Table 2). The greatest mean fruit length and diameter was recorded at T3 (4.66 and 4.44 cm), respectively, at par with T4 (4.56 and 4.42 cm), respectively. However lowest fruit length and diameter were observed in control (3.94 and 3.69 cm), respectively. Fruit size was found to be enlarged significantly with the increased in fruit spacing, the fruits spaced at 20 cm on whole tree canopy produced quite bigger fruit (4.49 and 4.25 cm), respectively. The interaction between T × S was found significant for fruit size. The maximum fruit length and diameter were (4.79 and 4.56 cm) were recorded in T3 × S3 (thinning at 20 DAFS and fruit spaced at 20 cm) followed by T4 × S3 and T3 × S2. However, significantly higher fruit firmness (Table 2) was recorded in control (2.66) compared with other treatments. With regards to the spacing, fruit firmness was decreased linearly with increased in fruit spacing and more firm fruits were noticed at 10 cm (2.29) spacing. In interaction, fruit firmness did not differ significantly between the treatments. In present study, the fruit size was increased linearly with increasing spacing, while fruit firmness reduced might be due to larger fruit size that in turn decreases the strength of cell wall and lesser cohesion between the cells. These results are in tune with Njoroge and Reighard (9) and Drogoudi *et al.* (5).

Fruits peel colour has been often associated with consumer preference (visual and eating quality) and sale of peaches (Table 3) determined with Hunter colour values, *viz.*, *L** (lightness), a^* (redness) and b^* (yellowness). The maximum lightness (56.10); redness (14.07) and yellowness (19.38) value of fruit peel was observed in T3, while lowest L^* (41.13), a^* (9.13) and b^* (14.51) values were recorded in control. The effect of spacing was significant and peel colour values were found to be rise with the increased in fruit spacing. The highest lightness (50.91); redness (13.14) and yellowness (17.05) values of fruit peel were observed at 20 cm spacing. Regarding the interaction, significant variations was notices for L^*, a^* and b^* value. The maximum L^* value (59.14) and a^* value (16.34) was noticed at T3 × S3 at par with T3 × S2 for L^* value and T5 × S3 for a^* value. While maximum b^* value (19.68) was recorded in T3 × S2 at par with T3 × S3. In present study, manual fruit thinning at 20 DAFS and fruit spaced at 15 to 20 cm registered higher fruit peel colour value might be due to enhanced photosynthetic efficiency and lessen the adverse effect on carbon partitioning by improved light interception through greater exposure within the canopy (Sansavini and Grappadelli, 12).

Thinning time and fruit spacing had shown significant positive relationship with fruit quality attributes. The total soluble solids (TSS), titratable acidity and TSS: acid ratio (Table 4) content was

Table 2. Effect of thinning time and fruit spacing on fruit size and fruit firmness in peach cv. Flordasun.

Thinning time (DAFS*) Fruit spacing (cm)	Fruit length (cm)				Fruit diameter (cm)				Fruit firmness (kg/cm^2)			
	10	15	20	Mean (T)	10	15	20	Mean (T)	10	15	20	Mean (T)
T1 (0 DAFB)	4.01	4.15	4.43	4.20	3.81	3.96	4.30	4.02	1.86	1.74	1.64	1.75
T2 (10 DAFB)	4.19	4.61	4.52	4.44	3.99	4.21	4.26	4.15	2.07	1.95	1.82	1.95
T3 (20 DAFB)	4.52	4.66	4.79	4.66	4.26	4.51	4.56	4.44	2.12	2.00	1.90	2.01
T4 (30 DAFB)	4.34	4.61	4.72	4.56	4.21	4.50	4.53	4.41	2.42	2.28	2.07	2.26
T5 (40 DAFB)	4.00	4.26	4.47	4.24	3.85	4.03	4.13	4.00	2.59	2.25	2.06	2.30
T6 (unthinned)	3.91	3.94	3.98	3.94	3.67	3.69	3.72	3.69	2.66	2.63	2.61	2.63
Mean (S)	4.16	4.37	4.49		3.96	4.15	4.25		2.29	2.14	2.02	
LSD (P ≤ 0.05)												
Thinning time (T)		0.11				0.10				0.10		
Fruit spacing (S)		0.09				0.08				0.08		
T × S		0.20				0.17				NS		

*DAFB = days after full bloom; NS = non-significant

Table 3. Effect of thinning time and fruit spacing on fruit peel colour (*L**, *a** and *b**) in peach cv. Flordasun.

Thinning time (DAFS*) / Fruit spacing (cm)	'*L*'				'*a*'				'*b*'			
	10	15	20	Mean (T)	10	15	20	Mean (T)	10	15	20	Mean (T)
T1 (0 DAFB)	40.39	43.58	47.20	43.72	9.31	10.33	11.23	10.29	12.74	15.22	14.21	14.06
T2 (10 DAFB)	40.13	44.03	52.36	45.51	10.14	11.02	12.60	11.25	15.20	16.10	20.21	17.17
T3 (20 DAFB)	52.36	56.80	59.14	56.10	12.60	13.26	16.34	14.07	20.21	19.68	18.25	19.38
T4 (30 DAFB)	49.29	53.26	54.22	52.26	11.14	12.06	14.09	12.43	14.26	16.25	18.00	16.17
T5 (40 DAFB)	40.47	49.27	51.25	47.00	10.00	12.47	15.54	12.67	15.36	13.65	17.01	15.34
T6 (unthinned)	41.11	41.00	41.27	41.13	9.22	9.12	9.05	9.13	14.51	14.72	14.63	14.62
Mean (S)	43.96	47.99	50.91		10.40	11.38	13.14		15.38	15.94	17.05	
LSD (P ≤ 0.05)												
Thinning time (T)		2.84				1.00				0.66		
Fruit spacing (S)		2.20				0.78				0.51		
T × S		4.91				1.73				1.33		

*DAFB = days after full bloom

Table 4. Effect of thinning time and fruit spacing on TSS, acidity and TSS:acid ratio in peach cv. Flordasun.

