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Effect of manual and chemical thinning on graded yield and fruit quality in nectarine [*Prunus persica* (L.) Batsch var. *nucipersica*] cv. May Fire

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Abstract

The present investigations were conducted on 10-year-old May Fire nectarine plantations at the experimental orchard of Horticulture Research Station, Kandaghat, during 2011-2012. Experimental trees were given the treatments viz. retention of 3, 4 and 5 fruits per fruiting shoot after selective removal of fruits with hand at pea stage, foliar application of Ethrel at 200 and 300 ppm, NAA at 40 and 60 ppm and Thidiazuron at 20 and 40 ppm two weeks after petal fall and un-thinned control with three replications in Randomized Block Design. Foliar spray of NAA at 40 ppm significantly increased the per cent fruit thinning, the yield of "A" grade fruits, fruit size, weight, volume over the control. The contents of total soluble solids, total sugar and TSS/acid ratio were highest and titratable acidity lowest in the fruits from trees treated with NAA at 60 ppm and Ethrel at 300 ppm in the years 2011 and 2012, respectively. However, the higher increase in leaf to fruit ratio was recorded under the treatment of hand thinning to retain 3 fruits per shoot.

Key words: Nectarine, May Fire, manual thinning, chemical thinning, NAA, ethrel, thidiazuron.

Introduction

The peach [*Prunus persica* (L.) Batsch.] is one of the important stone fruits which requires comparatively warmer climate and is grown in low and mid hills. In India, peach cultivation extends from Northern plains to an elevation of 2000 m amsl.

Nectarines are fuzzless peaches due to a character attained upon genetic mutation in a tree that would otherwise produce what we call peach. The absence of fuzz (pubescence) on the nectarine fruit fundamentally is the only difference between peach and nectarine. Peaches and nectarines pomologically have been classified into five 'races' or 'groups' namely, Honey or South, Persian or True peaches, Spanish or Indian, Peen-to or Flat peaches and North China or Chinese cling .

In the recent years, the cultivation of nectarine is catching up in Kullu and Sirmour Districts, due to its attractive appearance and better remuneration in comparison to peaches. It can be cultivated all over the state except dry and cold region of Lahaul and Spiti and Kinnaur. However, mid hill zone, especially Rajgarh and Kullu Valley areas are the main centers of

peach and nectarine production because of highly congenial agro climatic conditions for the successful cultivation and can be also be grown through zone II of Himachal Pradesh which is a sub-temperate, sub-humid and mid hills zone having an altitude ranging from 915- 1523 m amsl .

May fire, being an early maturing cultivar, is the most important nectarine cultivar grown in the state. But, it invariably bears excessively resulting in the production of small sized fruits which are relatively less remunerative. For profitable and remunerative nectarine production, it is very important to have large sized fruit for better market demand.

Fruit thinning is one of the important agro techniques which increases fruit size, improves fruit colour and quality, reduces limb breakage and promotes general tree vigour (Sefick and Ridley, 1988). Traditionally, thinning of blossoms or fruit-lets had been carried out manually and still is in practice. Through this practice, only a small portion of an orchard may be best thinned at the optimum time. The manual thinning is a time consuming, labour intensive and expensive, therefore, the trends has shifted towards chemical thinning using plant growth regulators like Ethrel, NAA, Thidiazuron. Some plant growth regulators like Ethrel has been reported to give best results when sprayed at post bloom stage. Keeping this in mind, the investigation was conducted to study the effect of manual and chemical thinning on fruit yield, size and quality.

Materials and Methods

The trial was carried out on 10-year-old trees of nectarine cultivar May Fire raised on wild peach seedling rootstocks. The trees had been planted at a spacing of 3×3 meters and trained as open centres at the experimental orchard of Horticulture Research Station, Kandaghat during the years 2011 and 2012 in a randomized block design with ten treatments and three replications. The following were the treatment details T_1= Retention of 3 fruits per shoot; T_2= Retention of 4 fruits per shoot; T_3=Retention of 5 fruits per shoot; T_4= Ethrel200 ppm; T_5= Ethrel300 T_6=NAA 40 ppm; T_7=NAA 60 ppm; T_8=Thidiazuron 20 ppm; T_9= Thidiazuron 40 ppm; T_{10}=control. The hand thinning was done at pea stage and foliar application was given two weeks after petal fall.

