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Short communication

Chemical thinning improves the fruit size and quality in Silver King nectarine

Sharbat Hussain*, Rifat Bhat, Amit Kumar, Khalid Rasool Dar and Mohd Tauseef Ali**

Division of Fruit Science, SKUAST-Kashmir, Shalimar Campus, Srinagar 190 025, Jammu & Kashmir

ABSTRACT

The investigations were conducted to study the effect of chemical thinning on growth, yield and quality of Silver King nectarine during 2016-2017 at Division of Fruit Science, SKUAST-Kashmir, Srinagar, Jammu and Kashmir. Naphthalene acetic acid (NAA; 10, 20 and 30 ppm), ethephon (50, 100, 150 ppm) and urea (0.2, 0.4 and 0.6 %) were sprayed one week after petal fall. The chemical thinners significantly increased the growth and reduced the fruit set and yield. The plants sprayed with NAA @ 30 ppm recorded highest annual shoot extension growth (52.46 cm), plant height (278.70 cm) and leaf area (36.95 cm^2). Application of ethephon @ 150 ppm significantly reducted fruit set (52.91 %) and fruit yield (12.27 kg) alongwith increased fruit length (5.36 cm), fruit diameter (5.20 cm), fruit weight (73.12 g), soluble solid content (12.94°B), SSC/acid ratio (25.88) and total sugars (9.49 %) followed by NAA @ 30 ppm. On the basis of results obtained, it may be inferred that nectarine trees sprayed with ethephon @ 150 ppm one week after petal fall judiciously thinned the nectarine fruits, improved yield and quality of nectarine fruits and found to be more economical and effective chemical thinner.

Keywords: *Prunus persica*, fruit set, growth, NAA, ethephon.

Nectarines (*Prunus persica* L. Batsch var. *nucipersica*) are one of the newly introduced crop in Kashmir valley. In the recent years, nectarine production has increased dramatically due to its early access in the commercial markets, attractive appearance, higher market price and better remuneration and has also gained importance like peach in the fruit market. The area under nectarine has increased at a faster rate. Nectarine is known for its juicy fruit of excellent appearance and quality and is a good source of vitamins and minerals, being rich in carotene and thiamine. Nectarines have a habit to produce large numbers of flowers and if the environmental conditions are conducive, may set excessively large number of fruits per tree thereby, reduce the possibility of getting commercial fruit size with quality fruit at harvest. Therefore, fruit thinning is done to maintain tree growth, tree structure and it also stimulates floral initiation for next year crop, promotes return bloom and reduces the crop load (Byers *et al*., 2). The fruit size improvement has been attributed to the increase in vegetative growth which in turn enhances the availability of assimilates for fruit growth. Fruit weight and fruit soluble solids concentrations have been found to decrease with the increasing fruit load (Bussi *et al.,* 3). Traditionally, thinning of blossoms or fruit-lets had been carried out manually and is still in practice. However, hand thinning is more expensive and time consuming one. Therefore, the trend has shifted towards chemical thinning using different agents such as plant growth regulators like ethrel, NAA, thidiazuron and chemicals like urea, thiourea, ammonium thiosulphate etc. Plant growth regulators like NAA and ethrel have been reported to give best results in plant growth, reduction of crop load and production of quality fruits in nectarine, when sprayed at post bloom stage (Rajiv *et al*. 8 and Rimpika *et al*. 9). Thinning of peaches and nectarines with different concentrations of urea at pink bud stage, full bloom and the early fruit let stage reduces fruit set and increases plant growth (Taghipour *et al.,* 13). Therefore, the present investigation was undertaken to determine the response of NAA, ethephon and urea on growth, yield and quality of Silver King nectarine on thinning efficiency of fruits.