Thinning time (DAFS*) / Fruit spacing (cm)	TSS (°Brix)				Titratable acidity (%)				TSS: acid ratio			
	10	15	20	Mean (T)	10	15	20	Mean (T)	10	15	20	Mean (T)
T1 (0 DAFB)	9.33	9.88	10.11	9.77	0.85	0.81	0.72	0.79	10.98	12.19	14.04	12.40
T2 (10 DAFB)	10.00	11.00	11.79	10.93	0.81	0.71	0.68	0.73	12.34	15.49	17.27	15.03
T3 (20 DAFB)	11.79	11.91	12.10	11.93	0.68	0.64	0.60	0.64	17.27	18.61	20.17	18.68
T4 (30 DAFB)	10.92	11.10	11.56	11.19	0.72	0.76	0.64	0.71	15.17	14.61	18.06	15.94
T5 (40 DAFB)	10.75	11.00	11.30	11.02	0.75	0.85	0.81	0.80	14.33	12.94	13.94	13.74
T6 (unthinned)	9.00	9.05	9.07	9.04	0.93	0.91	0.93	0.92	9.68	9.95	9.75	9.79
Mean (S)	10.30	10.66	10.99		0.79	0.78	0.73		13.29	13.96	15.54	
LSD (P ≤ 0.05)												
Thinning time (T)		0.30				0.05				0.66		
Fruit spacing (S)		0.24				NS				0.53		
T × S		0.53				0.09				1.18		

*DAFB = days after full bloom; NS = non-significant

significantly affected by different treatments as compared to control. The highest mean TSS (11.93°B), TSS: acid ratio (18.68) and lowest mean titratable acidity (0.64%) were recorded in T3 followed by T4 (11.19°B, 15.94 and 0.71%), respectively. Meanwhile lowest mean TSS and TSS: acid ratio (9.04 and 9.79°B) and highest titratable acidity (0.93%) was noted in control (unthinned). Similarly, TSS and TSS: acid ratio was significantly increased with spacing. However, titratable acidity was not affected significantly by spacing. Regarding interaction effect, highest TSS (12.10°B); TSS: acid ratio (20.17) and lowest titratable acidity (0.60%) were recorded in T3 × S3 (thinned at 20 DAFS and fruits spaced at 20 cm) followed by T3 × S2. These results are in tune with Njoroge and Reighard (9) and Chanana *et al.* (3) reported highest total soluble solids and total sugars with hand thinning in peaches.

The perusal of data in respect to ascorbic acid content (Table 5) varied significantly among the different treatments. The highest ascorbic acid (6.27 mg/100 g) and total sugars (6.13%) content was recorded in T3, while the lowest in control. With increased in spacing between fruits, the ascorbic acid and total sugars content improved linearly and maximum mean value of ascorbic acid (5.91 mg/100

Table 5. Effect of thinning time × fruit spacing on ascorbic acid and total sugars content in peach cv. Flordasun.

Thinning time (DAFB*) Fruit spacing (cm)	Ascorbic acid (mg/100 g)				Total sugars (%)			
	10	15	20	Mean (T)	10	15	20	Mean (T)
T1 (0 DAFB)	5.19	5.01	5.47	5.22	4.90	5.16	5.22	5.09
T2 (10 DAFB)	5.34	5.94	6.03	5.77	5.47	5.14	6.01	5.54
T3 (20 DAFB)	6.03	6.26	6.52	6.27	6.01	6.22	6.17	6.13
T4 (30 DAFB)	5.80	6.00	6.23	6.01	5.97	5.86	6.12	5.98
T5 (40 DAFB)	6.02	6.14	6.17	6.11	5.86	5.96	6.12	5.98
T6 (unthinned)	5.07	5.06	5.10	5.08	4.98	4.98	5.00	4.99
Mean (S)	5.58	5.74	5.92		5.53	5.55	5.77	
LSD (P ≤ 0.05)								
Thinning time (T)		0.16				0.15		
Fruit spacing (S)		0.12				0.12		
T × S		0.27				0.26		

*DAFB = days after full bloom

g) and total sugars (5.77%) were recorded in fruit spaced at 20 cm. Regarding interaction significantly highest ascorbic acid content were obtained in T3 × S3 (6.52 mg/100 g) followed by T3 × T2 (6.26 mg/100 g). While highest total sugars content was recorded in T3 × S2 (6.22%) followed by T3 × S3. Treatment effect on fruit quality, *viz*., TSS, colour and TSS: acid ratio suggested a slight advancement in crop maturity. This might be due to reduced crop load due to thinning time and fruit spacing, resulted into more synthesis, transport and accumulation of nutrients in the remaining fruits. These results are in harmony with those of Satya and Nautiyal (13) on Early White Giant peach and Kumar *et al.* (8) on Flordasun peach. Thus, the results of the present investigation revealed that the manual thinning of fruits/ fruitlets at 20 days after full bloom and spacing of fruits at 20 to 15 cm along the shoot on whole tree canopy was highly effective in enhancing fruit maturity, improving fruit size, peel colour and quality attributes of Flordasun peach.

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