Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP1: 577-581

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(Special Issue- 1)
2nd International Conference
"Food Security, Nutrition and Sustainable Agriculture - Emerging Technologies"
(February 14-16, 2019)

Impact of chemical thinning with branch girdling on fruit yield and quality of peach (*Prunus persica* L. Batsch) cv. Shan-i-Punjab

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Abstract
The present investigations entitled "Impact of chemical thinning with branch girdling on fruit yield and quality of peach (*Prunus persica* L. Batsch) cv. Shan-i-Punjab" were conducted in the peach orchard of Department of Horticulture, Khalsa College, Amritsar during the year 2017-18. Ten year old uniform, vigorous and healthy trees were selected for the experiment. The experiment was carried out in Randomized Block Design (RBD) with ten treatments comprising of Urea (0.1% and 0.2%) and NAA (100 ppm and 200 ppm) which replicated thrice. The fruits were analysed for their physico-biochemical parameters in the laboratory of Department of Horticulture, Khalsa College, Amritsar. The results of the present study indicate that the combination of chemical thinning with branch girdling was the most effective treatment in improving yield and quality parameters of peach cv. Shan-i-Punjab. The peach trees that were girdled and sprayed with Urea 0.2 per cent (T_7) attained maximum fruit retention (62.40%) with fruit set per cent of 81.65 and yield of 78.05 Kg per tree and 17.56 tonnes per hectare. Moreover, the fruit quality was also enhanced with treatment T_7 in terms of TSS (12.53 °Brix), TSS: acid ratio (16.96), total sugars (8.20%), reducing sugars (3.50%) and ascorbic acid (14.50 mg/100g). Even, the above treatment gave excellent coloured fruits with prominent red blush and advanced the maturity of fruits with 68.67 days as compared to control.

Keywords: Shan-i-Punjab, branch girdling, chemical thinning, NAA, Urea

Introduction
Peach (*Prunus persica* L. Batsch) is an important stone fruit of the family Rosaceae, sub family Prunoidae and order Rosales. It is the third most widely distributed temperate fruit in the world. Peach trees normally produce significantly more fruits than the tree can carry to a marketable size crop (Miller and Tworkost 2010) [16]. Due to lack of proper cultural practices undersize, mis-shapen and inferior quality fruits are produced. Fruit thinning is an essential practice to optimize fruit size, maximize crop value, improve fruit colour, shape and quality, promote return bloom and to maintain tree growth and structure (Byers *et al.* 2003) [4]. Girdling is another important cultural practice, used to reduce vegetative growth, promote flowering, improve fruit set, increase yield and improve fruit quality by blocking the downward translocation of photosynthates and metabolites through the phloem, which in turn increases the accumulation of carbohydrates in the parts above wounds (Li Chun-Yao *et al.* 2003 and Eliwa 2003) [9].

Materials and Methods
The present research was carried out in the peach orchard of Department of Horticulture, Khalsa College, Amritsar during the year 2017-18. The trial was conducted on 10 year old uniform and vigorous peach trees. Branch girdling was done on selected trees during the dormancy period. The chemical thinners, Urea and Naphthalene acetic acid (NAA) were applied at two stages. First spray was given at full bloom stage and second at fruit set stage. The fruits were harvested at proper maturity stage for their physico-biochemical analysis.

Results and Discussion

All the thinning and girdling treatments advanced the fruit maturity as compared to control. Least number of days taken for maturity (68.67 days) was recorded in treatment T_7 (Urea 0.2% + branch girdling) which was found to be at par with the treatments T_2 (Urea 0.2%), T_5 (Branch girdling), T_6 (Urea 0.1% + branch girdling), T_8 (NAA 100 ppm + branch girdling) and T_9 (NAA 200 ppm + branch girdling) which took an average of 72.33 days, 72.67 days, 70.33 days, 71.33 days and 72 days respectively for fruit maturation. Maturation of fruits was also found to be earlier on the trees performed with branch girdling (T_5) as compared to trees solely sprayed with chemical thinners. The maximum number of days (81.67 days) to maturity was taken by the untreated trees (T_{10}). The advancement in fruit maturation may be attributed to the reduced crop load per tree (Webster and Hollands 1993) [26]. Moreover, girdling advanced maturity of fruits by ensuring more availability of metabolites for the development of retained fruits. Thinning is known to advance fruit maturity by faster accumulation of minerals and metabolites, availability of more sunlight and reduced competition among the developing fruits (Lata *et al.* 2014) [12]. An advancement in fruit maturity with the combination of girdling and thinning on peach have been registered by Chanana *et al.* (1998) [7] and Chanana and Beri (2004) [6].