The present investigation was carried out at Experimental Farm of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Campus during the year 2016 and 2017. The experimental site is situated at an altitude of 1585 m above mean sea level and between 34°N latitude and 74.9°E longitude. Four year old nectarine plants cv. Silver King having uniform growth, planted at a distance of 3 × 3 meters and trained to open centre system were kept under uniform recommended cultural practices during the entire course of investigation. The plants were sprayed with different concentrations of growth regulators/chemicals at one week after petal fall. The experiment consisted of ten treatments (T_1: control,

*Corresponding author's Email: sharbathort@gmail.com

**Department of Horticulture, FOA, SKUAST-Kashmir, Wadura Campus, Baramulla, J&K.

T_2: NAA @ 10 ppm, T_3: NAA @ 20 ppm, T_4: NAA @ 30 ppm, T_5: ethephon @ 50 ppm, T_6: ethephon @ 100 ppm, T_7: ethephon @ 150 ppm, T_8: urea @ 0.2 %, T_9: urea @ 0.4 %, T_{10}: urea @ 0.6 %) and the treatments were replicated thrice in Randomized Complete Block Design.

To record annual shoot extension growth four branches per plant were randomly selected in four directions and data was recorded with the help of measuring tape. Plant height was measured with the help of measuring pole and expressed in centimetres. Leaf area (cm^2) of ten developed and matured leaves was measured with help of automatic leaf area meter (221 Systronics) and averaged was worked out. Fruit set was determined as per the procedure suggested by Westwood (15). Four branches on all sides of the plant were marked and the total number of flowers per branch was counted. The per cent fruit set on these marked branches was recorded at pea stage. Fruit yield per plant (kg) was calculated by weighing whole fruits from a single plant. Ten fruits were randomly taken for recording physico-chemical characters. Fruit weight (g) was determined with the help of digital weighing balance, however fruit length (cm) and diameter (cm) were determined using a digital Vernier caliper. Fruit flesh firmness was determined with the help of a digital Effegi pressure tester plunger and expressed in kg/cm^2. Soluble solids contents (SSC) were determined by using digital hand refractometer whereas acidity was measured in terms of malic acid. Total sugars were determined as per the standard procedures (AOAC, 1). Economic analysis of various thinning treatments was calculated by comparing the net benefits of different treatments with that of control. Costs of thinning under various treatments included the labour charges and cost of growth regulators/chemicals, other management costs for different treatments and control were the same and have not been included in the analysis. Data collected on various parameters were statistically analyzed as per the procedure given by Snedecor and Cochran (12).

Pooled data of two years presented in Table 1 reveals that application of NAA @ 30 ppm (T_4) (278.70 cm) recorded maximum plant height which was significantly higher among all the treatments followed by NAA @ 20 ppm (T_3) (276.77 cm) and urea @ 0.6 per cent (T_{10}) (275.73 cm). Maximum annual shoot extension growth was attained with the application of NAA @ 30 ppm (T_4) (52.46 cm) which was significantly higher among all the treatments followed by urea @ 0.6 per cent (T_{10}) (50.74 cm) and NAA @ 20 ppm (T_3) (50.21 cm). Significantly higher leaf area (36.95 cm^2) was recorded with NAA @ 30 ppm (T_4) followed by treatment T_{10} (35.69 cm^2) and treatment

Table 1. Effect of chemical thinning on growth, foliage and fruit set of nectarine cv. Silver King (Pooled means).

Treatments	Plant height (cm)	Annual shoot extension growth (cm)	Leaf area (cm^2)
T_1: Control	264.19	43.98	31.90
T_2 : NAA@ 10 ppm	266.76	45.03	32.50
T_3 : NAA@ 20 ppm	276.77	50.21	34.83
T_4 : NAA@ 30 ppm	278.70	52.46	36.95
T_5 : Ethephon @ 50 ppm	270.55	46.97	33.44
T_6 : Ethephon @ 100 ppm	271.94	47.61	33.69
T_7 : Ethephon @ 150 ppm	273.14	49.21	33.81
T_8 : Urea @ 0.2 %	266.40	44.75	32.29
T_9 : Urea @ 0.4 %	268.92	46.30	34.34
T_{10}:Urea @ 0.6 %	275.73	50.74	35.69
$CD_{0.05}$	1.59	0.77	0.51

T_3 (34.83 cm^2). Minimum plant height (264.19 cm), annual shoot extension growth (43.98 cm) and leaf area (31.90 cm^2) was recorded under control (T_1). Highest vegetative growth as a result of NAA @ 30 ppm (T_4) may be attributed to the greater availability of photosynthates and nutrients to the developing shoots and leaves which in turn enhanced cell division and plasticity of cell wall thus causing more vigorous growth. Another reason might be due to the fact that fruit thinning reduces the crop load as result of which the number of sinks decreases on the plant and consequently there is more vegetative growth of remaining growing shoots as compared to control where higher number of fruits are greater sink which may reduce vegetative growth because of more competition for metabolites among these sinks. The present results are in agreement with the findings of Taghipour *et al*. (13) and Rimpika *et al.* (9) who observed that vegetative growth including annual extension growth, tree height and leaf area of nectarine trees was increased with application of NAA.

