EFFECT OF GIRDLING AND GROWTH REGULATORS APPLICATION ON FRUIT QUALITY AND YIELD OF PEAR (PYRUS COMMUNIS) CV. PUNJAB NECTAR

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INTRODUCTION

Pear (Pyrus communis) is one of the important temperate fruit crop next only to apple, it is placed in the family Rosaceae, sub-family Pomoideae, along with apple and quince. Cultivated pear (Pyrus communis L.) is major pear of commerce possibly derived from Pyrus caucasica and Pyrus nivalis its probable progenitors are native to Eastern Europe and Asia Minor near the Mediterranean widely distributed throughout Europe. The Asian pear (Pyrus pyrifolia (Burm) Nakai) was originated in China, where its cultivation dates back to 2500-3000 years. A temperature range of 27ºC to 33ºC in summer is very congenial for pear cultivation. At the same time a winter temperature of 7ºC or below for 2-3 months is essential for most of the English and Chinese varieties of pear (Nauriyl and Prakash, 1990). Major pear producing countries of the world, the improved pear cultivars in India were introduced in the later part of the 19th century and the cultivation got momentum with success of Bartlett and Gola cultivars in hills of Himachal Pradesh and Jammu Kashmir. In India, pear occupies the second place among temperate fruits both in area and production.

Pear fruit is cultivated in Kashmir valley, upper hills of Himachal Pradesh, Utra-Khand, Punjab and Assam. The area under pear in India is 37970 ha with the annual production of 382000 tonnes (Anon., 2012). Semi soft cultivar of pear like Baggugosha and Le Conte which are popularly grown in lower hilly areas are shy and irregular bearer. New strains of semi soft pear like Punjab Beauty, Punjab Gold, Punjab Nectar and Punjab Soft collected from indigenous and exotic sources approved by P.A.U., Ludhiana are gaining popularity amongst the orchardists of Punjab in the low chilling pear growing areas. These seem to be actually natural hybrid of Asian and European pear cultivars. The area under different pear cultivars has been steadily increasing in Punjab state, next only to citrus and mango. Pear occupies an area about 2665 ha with an annual production of 60176 MT (Anon., 2011).

The district of Amritsar and Tarn ranks top in Punjab with respect to pear growing. In Punjab, the hard pear cv. like Patharnakh (90 per cent) is predominant but its demand is steadily declining and the orchardists are trying the semi soft pear cultivars. The fruit of semi soft pear has good flavour and on ripening it becomes more acceptable and thus sells at a premium than Patharnakh. Pear is known source of dietary fiber, in the form of pectin, which is a soluble fiber that helps to control blood cholesterol level, another fiber is cellulose, which is insoluble fiber that promotes normal bowel function. Pear is a source of protein, minerals like phosphorous and vitamin C. Most of the pears in European and United States are eaten fresh, some are canned, diced in fruit cocktails and others are processed for cider known as Perry.

Girdling of pear fruit tree trunks is a practice used in order to control the excessive vegetative growth in fruit trees and consequently enhance yield by increasing fruit set, fruit size or both (Smit et al., 2005). Total soluble solids content might also be increased, as well as colour might be improved and maturity at harvest might be advanced. The growth regulators...
include both growth promoters and retardants which modify the canopy structure and other yield attributes. Among growth regulators, Gibberellic acid plays a vital role in the development of morphological characters of plants and their fruits. The application of gibberellins along with auxins (naphthalene acetic acid) is known to influence the seed germination, plant growth, development, flowering and fruit characters. To get maximum benefits from the crop, it is indeed a requirement to study the effect of different mechanical and chemical treatments on productivity and quality of semi soft pear cultivars.

Keeping above facts in mind, the experiment was planned to judge the effect of girdling and different growth regulators on the fruit quality and yield of newly recommended semi soft pear cv. Punjab Nectar.

**MATERIALS AND METHODS**

The present experiment “Effect of Girdling and Growth Regulators Application on Fruit Quality and Yield of Pear cv. Punjab Nectar” was conducted in the Punjab Government progeny Orchard and Nursery, Attari, Amritsar on 15 years old soft pear (Punjab Nectar) trees during the fruiting year 2012. The experimental pear trees were applied with uniform cultural practices as per recommendations of PAU Ludhiana.

