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Fruit set and quality improvement studies on semi-soft pear cv. Punjab Beauty

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ABSTRACT

To improve fruit set in pear cv. Punjab Beauty, some chemicals like GA_3 (10, 20 and 30 ppm), sucrose (5, 10 and 15%) and boric acid (100, 200 and 300 ppm) were sprayed at two stages; full bloom and petal fall. Fruit set was significantly improved by 4.16% with sucrose (15%) and 3.43% with GA_3 (20 ppm) as compared to control. It was higher when these chemicals were sprayed at full bloom stage. However, fruit retention at fruit harvest stage was better with GA_3 20 ppm followed by sugar 15 per cent. The same treatments also improved fruit yield significantly by 55.15 and 48.58%, respectively over control. Application of GA_3 at 20 ppm reduced the seed number in fruits by 61 per cent over control. All the treatments improved fruit quality in terms of higher TSS and reduced acidity over control. Treatments GA_3 20 ppm and sucrose 15 per cent applied at given at full bloom stage proved efficient in improving fruit set and increasing fruit yield.

Key words: Boric acid, fruit set, GA_3, petal fall stage, sucrose.

INTRODUCTION

Pear is one of the superior temperate fruit. It is considered third of deciduous and fourth among all fruits in its global distribution (FAO, 5). It is being grown in both the temperate and the sub-tropical conditions, because of its comparatively low chilling requirements and adaptations to wide range of soil conditions. In India, pear ranks second among temperate fruits both in area and production. The pear varieties grown commercially in India belong to either *Pyrus communis* or *Pyrus pyrifolia* or the hybrids of these two species. Though, the major area is under Patharnakh (*P. pyrifolia* Burm. F. Nakai), yet the area under semi-soft pears (inter-specific hybrids between *P. communis* and *P. pyrifolia*) is considerably increasing. A strain of semi-soft pear 'Punjab Beauty' has been released few years back for general cultivation in the Punjab state. This variety is also becoming popular in adjoining areas of north-west India. Its fruit has good flavour and are more characteristic red blush, which makes it very attractive. Despite of its advantages growers are hesitant to grow semi-soft pears mainly because of their shy bearing habit. The shy bearing habit may be due to numerous factors like abortion of ovules, defective flowers, dichogamy, poor pollen germinability, premature or delayed pollination, competition among flowers and leaves, excessive flower abscission and low fruit retention. The pathway to increase yield is to increase the fruit set. Due to non-synchronization of bloom period of any other commercial pear variety with that of Punjab Beauty, it is imperative to improve fruit set by reducing the flower and pistil drop with the use of cross pollination, plant growth regulators (PGRs), nutrients and chemicals (Mostafa *et al*., 11). Apart from crop regulation, the growth regulators also contribute towards fruit growth and development. Some of the plant growth regulators and biochemicals are synthesized endogenously, but occasionally, they need to be supplemented exogenously for the intended purpose of improving fruit set, quality and yield (Goldwin, 6). Application of synthetic gibberellins is widely known to improve fruit set in apple and pear. Application of bio-regulators by using both GA_3 and GA_3 + GA_{4+7} sprayed at 12 ml ha^{-1} shortly after full bloom to pear tree gave best fruit set of 78 and 77 per cent, respectively as compared to unsprayed control with 32 per cent (Ouma, 12). Wojick and Wojick (14) reported the increase in fruit set of 'Conference' pear at full bloom with foliar application of boric acid 0.2 kg/ha in spring and 0.8 kg/ha in fall. Significant initial fruit set was recorded with 5 per cent sucrose application at full bloom in two successive seasons for Le Conte pear. Also 20 per cent sucrose spray at full bloom resulted in highest final fruit set (Yehia and Hassan, 15). Keeping in view the above points, the present investigation was undertaken to assess the effect of different chemicals, *viz*. GA_3, boric acid and sucrose on fruit set and yield of pear cv. Punjab Beauty.

MATERIALS AND METHODS

A field experiment was conducted on 12-year-old trees of uniform vigour during 2008-2009 at New

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Orchard, Punjab Agricultural University, Ludhiana. The experiment was laid out in Randomized Block Design and was replicated three times. A single tree served as treatment unit. Three concentrations of each GA_3 (10, 20 and 30 ppm), sucrose (5, 10 and 15%) and boric acid (100, 200 and 300 ppm) were sprayed at full bloom and petal fall stages.