Per cent fruit thinning per treatment were calculated by using the following formula

$$\text{Thinning percentage}=\frac{\text{Initial fruit set - Final fruit set}}{\text{Initial fruit set}} \text{ X100}$$

Leaf/fruit ratio was worked out by dividing the total number of leaves with total number of fruits. The fruit retained after thinning were taken as yield. Fruit size in terms of length and breadth of ten randomly selected fruits per replication was recorded with a Digital calliper. Fruit breadth was worked out by averaging the values of cheek and suture diameter which had been recorded separately. The selected fruits taken for recording the fruit size data were weighed on electronic top pan balance and the average fruit weight was expressed in gram per fruit (g/fruit). Volume of fruits was measured by water displacement method. The fruit firmness was determined by a pressure tester (Magness-Taylor). Skin colour of randomly selected fruits was determined as per 4 point scale (< 25% colour =1; 25 - 49%colour = 2; 50 – 74% colour = 3 and >75 % colour = 4). The total soluble solids content in fruits were determined by Erma hand refractometer (0-32° Brix). Total sugars of the fruits were estimated by volumetric method suggested by (AOAC, 1980). The total titratable acidity was calculated in terms of malic acid on the basis of one ml of 0.1 N NaOH equivalents to 0.0067 g of anhydrous malic acid. The TSS/acid ratio was obtained by dividing the corresponding value of total soluble solids to the malic acid content of the fruit juice.

Results and Discussion

In the present study, different hand and chemical thinning treatments exerted a significant effect on per cent fruit thinning. A perusal of data presented in Table 1 revealed that NAA applied at 40 ppm induced the maximum fruit thinning during both the years (60.40 & 30.47%, in 2011 & 2012, respectively). These results are in accordance with the findings of Brar *et al*. (1992) and Sharma *et al*. (2003), who found optimum fruit thinning with 40 ppm NAA when applied after petal fall in peaches. Exogenous application of NAA may increase auxin in seeds to supra optimal level, which interfere in the development of embryo and endosperm, and also stimulate ethylene evolution, causing abscission of young fruit-lets (Krishnamoorthy, 1981). In the present study, leaf /fruit ratio (Table 1) was found to be higher in the trees hand thinned to retain 3 fruits per shoot tree (49.87:1 & 43.08:1 in 2011 & 2012, respectively). Hand thinning reduced the number of fruits per unit area, as a consequence of which the increase in the leaf to fruit ratio in the present study is quite understandable. There are also reports to suggest that hand thinning increased the leaf to fruit ratio in peaches (Sharma *et al*., 2003; Weinberger, 1981).

Trees under hand thinning treatments retaining

Table 1. Effect of manual and chemical thinning on per cent fruit thinning and leaf to fruit ratio in nectarine cv. May Fire

Treatment		Fruit thinning (%)		Leaf to fruit ratio	
		2011	2012	2011	2012
T_1	Retention of 3 fruits per shoot	37.25 (37.61)	29.94 (33.17)	49.87	43.08
T_2	Retention of 4 fruits per shoot	33.47 (35.29)	26.56 (30.98)	43.07	40.89
T_3	Retention of 5 fruits per shoot	30.53 (33.49)	23.34 (28.84)	32.43	35.45
T_4	Ethrel 200 ppm	48.70 (44.24)	21.31 (27.48)	32.37	32.33
T_5	Ethrel 300 ppm	48.92 (44.38)	24.15 (29.41)	34.70	34.68
T_6	NAA 40 ppm	60.40 (51.04)	30.47 (33.38)	35.60	35.86
T_7	NAA 60 ppm	57.45 (49.33)	29.00 (32.56)	33.07	32.33
T_8	Thidiazuron 20 ppm	27.46 (31.55)	19.81 (26.41)	25.72	28.92
T_9	Thidiazuron 40 ppm	30.01 (33.21)	19.18 (25.90)	29.51	29.14
T_{10}	Control (No thinning)	21.51 (27.61)	13.49 (21.47)	25.50	24.73
CD (P=0.05)		5.22	4.12	8.86	6.23