The trees treated with the combination of Urea and branch girdling registered maximum increase in the length and breadth of the fruits. The maximum fruit size (7.06 cm × 6.78 cm) was recorded in fruits obtained from trees treated with the treatment T_7 (Urea 0.2% + branch girdling) which were further followed by the treatment T_6 (Urea 0.1 + branch girdling) having fruit length and breadth of 6.41 cm and 6.24 cm respectively. According to Day and Dejong (1990) [8], the increase in fruit size with thinning resulted due to reduction in crop load, thereby making more photosynthates and moisture available to the remaining fruits which definitely improved the fruit size. Fruit size (5.71 cm × 5.69 cm) was also found to be better in trees which were performed with branch girdling (T_5) as compared to the trees sprayed with chemical thinners. Improvement in fruit size by girdling might be pertained to the fact that it ensures greater availability of carbohydrates above the girdled portion. The control trees, however, gave minimum fruit length and breadth of 4.77 cm and 4.32 cm respectively. An increase in fruit size of peaches and nectarines with the application of Urea was observed by many investigators including Erej (1975) [10], Zilkah *et al.* (1988) [28] and Brar *et al.* (1992) [3]. Similar response of Urea was also reported in different cultivars of apricot by Chandel (1985) [5], Taha and Abbass (1987) [23] and Bishnoi (1988) [1]. A positive effect of Urea application along with girdling on fruit size of apple cv. Fuji was recorded by Zhao *et al.* (2013) [27].

Maximum weighted fruits (88.07 g) were obtained from treatment T_7 (Urea 0.2% + branch girdling) which was followed by treatment T_6 (Urea 0.1% + branch girdling) with a fruit weight of 84.38 g. Increase in fruit weight might be due to reduction in number of fruits per tree which increased the leaf to fruit ratio, thus resulting into increased availability of photosynthates and lesser nutritional competition among the developing fruits, thus improving the fruit weight effectively (Meitei *et al.* 2013) [15]. Also, sole application of branch girdling (T_5) gave an improved fruit weight (81.99 g) as compared to the sole application of chemical thinners. This may be because girdling reduces fruit competition for assimilation on tree and thus helps the fruit in gaining more weight (Lata *et al.* 2014) [12]. The data is in conformity with the findings of Beri (2003) [2] regarding increased fruit weight with the combined treatment of thinning and girdling in peach cv. Shan-i-Punjab. Taghipour *et al.* (2011) [22] observed that thinning with both Urea and NAA gave an increase in the fruit weight.

Maximum fruit volume of 99.46 cc was recorded under treatment T_7 (Urea 0.2% + branch girdling) and was closely followed by treatment T_6 (Urea 0.1% + branch girdling) with a fruit volume of 95.86 cc. It was also noticed that fruits obtained from the trees treated with branch girdling (T_5) attained more fruit volume (90.23 cc) than that of fruits from the trees treated with chemical thinners.

The fruit firmness was significantly decreased with girdling and thinning practices. The minimum fruit firmness i.e. 4.77 Kg/cm^2 was registered under the treatment T_7 (Urea 0.2% + branch girdling) being at par with the treatment T_6 (Urea 0.1% + branch girdling) with fruit firmness of 4.93 Kg/cm^2. The trees performed with branch girdling (T_5) also gave fruits with less firmness (5.53 Kg/cm^2). The decrease in fruit firmness by chemical thinning may be attributed to the accumulation of nitrogen in fruit resulting in fruit softening via activation of cell wall enzymes (Meitei *et al.* 2013) [15]. Girdling also contributes to reduction in fruit firmness by increasing fruit size, fruit weight and advancement in fruit maturation (Lata *et al.* 2014) [12]. The results of decreased fruit firmness with the combination of girdling and thinning are in conformity with the findings of Lata *et al.* (2014) [12] on plum cv. Satluj Purple.