Observations on fruit set were recorded with respect to flower number after petal fall at pea stage. The number of fruit set and harvested fruits from three tagged branches on each tree were counted. The difference based on the former was expressed as per cent fruit drop. Per cent fruit retention from tagged branches was calculated by difference of fruit set and fruit drop. The fruits from the whole tree was harvested at the physiological mature stage and fruits were weighed to record the yield. After harvest, each fruit was cut cross section wise and bold seed number was counted. The length and diameter of fruits were measured with the help of Digimatic Callipers. The fruit colour was observed by Royal Horticultural Society Colour chart. The TSS, acidity and reducing sugars were estimated as per the methods given by AOAC (1). The statistical analysis of the data on all the parameters was carried out on factorial arrangement in randomized block design using 10 treatments at two bloom stages, as per the procedure described by Gomez and Gomez (7).

RESULTS AND DISCUSSION

Fruit set is one of the most important factors, which decide the net production potential of the fruit crop. All the chemicals tested in this study to improve the fruit set showed that their application at full bloom stage was better as compared to the petal fall stage (Table 1). A significant increase in yield was recorded over control with all the treatments. Sucrose at 15 per cent significantly enhanced fruit set when compared with other chemicals. It is well documented that fruit set is the resultant of gibberellins produced by immature seeds following pollination and fertilization, while GA, if applied to unfertilized flowers induced parthenocarpic fruit set (Dennis, 4). The general desirable effects of sucrose and boric acid applications could be attributed to enhanced pollen germination and pollen tube growth which increases fruit set and yield (Yehia and Hassan, 15). The application of boron reported to improve the fruit set in LeConte pear (Badawi *et al*., 2). Thus, exogenous application of GA_3 and sucrose on pear trees has shown good response. Significantly lower fruit drop was obtained with GA_3 20 ppm. This was followed by sucrose 15 per cent and GA_3 30 ppm, which reduced fruit drop significantly as compared to the control. When the stage of application was compared, comparatively low fruit drop was obtained at full bloom stage (Table 1).

Non significant differences were observed in fruit retention when comparison was made two stages of application in all treatments (Table 1). However, it was better when the treatments were applied at full bloom stage. All the treatments proved to enhance fruit retention in comparison to control. The maximum mean fruit retention was recorded with GA_3 20 ppm. The minimum number of seeds/fruit was obtained with GA_3 20 ppm. The next best treatments were GA_3 10 and 30 ppm for reducing seed number in fruits. These treatments lowered the seed number in comparison to the control. Sucrose and boric acid treatments had no effect on seed numbers in the fruits. The minimum seed number was recorded with GA_3 20 ppm both at full bloom and petal fall stages. The findings of Honeyborne (9) also suggest that the number of normal seeds per fruit was significantly lower in GA_3 treated fruits and a large proportion of treated fruits were parthenocarpic.

The stage of application for different chemicals did not affect the fruit length (Table 2). Different treatments do caused significant effect on fruit length. Maximum fruit length was observed with GA_3 20 ppm. The other concentrations of GA_3 (10 & 30 ppm) also recorded fruit length comparable with GA_3 20 ppm. All the treatments increased the fruit length as compared to control, except sucrose 15 per cent. Application of sucrose 10 and 15 per cent and boric acid 100 ppm at full bloom stage and sucrose 15 per cent at petal fall stage gave results statistically at par with the control. More fruit length with gibberellins treatment was because of auxin balancing power of GA due to that carpel developed at a faster rate. Fruit diameter was more when treatments were applied at full bloom stage as compared to petal fall stage (Table 2). Mean fruit diameter was significantly affected by different spray treatments. Fruit diameter with the application of sucrose 15 per cent was significantly higher than control. The data also supports that stage of application and treatment affected the fruit diameter. Sucrose 10 per cent when applied at full bloom stage gave maximum fruit diameter. Similar results were also obtained with sucrose 15 per cent, boric acid 300 ppm, sucrose 5 per cent and boric acid 200 ppm all at full bloom stage. Increase in flowering may lead to more fruits and coupled with increase in fruit size may be determined by increased cell layer formation and cell division, and increased sink strength of fruit. Fruit size increase due to cytokinins and gibberellins application to apple, cucumber and grape was suggested to be caused by increased cell division and elongation and cell wall extensibility (Batlang, 3).