Different chemical thinners (NAA, ethephon and urea) showed a significant impact on fruit set and fruit yield. Persual of pooled data presented in Figure 1 depicts that minimum fruit set was recorded in treatment T_7 i.e. ethephon @ 150 ppm (52.91 %) which was statistically at par with treatment T_4 i.e. NAA @ 30 ppm (53.68 %), however other treatments differs significantly from treatment T_7 and T_4. Treatment T_1 i.e. control recorded maximum fruit set (73.98 %). Among the different chemical thinners ethephon @ 150 ppm resulted in 22 per cent

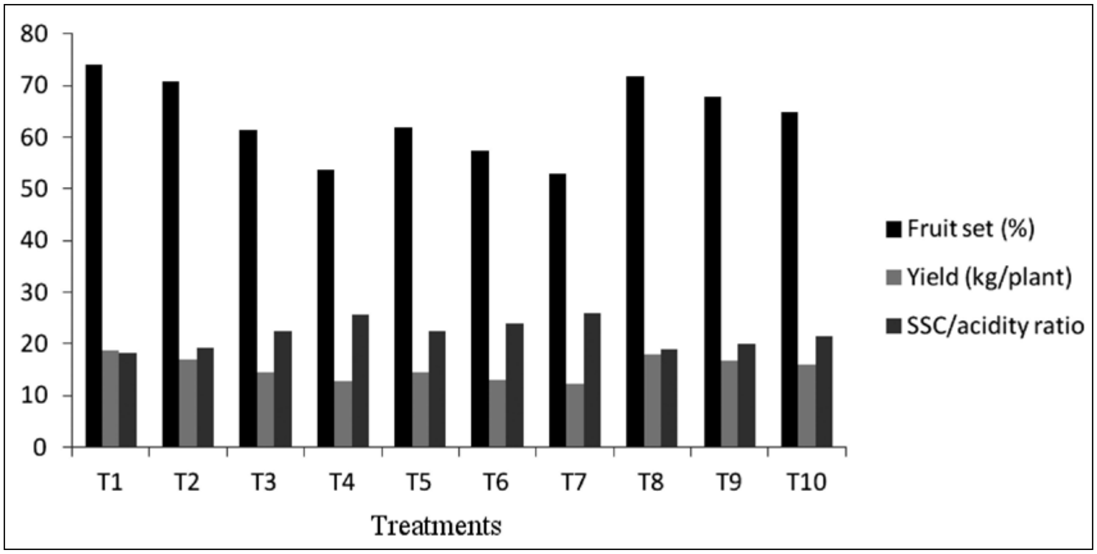

Fig. 1. Fruit set, yield and SSC/acid ratio of nectarine cv. Silver King affected by chemical thinning (Pooled means).

thinning of fruit. This might be due to the exogenous application of NAA which had stimulated ethylene evolution causing abscission of young fruitlets and secondly the thinning of fruits due to ethephon spray resulted in the activation of specific genes which stimulated the secretion of cell wall degrading enzymes such as EG (endo-β-1,4-glucanase) in the separation zone, resulting in the mechanically breakage of non-living elements (Devlal *et al*., 5). Ethephon also promotes abscission zone possibly by enhancing cellulose enzyme activity at abscission zone and causing abscission of young fruitlets. An increase in ethylene production preceding abscission might hamper the polar auxin transport from seeds down through the stalk and cause fruitlet abscission (Chandel and Singh, 4). Urea also induced fruit thinning in peaches and nectarine leads to lower fruit set compared to control. The results with respect to NAA, ethephon and urea on fruit thinning resulting in lower fruit set in the present study are in agreement with findings of Rajiv *et al*. (8) and Rimpika *et al*. (9). Among different chemical thinners ethephon resulted more thinning compared to NAA and urea.