The district of Amritsar represents the climatic conditions prevailing in the sub-tropical humid zone of the Punjab state. It is situated at 31º-38’ N latitude and 74º-522’ E longitude at an elevation of 236 m above MSL. This tract in characterized by semi-humid climate where both winters and summers are extreme. The experimentation consisted of trunk girdling, NAA 20 ppm and GA3 (10, 20 and 30 ppm). The girdling was performed during the dormant period; NAA was applied at full bloom whereas GA3 was superimposed after one week of the application of NAA. The treatment comprised T1 (Trunk Girdling + 20 ppm NAA + 10 ppm GA3), T2 (Trunk Girdling + 20 ppm NAA + 20 ppm GA3), T3 (Trunk Girdling + 20 ppm NAA + 30 ppm GA3), T4 (Trunk Girdling + 20 ppm NAA + 10 ppm GA3), T5 (Main Branch Girdling + 20 ppm NAA + 20 ppm GA3), T6 (Main Branch Girdling + Water Spray), T7 (Main Branch Girdling + 20 ppm NAA + 30 ppm GA3), T8 (Main Branch Girdling + Water Spray), T9 (Ungirdling + 20 ppm NAA + 10 ppm GA3), T10 (Ungirdling + 20 ppm NAA + 20 ppm GA3), T11 (Ungirdling + 20 ppm NAA + 30 ppm GA3), and T12 (Control (Ungirdling + Water Spray). Growth, yield and physio-chemical parameter were estimated as; Fruit set percentage, Fruit yield/tree (kg), Physical Characters, Fruit size (cm), Fruit weight (gm), Fruit volume (cc) by water displacement method and specific gravity (weight/volume), Fruit specific gravity, Fruit colour (score card), Fruit firmness, Fruit juice percentage (%), Chemical Characters, Total soluble solids (%) was determined with the help of digital refractometer, Acidity, TSS: acid ratio, Reducing sugars (%), and Total sugars (%) were estimated by standard method described in AOAC (1990). The data was statistically analyzed by method of analysis of variance using RBD as described by Panse and Sukhatme (1989).

**RESULTS AND DISCUSSION**

The results obtained from the studies entitled “Effect of girdling and growth regulators application on fruit quality and yield of pear cv. Punjab Nectar” are presented in Table 1, it is revealed that a significant improvement of fruit set through girdling. Branch girdling was found better to trunk girdling. Maximum fruit set per cent (18.40) recorded under the treatment T7, and was followed by treatment T4 with fruit set of 17.60 %. Minimum fruit percent (12.00) recorded under control.

The findings lend support from the previous studies of Dokoozlian et al. (2001) in ‘Autumn Royal’ grapes, Sharma and Singh (2009) in strawberry with the application of GA3, and Gaur et al. (2014) Foliar spray of GA3, 50ppm caused 43.75 % fruit set, 39.87% fruit retention. Similar results with the use of NAA also reported by Singh and Chadha (1990) and Singh et al. (2002) in delicious apples. Nawaz et al. (2008) in Kinnow mandarin also found similar results. The increase in fruit set through girdling could be attributed to accumulation of food reserves (metabolites) in the tree canopy as the phloem removal would have act as a barrier of the drainage of food reserves. The further improvement by the GA3 would have been the resultant of maintenance of growth hormone. Fruit set increase with girdling also reported by Hartmann (1950) in Olive.

<table>
<thead>
<tr>
<th>Treatments Code</th>
<th>Fruit set (%)</th>
<th>Fruit yield (kg)</th>
<th>Fruit length(cm)</th>
<th>Fruit breadth (cm)</th>
<th>Fruit weight (gm)</th>
</tr>
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<td>T1</td>
<td>13.80</td>
<td>69.00</td>
<td>7.80</td>
<td>6.30</td>
<td>180.00</td>
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<td>14.60</td>
<td>73.00</td>
<td>8.00</td>
<td>6.70</td>
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<td>T3</td>
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<td>77.00</td>
<td>8.40</td>
<td>7.00</td>
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</tr>
<tr>
<td>T4</td>
<td>13.00</td>
<td>65.00</td>
<td>8.00</td>
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<td>T5</td>
<td>16.60</td>
<td>83.00</td>
<td>8.00</td>
<td>6.73</td>
<td>188.00</td>
</tr>
<tr>
<td>T6</td>
<td>17.60</td>
<td>88.00</td>
<td>8.50</td>
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<td>60.00</td>
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<td>7.99</td>
<td>6.59</td>
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<td>6.20</td>
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Theron and Steyn (2008) in pear, Silva et al. (2010) in ‘Gerbera’ pear, Choi et al. (2010) in Persimmon and Huang et al. (2012) in Litchi. The data relating to fruit yield of soft pear cv. Punjab Nectar as influenced by different girdlings and concentrations of growth regulators are presented in table 1. From the data given in table, it was observed that plants treated with branch girdling along with GA3 and NAA application enhanced yield per plant in pear trees. Treatment T7 resulted in an increase in yield of pear fruits from 60.00 kg (under control) to 92.00 kg. Yield is a complex character and is characterized by an increase in number of fruits and also due to increase in weight of individual fruit. The present results may be due to the fact that gibberellins enhanced the translocation and mobilization of shared metabolites or photosynthates from source to sink. Further, it could be partly due to increase in auxin synthesis in ovaries.