Table 1. Effect of chemicals sprayed at different flowering stages of semi-soft pear cultivar 'Punjab Beauty' on fruit set, fruit drop, fruit retention and seed number (mean data).

Treatment	Fruit set (%)			Fruit drop (%)			Fruit retention (%)			Seed number		
	Full bloom	Petal fall	Mean	Full bloom	Petal fall	Mean	Full bloom	Petal fall	Mean	Full bloom	Petal fall	Mean
GA_3 10 ppm	5.31	4.26	4.78	34.74	39.38	37.01	65.22	60.60	62.91	2.17	2.29	2.23
GA_3 20 ppm	7.51	5.61	6.56	27.94	32.17	30.05	72.04	67.84	69.94	2.00	2.00	2.00
GA_3 30 ppm	6.68	5.01	5.85	38.39	34.40	36.40	61.67	65.68	63.67	2.49	2.29	2.39
Sucrose 5%	5.20	4.98	5.09	51.26	45.92	48.59	48.64	54.09	51.37	4.17	4.43	4.30
Sucrose 10%	6.12	5.83	5.97	41.49	40.41	40.95	58.51	59.62	59.06	4.67	4.87	4.77
Sucrose 15%	7.36	7.22	7.29	40.82	31.20	35.99	59.24	68.85	64.04	4.67	4.87	4.77
Boric acid 100 ppm	6.82	5.39	6.10	42.48	42.06	42.27	57.47	57.44	57.46	4.67	4.67	4.67
Boric acid 200 ppm	5.16	5.16	5.16	44.38	43.46	43.92	58.57	56.47	57.52	4.67	4.73	4.70
Boric acid 300 ppm	4.62	4.59	4.61	42.99	45.96	44.47	57.02	54.14	55.58	5.17	5.17	5.17
Control	3.13	3.13	3.13	61.75	61.45	61.6	38.40	38.25	38.32	5.17	5.17	5.17
Mean	5.79	5.16		42.62	41.64		57.68	58.30		3.98	4.05	
$CD_{0.05}$												
Stage		0.02			0.63			NS			0.10	
Treatment		0.05			1.42			4.58			0.22	
Interaction		0.07			2.01			6.48			0.31	

Table 2. Effect of chemicals sprayed at different flowering stages of semi-soft pear cultivar 'Punjab Beauty' on fruit length, fruit diameter, fruit weight and yield (mean data).

Treatment	Fruit length (cm)			Fruit diameter (cm)			Fruit weight (g)			Fruit yield (kg/tree)		
	Full bloom	Petal fall	Mean	Full bloom	Petal fall	Mean	Full bloom	Petal fall	Mean	Full bloom	Petal fall	Mean
GA_3 10 ppm	7.01	7.23	7.12	5.83	5.74	5.78	115.59	118.93	117.26	44.00	38.95	41.48
GA_3 20 ppm	7.08	7.24	7.16	5.32	5.14	5.23	106.30	108.87	107.58	47.68	45.375	46.53
GA_3 30 ppm	7.41	6.81	7.11	5.47	5.66	5.56	110.09	113.22	111.65	42.53	41.635	42.08
Sucrose 5%	6.89	6.76	6.82	6.13	6.08	6.10	117.90	115.24	116.57	33.85	33.69	33.77
Sucrose 10%	6.43	6.51	6.47	6.26	6.06	6.16	117.48	108.39	112.93	38.64	38.915	38.78
Sucrose 15%	6.17	6.38	6.28	6.23	6.11	6.17	113.42	107.14	110.28	41.79	47.325	44.56
Boric acid 100 ppm	6.42	6.53	6.47	6.13	5.54	5.83	109.25	109.75	109.50	37.12	35.55	36.33
Boric acid 200 ppm	6.85	6.74	6.79	6.02	5.52	5.77	109.35	112.17	110.76	38.87	35.75	37.31
Boric acid 300 ppm	6.74	6.80	6.77	6.17	5.74	5.96	119.67	117.30	118.48	36.62	35.6	36.11
Control	6.38	6.15	6.26	5.85	5.85	5.85	108.74	108.59	108.66	29.35	30.6	29.99
Mean	6.73	6.71		5.94	5.74		112.78	111.96		39.04	38.339	
$CD_{0.05}$												
Stage		NS			0.10			0.08			0.65	
Treatment		0.07			0.23			0.17			1.45	
Interaction		0.10			NS			0.243			2.06	