Figures in the parentheses are arc sine transformed values

3 or 4 fruits per shoot and chemical thinning with NAA at 40 ppm produced appreciably higher proportion of "A" and "B" grade fruits, whereas, trees under control produced only negligible amount of superior grade fruits (Table 2). The present studies are in line with the findings of Baroni *et al*. (1986) who reported that hand thinning of several peach cultivars though decreased the total yield but increased the proportion of better grade fruits. Reduction in total fruit yield may be the direct result of reduction in crop load because of the removal of fruits in the thinning operation. In this study, reduction in average fruit yield was almost parallel to the extent of fruit thinning induced by different treatments.

A perusal of data presented in Tables 3 and 4 revealed that fruit size, weight and volume increased greatly with the applications of NAA at 40 ppm. The findings are in accordance with those of Sharma *et al.* (2003), who observed that application of NAA and Ethrel at 14-15 mm fruitlet diameter stage significantly increased fruit size and weight in Redhaven peach. However, the increase in fruit size and weight by auxin may not be entirely due to the reduction in crop competition, but also be due to the direct effect of auxin on sink strength of the fruit (Guardiola and Luis, 1997).

Fruits from the control trees as evident from Table 5 registered higher firmness compared to those under different thinning treatments. In the present findings, it was observed that fruit firmness had a somewhat inverse correlation with fruit size i.e. larger the fruit size lesser the firmness and vice versa. Quast and Graf (1987) observed enhanced ripening by above two weeks and reduction in fruit firmness by

Table 2.Effect of manual and chemical thinning treatments on graded yield of May Fire nectarine

	Treatment	A grade fruits (%)	B grade fruits (%)	C grade fruits (%)
T_1	Retention of 3 fruits per shoot	37.10(37.52)	36.58(37.22)	26.32(30.86)
T_2	Retention of 4 fruits per shoot	34.20(35.79)	35.17(36.37)	30.63(33.57)
T_3	Retention of 5 fruits per shoot	31.67(34.24)	35.00(36.27)	33.33(35.25)
T_4	Ethrel 200 ppm	15.00(22.78)	35.00(36.27	50.00(45.00)
T_5	Ethrel 300 ppm	22.86(28.55)	31.41(36.06)	45.73(42.49)
T_6	NAA 40 ppm	48.14(43.94)	37.05(37.49)	14.81(22.60)
T_7	NAA 60 ppm	30.00(33.20)	30.00(33.20)	40.00(39.23)
T_8	Thidiazuron 20 ppm	20.83(27.15)	30.50(33.52)	48.60(44.20)
T_9	Thidiazuron 40 ppm	13.60(21.63)	37.50(36.57)	48.90(44.37)
T_{10}	Control (No thinning)	5.60(13.65)	5.60(13.65)	88.80(70.50)
CD (P=0.05)		1.04	2.19	1.98

Figures in the parentheses are arc sine transformed value

Table 3. Effect of manual and chemical thinning on fruit size of nectarine

Treatment		Fruit length (cm)		Fruit breadth	
		2011	2012	2011	2012
T_1	Retention of 3 fruits per shoot	5.07	4.32	5.15	4.12
T_2	Retention of 4 fruits per shoot	5.01	4.31	5.00	4.13
T_3	Retention of 5 fruits per shoot	5.07	4.34	5.09	4.09
T_4	Ethrel 200 ppm	5.23	3.99	4.98	4.00
T_5	Ethrel 300 ppm	4.96	4.22	5.11	4.00
T_6	NAA 40 ppm	5.26	4.35	5.21	4.33
T_7	NAA 60 ppm	5.13	3.83	4.89	4.15
T_8	Thidiazuron 20 ppm	5.00	4.15	4.89	4.13
T_9	Thidiazuron 40 ppm	4.89	3.83	4.88	3.98
T_{10}	Control (No thinning)	4.32	3.42	4.19	3.33