The present results of yield with the use of GA3 are in conformity with the findings of Gayakvad et al. (2014) in ‘Jatropha curcas’ L., Clark et al. (1998) in ‘Venus’ and ‘Saturn’ grapes, Ozcugen et al. (2002) and Sharma and Singh (2009) in strawberry. Wahdan et al. (2011) in ‘Succeary Abiad’ mango and Singh and Chadha (1990) in delicious apples also found similar results with the use of growth regulators. Harhash and Obeed (2007) in ‘Barhee’ and ‘Shahli’ cultivars of datepalm also reported positive relation of NAA with the fruit yield. Girdling is a practice used in order to control the excessive vegetation and thereby improving the crop yield due to increase of fruit set and fruit size (Raffo et al., 2011). Increase in fruit yield with the girdling also reported by Hartmann (1950) in Olive, Chanana and Gill (2008) in grapes, Nikola et al. (2009) in ‘Elstar’ apple, Raffo et al. (2011) in ‘Bartlett’ pear and Huang et al. (2012) in ‘Nuomici’ and ‘Guiwei’ cultivars of litchi.

The data given in Table 1 showed that there was a significant increase in fruit length with girdling and increased application of growth regulators. Maximum fruit length (9.00 cm) was recorded in plants treated with treatment T7, followed by treatment T6 with fruit length 8.50 cm, respectively and these were recorded significantly higher fruit length than control (6.50 cm). The present results are in accordance with Gill et al. (1987) and Cooper et al. (1993) in ‘Thompson Seedless’ grapes, Kashyap et al. (1989) in grapes, Khan and Singh (1989) in ‘kishmish Charni’; Dokoozlian et al. (2001) in ‘Autumn Royal’ and Wo-Jun et al. (2001) in ‘Fujiminori’, Zioziou et al. (1999) in ‘Sultaniana’ grapes. Lakshamanan et al. (1992) also reported the positive effect of GA 3 on berry length in various varieties of grapes as ‘Tas-e-Ganesh’, ‘Anab-e-Shahi’, ‘Thompson Seedless’ etc. The results of NAA on fruit length are in conformity with those reported by Harhash and Obeed (2007) in ‘Barhee’ and ‘Shahli’ and Hesami and Abdi (2010) in ‘Kabkab’ cvs. of datepalm. Similar findings were also reported.
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observed that increase in concentration of GA3 and NAA, girdling progressively increase the fruit weight. It can be Increase in concentration of growth regulators alongwith and Murakami (2012) in 'Rainbow Red' kiwifruit. Increase in fruit size by girdling also reported Allan (2010) in 'Kabkab' datepalms. support the findings of GA3 treatments. The results of present study are in conformity with the findings of Southwick (2005) in 'Packham’s Triumph’ pear and Yahuaca et al. (2001) in grapes. The results clearly indicate that GA3, NAA and girdling treatments viz. trunk and branch girdling, has caused reduction in fruit firmness. Minimum fruit firmness i.e. 6.80 kg/cm² was recorded in treatment T7. This may be pertained to the advancement in maturity of fruits due to girdling which leads to the reduction in fruit firmness. Similar results were also obtained by Murayama et al. (2006) in ‘Bartlett’ pear, Smit et al. (2005) in ‘Packham’s Triumph’ pear and Yahuaca et al. (2001) in grapes. Contrary to this, the trees with application of NAA 20 ppm and superimposed with GA3 30 ppm produced the fruits with maximum fruit firmness (9.70 kg/cm²) likewise the growth regulator application i.e. 20 ppm NAA and 20 ppm GA3 also helped to increase the firmness. However, these were found to be significant to the control. The role of growth regulator has been well documented for delaying the fruit maturity and increase fruit firmness. The results of present study are in accordance with the findings of Southwick et al. (2000) in French Prune and Wahdan et al. (2011) in ‘Succary Abiad’ mango and Rahemi and Attahoseini (2004) in pomegranate in response to GA3 and NAA.