There was a significant difference in fruit weight at both stages of chemical application (Table 2). Fruits were heavier when treatments were applied at full bloom stage as compared to that of at petal fall stage. Boric acid at 300 ppm had the maximum effect on mean fruit weight. The next best treatments which increased fruit weight were GA_3 (10 ppm) and sucrose (5%). Heavier fruits with these treatments might be attributed to lower fruit set and lower yield than other treatments due to that, more photosynthates were available to lesser number of fruits on a tree. However, the maximum fruit weight was recorded with GA_3 10 ppm at petal fall stage. The next best treatments were boric acid 300 ppm at petal fall stage and sugar 5 per cent at full bloom stage. The minimum fruit weight was obtained by GA_3 20 ppm at full bloom stage and sucrose 15 per cent at petal fall stage and these treatments recorded even lower fruit weight than control treatment. These results confirm the thesis of additional fruit growth after GA application (Looney *et al.*, 10).

The fruit yield was significantly affected by the concentration of chemicals applied and stage of their application. Higher fruit yield (kg/tree) was obtained when treatments were applied at full bloom stage than at petal fall stage (Table 2). Fruit yield was significantly affected by different treatments. 'Punjab Beauty' pear trees produced highest mean yield when treated with GA_3 20 ppm, which was significantly higher than all other treatments. GA_3 20 ppm sprayed at full bloom resulted in higher yield followed by sucrose 15 per cent sprayed at petal fall stage. The highest fruit yield was recorded with GA_3 20 ppm at full bloom stage, which differed significantly from petal fall stage applications. Second best treatments were sucrose 15 per cent and GA_3 20 ppm sprayed at petal fall stage, which also proved useful in improving fruit yield. Minimum mean fruit yield was obtained from control trees. The higher fruit yield among these treated trees was the result of higher fruit set and higher fruit retention. The application of GA_3 would have provided additional stimulus and supplemented the levels of growth promoting substances, which were synthesized *de novo* in plant and resulted in higher yield. The application of sucrose might have increased the yield by stimulating the translocation and mobilization of metabolites, photosynthates and carbohydrates to fruits in large amounts (Singh, 13).

The TSS content of pear juice was not affected by stage of application of different chemicals (Table 3). However, different treatments significantly affected the TSS content. The mean TSS was highest with boric acid 100 ppm. All treatments produced higher amount of TSS as compared to control. While comparing different treatments and stages of application, boric acid 100 ppm, when sprayed at full bloom stage gave maximum TSS. Sucrose 15 per cent sprayed at both full bloom and petal fall stages gave similar TSS value. These chemicals hasten the hydrolysis or degradation of starch into simpler sugars or loading/ mobilization of simple sugars into fruits by the use of boron and the conversion of soluble sugars into ascorbic acid, which is a major component of TSS in pear. A similar increase in TSS was obtained with GA_3 and boric acid treatments in LeConte pear (Hegazi, 8). There were no significant differences among different stages of chemical application regarding acid content in pear fruit juice. Sucrose 15 per cent yielded the lowest mean acidity, where as sucrose 10 per cent, GA_3 10 ppm, GA_3 30 ppm were statistically at par with it. Sucrose 15 per cent had minimum acidity for both full bloom and petal fall sprays. Maximum acidity, however, was recorded in control treatment. The stages at which the chemicals were sprayed had no significant effect on TSS/acid ratio (Table 3). However, petal fall stage had more TSS/acid ratio as compared to that of full bloom stage. All treatments significantly increased TSS/acid ratio. The maximum increase in TSS/acid ratio was recorded with the application of sucrose 15 per cent. While comparing stage and treatment together, sucrose 15 per cent sprayed at full bloom gave the highest TSS/acid ratio. TSS/acid ratio is the direct outcome of the TSS and acidity produced by different treatments. The treatments which recorded higher TSS and lower acidity noted higher TSS/acid values.