Table 4. Effect of manual and chemical thinning on fruit weight and volume of nectarine

Treatment		Fruit weight (g)		Fruit volume(cc)	
		2011	2012	2011	2012
T_1	Retention of 3 fruits per shoot	74.45	37.97	77.33	39.33
T_2	Retention of 4 fruits per shoot	71.60	38.55	72.00	38.67
T_3	Retention of 5 fruits per shoot	68.95	39.29	69.33	39.33
T_4	Ethrel 200 ppm	69.72	35.67	72.67	35.67
T_5	Ethrel 300 ppm	71.96	36.91	74.67	38.33
T_6	NAA 40 ppm	75.26	41.12	78.00	41.67
T_7	NAA 60 ppm	67.75	40.85	70.67	41.00
T_8	Thidiazuron 20 ppm	70.11	33.95	73.33	34.00
T_9	Thidiazuron 40 ppm	61.99	32.64	64.00	34.00
T_{10}	Control (No thinning)	49.83	20.44	52.67	21.33
CD (P=0.05)		12.07	9.08	8.73	7.44

Table 5. Effect of manual and chemical thinning on fruit firmness and fruit colouration of nectarine

Treatment		Firmness (kg/cm^2)		Fruit colouration (4 point scale)	
		2011	2012	2011	2012
T_1	Retention of 3 fruits per shoot	4.70	6.26	3.66	2.13
T_2	Retention of 4 fruits per shoot	4.35	6.46	3.66	2.40
T_3	Retention of 5 fruits per shoot	4.30	6.46	3.40	2.06
T_4	Ethrel 200 ppm	3.90	6.15	3.60	2.33
T_5	Ethrel 300 ppm	3.87	6.00	3.80	2.60
T_6	NAA 40 ppm	4.00	6.23	3.23	2.13
T_7	NAA 60 ppm	3.67	6.10	3.60	2.00
T_8	Thidiazuron 20 ppm	4.02	6.56	3.33	2.33
T_9	Thidiazuron 40 ppm	5.02	6.80	3.33	2.33
T_{10}	Control (No thinning)	5.23	7.53	2.83	1.06
CD (P=0.05)		0.69	0.97	0.38	0.66

Ethrel treatment in apple cv. Jamba. Ethylene accelerates changes that takes place during the fruit ripening including softening of fruits, through enzymatic changes in pectic substances and changes in respiration rate. Higher colour development in Ethrel treated fruit in the present study may be due to ethylene induced enhanced anthocyanin pigmentation (Whale *et al.,* 2012). Sharma *et al*. (2001) reported that Ethrel at 200-300 ppm when applied at 14-15 mm fruitlet stage improved fruit skin colour peach cv. Redhaven.

In 2011, highest total soluble solids (9.90%) was observed in fruits from the trees treated with NAA at 60 ppm which was found to be statistically at par with Ethrel at 300 ppm (Table 6). During 2012, highest TSS contents was recorded in fruits under the treatment of Ethrel at 300 ppm which was observed to be at par with hand thinning treatment of retaining 3 and 4 fruit per shoot and NAA 60 ppm. The present findings are in line with those of Sandhu and Singh (2001) and Sharma *et al.* (2003), who observed that post bloom application of Ethrel at 200-300 ppm increased TSS and sugar contents in peach cvs. Sharbati and Redhaven, respectively. Dhiman (1995) also observed an increase in the soluble solid accumulation in fruits following the treatments with higher concentrations of NAA and ethephon when applied at petal fall stage in New castle apricot. Auxin at higher concentration may stimulate ethylene production in plants (Imaseki *et al.,* 1977) and thus enhance the fruit ripening. The highest contents of total sugar was found in the fruits from trees treated with NAA at 60 ppm, during the year 2011. However, in the year 2012, the highest values of total sugar was observed in fruits from trees given thinning treatment with Ethrel at 300 ppm though it was statistically at par with NAA at 60 ppm. It also seems that exogenous application of Ethrel and NAA increased fruit sugar contents by triggering ethylene production which has a stimulatory role in fruit ripening process (Hansen, 1967). Similar increase in sugar accumulation in the fruits has been reported earlier following the application of NAA at petal fall stage in apricot cv. New Castle (Dhiman, 1995).The present results are also in agreements with those of Sharma *et al*. (2001) who observed exogenous application of Ethrel at 200 to 300 ppm increased total sugar fruits in Redhaven peach.