Different thinning treatments significantly decreased the fruit yield (Fig.1). Pooled data of two years depicts that minimum fruit yield was recorded with ethephon @ 150 ppm (T_7) (12.27 kg) which was statistically at par with NAA @ 30 ppm (T_4) (12.68 kg) and ethephon @ 100 ppm (T_6) (13.14 kg) whereas maximum fruit yield was recorded in control (T_1) (18.65 kg) closely followed and statistically at par with urea @ 0.2 per cent (T_8) (17.90 kg). The results are in conformity with the earlier findings of Sharma *et al.* (11) in peach and Rimpika *et al.* (9) in nectarine who observed that fruit thinning with ethephon and NAA lead to a decrease in total yield and increase in the production of quality fruits. Furthermore Rajiv *et al.* (8) observed significant reduction in total yield and the production of quality fruits with the application of ethrel @ 200 and NAA @ 40 ppm two week after petal fall in nectarine cultivar Snow Queen.

Pooled data of two years presented in Table 2 reveals that all the physical characters of fruits were significantly influenced by different thinning treatments. Maximum fruit length was measured in treatment T_7 i.e. ethephon @ 150 ppm (5.36 cm) which was closely followed and statistically at par with application of NAA @ 30 ppm (T_4) (5.35 cm) and ethephon @ 100 ppm (T_6) (5.12 cm). Similar trend was recorded for fruit diameter where treatment T_7 (5.20 cm) registered maximum value which was statistically at par with treatment T_4 i.e. NAA @ 30 ppm (5.15 cm). Minimum fruit length (4.08 cm) and fruit diameter (3.87 cm) was recorded in treatment T_1 (control). Application of ethephon @ 150 ppm i.e. (T_7) (73.12 g) recorded maximum fruit weight which was statistically at par with treatment T_4 i.e. NAA @ 30 ppm (71.53 g) and treatment T_6 i.e. ethephon @ 100 ppm (67.91 g) (Table 2). Minimum fruit weight was recorded in treatment T_1 i.e. control (48.92 g). The increased fruit size and weight can be attributed to a significant increase in the level of the source (leaf area, canopy surface area) and sink ratio as reflected by increase in leaf to fruit ratio and photosynthetic production which helps in the translocation of assimilates to the remaining developing sinks (fruits) following the reduction in competing sinks in the path of transport after thinning

Table 2. Effect of chemical thinning on fruit physico-chemical characters (pooled data) of nectarine cv. Silver King and net returns (Pooled means).

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit firmness (kg/cm²)	SSC (°B)	Acidity (%)	Total sugars (%)	Av. gross returns (Rs./plant)	Benefit Cost ratio
T_1: Control	4.08	3.87	48.92	9.12	11.11	0.61	8.32	764.65	1.60
T_2 : NAA@ 10 ppm	4.31	4.08	53.96	8.97	11.27	0.59	8.45	803.70	1.67
T_3 : NAA@ 20 ppm	4.97	4.71	61.64	8.59	11.85	0.53	9.04	1024.80	2.12
T_4 : NAA@ 30 ppm	5.35	5.15	71.53	8.17	12.76	0.50	9.43	1115.50	2.31
T_5 : Ethephon @ 50 ppm	4.97	4.77	62.96	8.47	12.05	0.54	9.10	1019.20	2.12
T_6: Ethephon @ 100 ppm	5.12	4.92	67.91	8.37	12.27	0.51	9.19	1051.20	2.18
T_7: Ethephon @ 150 ppm	5.36	5.20	73.12	8.10	12.94	0.50	9.49	1141.58	2.36
T_8 : Urea @ 0.2 %	4.29	4.03	52.06	9.02	11.21	0.59	8.40	805.50	1.68
T_9 : Urea @ 0.4 %	4.53	4.29	54.84	8.88	11.43	0.58	8.59	809.28	1.69
T_{10}:Urea @ 0.6 %	4.69	4.45	57.10	8.87	11.72	0.55	8.73	923.94	1.92
$CD_{0.05}$	0.22	0.17	5.34	0.12	0.26	0.02	0.20	-	-

(Garcia-Luis *et al*., 6). 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, 7). The results obtained are in conformity with earlier findings that the application of ethephon and NAA after one to two weeks of petal fall increased fruit size and weight in peaches and nectarine (Rimpika *et al*., 10; Rimpika *et al.* (9).