From the data given in the Table 2, it is cleared that specific gravity showed negative correlation with increasing concentrations of growth regulators alongwith girdling. Minimum specific gravity (1.077) was recorded under treatment T9. This increase or decrease in specific gravity of fruit is directly proportional to the weight of the fruit and is inversely proportional to the volume of water displaced by the fruit. Decrease in specific gravity might be due to the increasing amount of inter-cellular space in fruit (Bal and Singh, 1978).

The data presented in Table 2 showed that there is no significant difference in colour of pear fruits treated with different concentrations of growth regulators and girdling. Bright yellowish green of fruits observed under T9 (Trunk girdling), T8 (Branch girdling) and T11 (20 ppm NAA + 30 ppm GA3) when compared with control (green coloured fruits). The improvement of fruit colour due to girdling can be owed to the resultant of advancement of fruit maturity as reported by Green and Lord, 1986 and Goren et al., 2004. Similar results were also recorded by Saleem et al. (2008) in ‘Blood Red’ sweet orange with the application of GA3. The present study is in conformity with the findings of Singh et al. (1994) in ‘Le Conte’ pear and Singh et al. (2002) in ‘Royal Delicious’ apple. Fruit colour improved by girdling also found by Choi et al. (2010) in persimmon fruits.

The results of present study are in conformity with the findings of Nawaz et al. (2008) in Kinnow mandarin and Saleem et al. (2008) in ‘Blood Red’ Sweet orange in response to the application of growth regulators.

The data with regard to total soluble solids of soft pear fruits cv. Punjab Nectar as influenced by different girdlings and growth regulators treatments are presented in Table 3. It was


Increase in concentration of growth regulators alongwith girdling progressively increase the fruit weight. It can be observed that increase in concentration of GA3 and NAA, with girdling resulted in increase in fruit weight from minimum (158.00 g) to maximum (200.00 g) with treatment T1, and was followed by T3, with fruit weight 195.00 g, respectively. It might be due to the fact that growth regulators as GA3 show indirect effect through auxin stimulation while NAA show direct effect on the cell elongation by the enlargement of vacuoles and loosening of cell wall after increasing its plasticity, which lead to increase in fruit weight. Study conducted by Wo-Jun et al. (2001) in ‘Fujimominori’ grapes and Sharma and Singh (2009) in strawberry support the findings of GA3 treatments. Rahemi and Attahoseini (2004) in pomegranate and Harhash and Obeed (2007) in ‘Barhee’ and ‘Shahl’ datapelmas. support the findings of NAA. The results are in conformity with those reported by Agusti et al. (1998) in peach, Meintjes et al. (2005) in ‘Flamingo’ pear, Reynolds and Savigny (2004) in ‘Sovereign Coronation’ grapes and Jin Yong et al. (2005) in grapes. The present results are in accordance with those reported by Ahmad and Zargar (2005) in Perlette and Jin Young et al. (2005) in ‘Red Globe’ grapes in response to GA3, and girdling. The data regarding fruit volume as affected by different girdlings and concentrations of growth regulators are presented in Table 2. Maximum fruit volume (177.50 cc) was presented in Table 2. Maximum fruit volume (175.00 cc), respectively. All the treatments found to be statistically significant over control (144.00 cc). The increase in fruit volume is directly related with the increase in weight and size of fruit with the advancement of the maturity. The results of present study are in conformity with the findings of Wahdan et al. (2011) in ‘Succary Abiad’ mango and Rahemi and Attahoseini (2004) in pomegranate in response to GA3 and NAA.
revealed from the data that GA₃, NAA and girdling treatments significantly increased the total soluble solids content over control. Maximum TSS (14.96 %) were noted in treatment T₇. Increase in TSS during maturation process may be due to the conversion of starch and other polysaccharides into simple sugars. Similar findings on increased TSS in grapes with the application of GA₃, by Urma (1991), Khan and Singh (1989) and Dokoozlian et al. (2001). Lakshmanan et al. (1992) in ‘Tas-a-Ganesh’, ‘Thompson Seedless’ and ‘Arkavati’, Panwar et al. (1994) in ‘Beauty Seedless’, Qadir et al. (1998) in ‘Flame Seedless’ also show similar findings. Increase in TSS with the GA₃ application also noted by Nawaz et al. (2008) in Kinnow and Saleem et al. (2008) in ‘Blood Red’ sweet orange. The increased TSS in the juice of NAA treated fruits was due to the increased mobilization of carbohydrates from the source to fruits by auxin treatments. The increase in TSS with NAA evidenced in the present study is in line with the findings of Singh et al. (1994) in ‘Le Conte’ pear, Wu and Lin (2003) in loquat, Nawaz et al. (2008) in Kinnow and Harhash and Obeed (2007) in ‘Barhee’ and ‘Shahl’ cultivars of datepalm. Increase in TSS with girdling have also been reported by Fujishima et al. (2005) and Yamane and Shibayama (2007) in grapes, Allan et al. (1993) and Chanana and Gill (2006) in ‘Florida Prince’ peach, Smit et al. (2005) and Sousa et al. (2008) in ‘Packham’s Triumph’ and ‘Rocha’ pear respectively and Huang et al. (2012) in ‘Nuomici’ and ‘Guiwei’ litchi. Kaur et al. (2008) also reported similar findings with the application of GA₃ + Girdling in ‘Perlette’ grapes.