Fruit colour enhanced in peach fruits with chemical thinning and girdling. The fruits harvested from the peach trees that were performed with branch girdling and also applied with Urea 0.2 per cent (T_7) attained maximum red blush (9.40). The enhancement in fruit colour by girdling might be due to the accumulation of carbohydrates above the ring, which is the precursor of anthocyanin, flavonoids and other pigments thereby attributing to an increased colour development of fruits (Kumar 1999) [11]. The improvement in fruit colour was also noticed by thinning due to increased availability of light and photosynthates to the retained fruits (Lata *et al.* 2014) [12].

The maximum pulp weight i.e. 67.90 g was found in fruits obtained from trees under treatment T_7 (Urea 0.2% + branch girdling) and it was in close proximity with the treatment T_6 (Urea 0.1% + branch girdling) having pulp weight of 65.21 g. The stone weight of Shan-i-Punjab peaches was recorded to be maximum under treatments T_6 (Urea 0.1% + branch girdling) and T_9 (NAA 200 ppm + branch girdling) both having a stone weight of 7.93 g. The highest pulp: stone ratio (9.51) was given by the treatment T_7 (Urea 0.2% + branch girdling). An increased pulp to stone ratio with girdling was observed by Sharma (2011) [18] in plum cv. Satluj Purple. Similarly, positive effects of NAA application on pulp: stone ratio of apricot cvs. Priana and Beliana were given by Son (2004) [21] and that of Urea on apricot fruits by Taghipour *et al.* (2011) [22].

Table 1: Impact of chemical thinning with branch girdling on fruit physical characters of peach (*Prunus persica* L. Batsch) cv. Shan-i-Punjab.

Treatments	Apparent fruit maturity (days)	Fruit size		Fruit weight (g)	Fruit volume (cc)	Fruit firmness (Kg/cm^2)	Fruit colour	Pulp weight (g)	Stone weight (g)	Pulp: stone ratio
		Fruit length	Fruit breadth							
T_1 (Urea 0.1%)	73.67	5.58	5.45	80.87	86.10	5.85	8.40 (Yellow)	58.55	7.82	7.56
T_2 (Urea 0.2%)	72.33	5.59	5.50	81.45	88.86	5.80	8.52 (Yellow)	58.74	7.40	7.97
T_3 (NAA 100 ppm)	73.33	5.32	5.20	78.00	87.33	5.91	8.40 (Yellow)	56.30	7.21	7.89
T_4 (NAA 200 ppm)	74.00	5.27	5.12	77.60	85.25	5.98	8.25 (Yellow)	55.39	7.67	7.33
T_5 (Branch girdling)	72.67	5.71	5.69	81.99	90.23	5.53	8.71 (Yellow)	59.12	7.56	7.95
T_6 (Urea 0.1% + BG)	70.33	6.41	6.24	84.38	95.86	4.93	9.25 (Yellow with red blush)	65.21	7.93	8.26
T_7 (Urea 0.2% + BG)	68.67	7.06	6.78	88.07	99.46	4.77	9.40 (Yellow with red blush)	67.90	7.20	9.51
T_8 (NAA 100 ppm + BG)	71.33	6.15	5.91	83.13	92.00	5.21	9.00 (Yellow with red blush)	64.45	7.74	8.35
T_9 (NAA 200 ppm + BG)	72.00	5.82	5.74	82.43	90.35	5.42	8.96 (Yellow)	61.92	7.93	7.89
T_{10} (Control)	81.67	4.77	4.32	69.63	76.95	6.10	7.28 (Light yellow)	51.40	7.38	7.13
C.D (p=0.05)	3.59	0.55	0.23	2.86	2.73	0.38	0.32	2.08	0.49	0.57