Minimum fruit firmness was recorded with ethephon @ 150 ppm (T_7) (8.10 kg/cm²) and 8.04 kg/cm²) which was statistically at par with treatment T_4 i.e. NAA @ 30 ppm (8.17 kg/cm²) whereas maximum fruit firmness was recorded in control treatment (9.12 kg/cm²). The decrease in fruit firmness under chemical thinning may be due to higher accumulation of nitrogen in the fruit resulting in the activation of cell wall softening enzyme and dissolution of calcium, and side by side ethylene also accelerates maturation and ripening which results in quicker hydrolysis and breakdown of protopectin cementing middle lamella and cellulosic walls to pectin and then to pectic and pectinic acid and changes in respiration rate. The present results are in accordance with the findings of Chandel and Singh (4) and Devlal *et al*. (5) who reported that ethylene production induces the activity of cell wall and membrane degrading enzymes such as polygalacturonase, pectic methyl esterase (PME) and cellulase thus resulting decrease in fruit firmness in peaches and nectarines.

Significant differences were obtained among different chemical thinning treatments in pooled data for all the studied fruit chemical characters (Table 2 and Figure 1). Ethephon @ 150 ppm i.e. T_7 treatment (12.94°B) recorded maximum soluble solid content which was statistically at par with NAA @ 30 ppm (T_4) (12.76°B) whereas minimum soluble solid content was recorded in control i.e. T_1 (11.15°B). Minimum acidity was recorded with the application of NAA @ 30 ppm (T_4) (0.50 %) and ethephon @ 150 ppm (T_7) (0.50 %) which was statistically at par with ethephon @ 100 ppm (T_6) (0.51 %) whereas maximum acidity was recorded in control (T_1) (0.61 %). Figure 1 depicts that application of ethephon @ 150 ppm (25.88) and NAA @ 30 ppm i.e. (T_4) (25.78) showed statistically at par results for SSC/acid ratio whereas minimum SSC/acid ratio was recorded in control (18.36). Application of ethephon @ 150 ppm i.e. (T_7) (9.49 %) registered maximum total sugar which was statistically at par with treatment T_4 i.e. NAA @ 30 ppm (9.43 %) whereas minimum total sugar was recorded under control (T_1) (8.32 %). The present observations are in accordance with the earlier findings of Taheri *et al.* (14) and Rimpika *et al*. (10) who observed that post bloom application of ethrel significantly, increased fruit SSC and sugar content while as decreases fruit acidity in peaches and nectarines. Increase of soluble solids and sugar content of fruits is due to exogenous application of ethephon which enhance the internal fruit ethylene concentration and triggers the ripening process and activates the enzymes responsible for hydrolysis of starch into sugar i.e. sucrose, glucose and fructose and consequently, enhances the total soluble solids and total sugars and decreases the fruit titratable acidity. Furthermore, increased fruit sugar content in these treatments can be attributed to the reduced fruit load and higher photosynthetic rate and consequently more supply of carbohydrates and metabolites to the developing fruits, as revealed by Chandel and Singh (4) in nectarine.

Results of economic feasibility of different chemical thinning treatments indicated that fruit thinning with ethephon @ 150 ppm gave highest cost benefit ratio (2.36) as compared to other treatments and control. The highest benefit may be due to higher production of better size fruits, which have higher market price.

On the basis of the results obtained in the present study, highest fruit thinning was recorded with ethephon @ 150 ppm (T_7) i.e. 22 per cent over control. However, the yield was recorded lowest in same treatment T_7 (ethephon @ 150 ppm). Therefore, it can be inferred that application of ethephon @ 150 ppm was found the most economical and effective chemical thinner to reduced the fruit load and improved the physico-chemical parameters of the fruits followed by NAA @ 30 ppm, when applied one week after petal fall in nectarine cv. Silver King also gave highest benefit cost ratio. Hence ethephon @ 150 ppm can be recommended for thinning in nectarine orchards.

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