No significant differences in reducing sugars were recorded among the stages at which chemicals were applied (Table 3). Within the treatments, the maximum mean reducing sugars were recorded with boric acid 100 ppm and sucrose 15 per cent. All other treatments increased reducing sugars, except boric acid 300 ppm, which was statistically at par with the control. However, stage of application had some effect on reducing sugars. Boric acid at 100 ppm applied at full bloom stage produced highest amount of reducing sugars. The control treatment rendered lowest level. The colour development as bright yellow green (YGG 145 A) was observed in fruits obtained from plants treated with sucrose 15 per cent both at full bloom and petal fall stages and sucrose 10 per cent at full bloom stage (Table 4). The colour development of fruit is considered a desirable character for local consumption. The fruits which have attractive colour fetch better market value due to good visible appeal. Relatively poor colour development, *i.e.* Light yellow green (YGG 145 C) was observed with GA_3 30 ppm (both at full bloom and petal fall

Table 3. Effect of chemicals sprayed at different flowering stages of semi-soft pear cultivar 'Punjab Beauty' on TSS, acidity, TSS/acid ratio and reducing sugars.

Treatment	TSS (%)			Acidity (%)			TSS/ acid ratio			Reducing sugars (%)		
	Full bloom	Petal fall	Mean	Full bloom	Petal fall	Mean	Full bloom	Petal fall	Mean	Full bloom	Petal fall	Mean
GA_3 10 ppm	13.04	13.05	13.04	0.225	0.260	0.243	58.6	50.3	54.5	7.24	7.52	7.39
GA_3 20 ppm	13.45	13.45	13.45	0.275	0.275	0.275	48.9	48.9	48.9	7.67	7.82	7.74
GA_3 30 ppm	13.07	13.27	13.17	0.255	0.255	0.255	51.3	52.0	51.7	7.83	7.72	7.77
Sucrose 5%	12.42	13.34	12.88	0.295	0.290	0.293	42.1	46.0	44.1	7.54	7.44	7.49
Sucrose 10%	13.44	13.54	13.49	0.255	0.255	0.255	52.7	53.1	52.9	7.61	7.82	7.71
Sucrose 15%	13.74	13.74	13.74	0.245	0.245	0.245	56.1	56.1	56.1	7.95	8.02	7.98
Boric acid 100 ppm	14.14	13.87	14.00	0.275	0.270	0.273	51.4	51.4	51.4	8.04	7.99	8.02
Boric acid 200 ppm	13.57	12.90	13.23	0.285	0.290	0.288	47.6	44.5	46.1	7.80	7.27	7.53
Boric acid 300 ppm	13.24	13.04	13.14	0.295	0.295	0.295	44.9	44.2	44.5	7.24	7.24	7.24
Control	12.70	12.15	12.43	0.360	0.335	0.348	35.6	36.3	36.0	7.12	7.07	7.09
Mean	13.27	13.23		0.276	0.277		48.9	48.3		7.60	7.59	
CD (%)												
Stage		NS			NS			NS			NS	
Treatment		0.26			0.02			3.75			0.06	
Interaction		0.36			NS			NS			0.09	

Table 4. Effect of chemicals sprayed at different flowering stages of semi-soft pear cultivar 'Punjab Beauty' on fruit colour.

Treatment	Full bloom stage	Petal fall stage
GA_3 10 ppm	YGG 145 B (Yellow green)	YGG 145 B (Yellow green)
GA_3 20 ppm	YGG 145 B (Yellow green)	YGG 145 B (Yellow green)
GA_3 30 ppm	YGG 145 C (Light yellow green)	YGG 145 C (Light yellow green)
Sucrose 5%	YGG 145 B (Yellow green)	YGG 145 B (Yellow green)
Sucrose 10%	YGG 145 B (Yellow green)	YGG 145 C (Light yellow green)
Sucrose 15%	YGG 145 A (Bright yellow green)	YGG 145 A (Bright yellow green)
Boric acid 100 ppm	YGG 145 C (Light yellow green)	YGG 145 C (Light yellow green)
Boric acid 200 ppm	YGG 145 B (Yellow green)	YGG 145 C (Light yellow green)
Boric acid 300 ppm	YGG 145 C (Light yellow green)	YGG 145 C (Light yellow green)
Control	YGG 145 B (Yellow green)	YGG 145 B (Yellow green)

stage), boric acid 200 ppm (petal fall stage), boric acid 300 ppm (both at full bloom and petal fall stage). The colour development of yellow green (YGG 145 B) of pear fruits was observed in rest of the treatments, which also attained consumer appeal and had good acceptability from the market point of view.

In overall, GA_3 20 ppm and sucrose 15 per cent sprayed at full bloom stage increased fruit set and resultantly fruit yield of Punjab Beauty pear.

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