The treatment T_7 (Urea 0.2% + branch girdling) gave maximum TSS content (12.53 °Brix), TSS: acid ratio (16.96) and the minimum titratable acidity (0.74%). The increase in TSS during maturation process may be attributed to the conversion of starch and other polysaccharides into simple sugars (Singh *et al.* 2016) [19]. The increase in TSS: acid ratio may be due to increased TSS content and decreased acidity level of fruits due to application of chemical thinners and girdling of branches. Reduction in acidity under chemical thinning treatments might be due to conversion of organic acids into sugar (Meitei *et al.* 2013) [15]. Girdling also contributes to reduction in acidity of fruits by accumulating more carbohydrates above the girdled ring and reducing inter fruit competition for water, minerals and other assimilates (Lata *et al.* 2014) [12].

The maximum percentage (8.20%) of total sugars was given by the treatment combination including Urea 0.2 per cent with branch girdling (T_7) which was found to be at par with the treatments T_5 (branch girdling), T_6 (Urea 0.1% + branch girdling), T_8 (NAA 100 ppm + branch girdling) and T_9 (NAA 200 ppm + branch girdling) having total sugars percentage of 7.79, 8.03, 7.96 and 7.89 per cent respectively. Also, the trees performed with branch girdling (T_5) gave higher total sugars content (7.79%) in comparison to trees sprayed with chemical thinners. Reducing sugars also followed similar trend as that of total sugars with maximum reducing sugars (3.50%) recorded under treatment T_7 (Urea 0.2% + branch girdling). Also, the former treatment was found to be at par with the treatments T_6 (Urea 0.1% + branch girdling) and T_8 (NAA 100 ppm + branch girdling) having reducing sugars of 3.20 per cent each. The results regarding sole treatment of branch girdling and chemical thinners followed similar trend as in total sugars as the girdled trees (T_5) gave a reducing sugars per cent of 3.00 which was higher in comparison to the sole application of chemical thinners. Positive effects of girdling, thinning and their combination on sugars level of peach cv. Flordaprince have been given by Chanana and Gill (2006). Similar observations with girdling were made by Singh *et al.* (2016) [20] on pear cv. Punjab Beauty. Patel *et al.* (2014) [17] also observed enhancement of total sugars and reducing sugars content with thinning performed on Flordasun cultivar of peach.

The ascorbic acid content was found to be maximum (14.50 mg/100g) in the fruits obtained from the trees under the treatment T_7 (Urea 0.2% + branch girdling) which was at par with the treatment T_6 (Urea 0.1% + branch girdling) having a value of 14.15 mg/100g. Ascorbic acid was also found to be higher (13.40 mg/100g) in fruits obtained from trees performed with branch girdling (T_5) as compared to the trees sprayed with chemical thinners. The data presented is observed to be positively correlated to the findings of Tahir and Hamid (2002) [24] with thinning. Zhao *et al.* (2013) [27] recorded the highest ascorbic acid value in apple cv. Fuji when girdling was combined with Urea 0.2 per cent.

The highest fruit set percentage was given by the combined application of chemical thinners along with branch girdling. The treatment T_7 (Urea 0.2% + branch girdling) gave highest fruit set percentage i.e. 81.65 per cent which was observed to be significant over all the other treatments. The trees that were solely performed with branch girdling (T_5) gave a fruit set of 76.12 per cent which was higher in comparison to the fruit set on the trees sprayed with chemical thinners. All the girdling and thinning combinations gave an increased fruit retention percentage as compared to control. Treatment T_7 (Urea 0.2% + branch girdling) showed significant fruit retention than all other treatments with a percentage of 62.40. Also, trees treated with branch girdling (T5) retained more fruit (56.84%) as compared to tree sprayed with chemical thinner.