A perusal of data presented in Table 7 revealed that total titratable acidity in fruits was recorded

Table 6. Effect of manual and chemical thinning on total soluble solid and total sugar contents of nectarine

	Treatment	TSS(°Brix)		Total sugar (%)	
		2011	2012	2011	2012
T_1	Retention of 3 fruits per shoot	9.40	8.80	6.27	5.50
T_2	Retention of 4 fruits per shoot	9.20	9.00	6.38	6.11
T_3	Retention of 5 fruits per shoot	8.70	8.73	6.76	5.52
T_4	Ethrel 200 ppm	8.21	8.56	5.88	5.81
T_5	Ethrel 300 ppm	9.73	9.13	6.91	6.17
T_6	NAA 40 ppm	8.28	8.60	6.60	6.01
T_7	NAA 60 ppm	9.90	8.80	7.22	6.12
T_8	Thidiazuron 20 ppm	9.23	8.20	5.87	5.65
T_9	Thidiazuron 40 ppm	8.55	8.00	5.91	6.11
T_{10}	Control (No thinning)	7.40	7.26	5.39	5.00
CD (P=0.05)		1.35	1.62	0.70	0.64

Table 7. Effect of manual and chemical thinning on fruit titratable acidity and TSS/acid ratio of nectarine

Treatment		Titratable acidity (%)		TSS/acid ratio	
		2011	2012	2011	2012
T_1	Retention of 3 fruits per shoot	0.39	0.45	25.00	20.52
T_2	Retention of 4 fruits per shoot	0.34	0.57	24.10	16.16
T_3	Retention of 5 fruits per shoot	0.42	0.56	21.86	15.88
T_4	Ethrel 200 ppm	0.45	0.45	19.42	19.02
T_5	Ethrel 300 ppm	0.38	0.44	25.60	20.79
T_6	NAA 40 ppm	0.34	0.54	24.35	15.71
T_7	NAA 60 ppm	0.33	0.55	26.55	16.61
T_8	Thidiazuron 20 ppm	0.42	0.64	21.97	12.84
T_9	Thidiazuron 40 ppm	0.46	0.64	18.58	12.50
T_{10}	Control (No thinning)	0.61	0.66	12.33	11.28
CD (P=0.05)		0.14	0.19	1.08	1.78

lower with the application of NAA at 40 or 60 ppm, in the year 2011. However, in the next year 2012, fruits from trees treated with Ethrel at 300 ppm and hand thinned to retain 3 fruits per shoot had lower acid contents though the observations are statistically at par with those under NAA treatments. The present findings are in accordance with that of Farmahan (1992), who reported decrease in acid content of the fruits with the foliar spray of NAA and Ethrel at pit hardening stage in peach cv. Redhaven. Taha and Abass (1987) also found significant increase in TSS content and decrease in acidity following the application of NAA at higher concentration in apricot cv. Chelatano. In the year 2011, fruit TSS/acid ratio (Table 7) was increased greatly with the application of NAA at 40 or 60 ppm and Ethrel at 300 ppm and with hand thinning treatments involving retention of 3 or 4 fruits per shoot. However in the year 2012, Ethrel at 200 or 300 ppm and hand thinning treatment of retaining 3 fruits per shoot caused higher increase in TSS/acid ratio. Higher TSS/acid ratio may indicate that the fruit had reached advanced stage of ripening in these treatments. It may be possible that exogenous application of Ethrel and NAA might have increased the fruit TSS/acid ratio by enhancing the ripening process, in the present study. The results are in agreement with the earlier findings that exogenous foliar application of ethephon (Chahill *et al.,* 1980) and NAA (Dhiman, 1995) increased TSS/acid ratio in different fruits.

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