The data given in Table 3 are clearly indicative of the fact that with the increase in concentration of growth regulators and girdling, there was a reduction of acidity in pear plants. Maximum acidity (0.416 %) was recorded in case of untreated plants, followed by T₇ treatment (Trunk girdling) with acidity (0.385 %). Minimum acidity (0.254 %) was found under treatment T₅. Decreased acid content brings sweet taste in the fruit which leads to better acceptability of fruit by the consumer.

Reduction in acidity level with the use of GA₃ treatments has also been reported by Urma (1991) and Dokoozlian et al. (2001) in grapes, Panwar et al. (1994) in ‘Beauty Seedless’. Reduction in acidity content with the use of NAA was also observed by Hashash and Obeed (2007) in ‘Barhee’ and ‘Shahl’ cultivars of datepalm. Acidity was also found to decrease with the girdling by Fujishima et al. (2005) in ‘Pion’ grapes, Chanana and Gill (2006) in ‘Florida Prince’ peach and Huang et al. (2012) in ‘Nuomici’ and ‘Guiwei’ cultivars of litchi. Kaur et al. (2008) also observed similar trend of reduction of acidity with the use of GA₃ and girdling.

The ratio of TSS to acidic contents was reported to be increased with growth regulators application and girdling. Maximum TSS: acid ratio (58.90) was observed under treatment T₇ as compared to control (33.04). This may be pertained to the fact that growth regulator application and girdling resulted in an increase in TSS content and decrease in acidity level of fruit than control, leading to higher level of solid: acid ratio. These results support the earlier findings by Singh et al. (1994) in ‘Le Conte’ pear, Singh et al. (2002) in ‘Royal Delicious’ apple and Wu and Lin (2003) in loquat in response to the application of growth regulators. The results of girdling are in accordance with Chanana and Gill (2006) in ‘Florida Prince’ peach and Peng et al. (1996) in Satsuma mandarin.

The data regarding reducing sugars as affected by different treatments are presented in Table 3 delineated that reducing sugars were found to be increased significantly with the application of growth regulators than control. However, maximum reducing sugars (9.30 %) were recorded under treatment T₅. The increase in reducing sugars with the application of GA₃ may be due to the fact that GA₃ is responsible for the synthesis of enzyme α-amylase, which converts starch into reducing sugars. Khan and Singh (1989) in ‘Kishmish Charni’ grapes and Saleem et al. (2008) in ‘Blood Red’ sweet orange observed an increasing trend in reducing sugars content with the application of GA₃. Kaur et al. (2008) also noticed increase in reducing sugars of ‘Perlette’ grapes with GA₃ application and girdling.

The data pertaining to total sugars showed that total sugars increased with the application of growth regulators and girdling than control. Total sugars found to be maximum (12.95 %) under T₇ treatment, followed by treatment T₆ with total sugars content of 12.6 respectively. The present study is in accordance with the findings of Wahdan et al. (2011) in ‘Succary Abaid’ mango in response to GA₃ and NAA application. Increase in total sugars content of fruits by girdling was also noted by Allan et al. (1993) and Chanana et al. (2006) in ‘Florida Prince’ cultivar of peach.

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