The maximum fruit yield (78.05 Kg/tree and 17.56 t/ha) was given by the trees treated with the combination of Urea 0.2% with branch girdling (T_7) which was found to be closely followed by the treatments T_6 (Urea 0.1% + branch girdling) and T_8 (NAA 100 ppm + branch girdling) with fruit yield of 77.59 Kg/tree (17.45 t/ha) and 75.7 Kg/tree (17.03 t/ha) respectively. The above treatments were found to be statistically superior to rest of the treatments. Fruit yield was also observed to be better (72.00 Kg/tree and 16.20 t/ha) from the trees performed with branch girdling (T_5) in comparison to the trees sprayed with chemical thinners. The increase in fruit yield with girdling might be due to increase in fruit set (Lavee *et al.* 1983) [13] and also due to increase in fruit size (Valentini and Arroyo 2002) [25]. There may be another two reasons behind better fruit yield with girdling and thinning treatment i.e. better fruit retention and increase in fruit weight.

Table 2: Impact of chemical thinning with branch girdling on fruit biochemical characters of peach (*Prunus persica* L. Batsch) cv. Shan-i-Punjab.

Treatments	TSS (°Brix)	Titratable acidity (%)	TSS: acid ratio	Total sugars (%)	Reducing sugars (%)	Ascorbic acid (mg/100g)
T_1 (Urea 0.1%)	11.43	0.83	13.84	7.69	3.06	12.70
T_2 (Urea 0.2%)	11.65	0.80	14.59	7.76	3.10	13.10
T_3 (NAA 100 ppm)	11.36	0.85	13.41	7.56	2.96	12.85

T_4 (NAA 200 ppm)	11.36	0.88	12.99	7.50	2.86	12.50
T_5 (Branch girdling)	11.76	0.80	14.83	7.79	3.00	13.40
T_6 (Urea 0.1% + BG)	12.03	0.76	15.88	8.03	3.20	14.15
T_7 (Urea 0.2% + BG)	12.53	0.74	16.96	8.20	3.50	14.50
T_8 (NAA 100 ppm + BG)	11.90	0.77	15.59	7.96	3.20	13.80
T_9 (NAA 200 ppm + BG)	11.83	0.79	14.99	7.89	3.13	13.55
T_{10} (Control)	10.56	0.93	11.42	6.92	2.20	12.00
C.D (p=0.05)	0.55	0.04	1.06	0.42	0.32	0.37

Table 3: Impact of chemical thinning with branch girdling on yield characters of peach (*Prunus persica* L. Batsch) cv. Shan-i-Punjab.

Treatments	Yield (Kg/tree)	Yield (tonnes/ hectare)	Fruit set (%)	Fruit retention (%)
T_1 (Urea 0.1%)	68.06	15.31	73.54	54.60
T_2 (Urea 0.2%)	71.41	16.06	75.24	55.97
T_3 (NAA 100 ppm)	66.98	15.07	74.89	55.18
T_4 (NAA 200 ppm)	65.30	14.69	71.63	53.81
T_5 (Branch girdling)	72.00	16.20	76.12	56.84
T_6 (Urea 0.1% + BG)	77.59	17.45	78.30	59.05
T_7 (Urea 0.2% + BG)	78.05	17.56	81.65	62.40
T_8 (NAA 100 ppm + BG)	75.70	17.03	78.70	58.96
T_9 (NAA 200 ppm + BG)	74.27	16.71	77.16	57.22
T_{10} (Control)	61.90	13.97	68.05	50.29
C.D (p=0.05)	3.10	0.69	2.66	2.19

Conclusion

It has been concluded from the present study that the application of chemical thinners along with branch girdling was considered to be the most effective treatment as compared to others in improving yield and quality of peach fruits cv. Shan-i-Punjab. The peach trees that were girdled and sprayed with Urea 0.2 per cent (T_7) gave maximum fruit yield with maximum retention of fruits. The fruits yielded from trees under treatment T_7 had maximum TSS, sugars and ascorbic acid, whereas, the titratable acidity was decreased. Moreover, the trees under treatment T_7 took minimum days for maturation. Hence, treatment T_7 proved to be the best in enhancing fruit quality as well as yield by improving fruit set and fruit retention percentage effectively.

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