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Effect of prohexadione calcium and chlormequat chloride on growth, yield and fruit quality of pear under high density planting

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ABSTRACT

The present experiment was conducted to evaluate the effect of plant bioregulators (PBRs) on vegetative growth, fruit yield and quality of quality of pear cv. Patharnakh trained on Y-trellis system. The foliar applications of prohexadione calcium (100, 200 and 400 ppm) and chlormequat chloride (250, 500 and 1000 ppm) was done on eight-years-old trees at 10 days after full bloom. The control trees were sprayed with water only. Observations on vegetative growth, fruit number/plant, fruit size, fruit quality and leaf nutrients were recorded. Reduction in pruning wood weight without any effect on return bloom was observed with different PBR treatments. Prohexadione calcium (400 ppm) was found most effective in reducing shoot number (70) and internodal length (4.18 cm). This treatment also increased fruit number (83 per tree), fruit size (8.04 cm × 7.51 cm), TSS content (12.33 °Brix), fruit firmness (62.94 N), and reducing sugars content (7.00%); however, the titratable acidity was not affected. As compared to control, fruit yield of pear tree was significantly improved (~35%) with the Pro-Ca 400 or 200 ppm treatments. Similarly, higher dose of chlormequat chloride (500 or 1000 ppm) significantly reduced the shoot number and intermodal length, and increased fruit yield as compared to control. The PBR treatments reduced the leaf nitrogen content but increased leaf phosphorus and potassium levels.

Key words: Pear, Prohexadione calciium, chlormequat chloride, High density planting.

INTRODUCTION

In India, pear is the second important temperate fruit crop after apple. Low chill cultivars of pear are successfully cultivated under subtropical conditions of north-western parts of India. Among various released pear cultivars for Punjab state, 'Patharnakh' occupies majority of pear growing area due to its high yield potential and resistance to various biotic and abiotic stresses. Pear has long juvenile period and during pre-bearing phase, large area is left unutilized due to wider tree spacing (7.5m × 7.5 m) under conventional system of planting.

Winter pruning is one of the methods used extensively to manage tree canopy which might increase vegetative growth, and negatively affect flowering and fruiting for next season (Albarracin *et al*., 2). Summer pruning during active growth is also a effective strategy but it adversely affect the fruit yield and return bloom (Asin *et al*., 3). So, the use of PBRs can be an appropriate strategy that efficiently regulates the vegetative growth. Chlormequat chloride (CCC) is the well-known onium compound that blocks the conversion of geranyl geranyl diphosphate into *ent*-kaurene; while, prohexadione calcium acts on the later stages of conversion of inactive GAs into active GAs (Rademacher, 15). Prohexadione calcium treatments have been used to increase fruit production along with the reduction in requirement of winter pruning in 'Hosui' pear (Hawerroth *et al*., 8) and in 'D'Anjou' pear (Einhorn *et al*., 7). Similarly, chlormequat chloride is reported to inhibit the growth and improve yield in 'Blanquilla' and 'Conference' pear (Asin and Vilardell, 4). However, most of these studies were conducted on temperate region and grown under conventional system of planting. Moreover, no information is available on effect of these bio-regulators on low chill pear cultivars grown under subtropical plains trained on Y-trellis system. Hence, the present study was undertaken to investigate the efficiency of bio-regulators on growth, yield and fruit quality of subtropical pear cv. 'Patharnakh' trained on the Y-trellis system.

MATERIALS AND METHODS

The present study was executed at Fruit Research Farm, Punjab Agricultural University, Ludhiana (30.903° N latitude, 75.79° E longitude and 244 m above msl altitude) and the experimental site represents the subtropical conditions. Foliar application of PBRs namely Regalis™ Plus (prohexadione calcium 10% WG @ 100, 200 and 400 ppm) and chlormequat chloride (250, 500 and 1000 ppm) was done at 10 days after full bloom (DAFB) on eight-years-old 'Patharnakh' pear trees raised on *Pyrus pashia* rootstock. Control trees were sprayed with water only. Experimental pear trees

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were established on Y-trellis training system at 3 m × 3 m spacing. Vegetative parameters were recorded after the onset of dormancy. The annual shoots were pruned during January month, and their number was counted. The internodal length of twenty-five uniform pruned shoots was measured using a measuring tape. The length of spurs was measured using digital vernier caliper. Length of 25 uniform annual pruned shoots was measured during the period of rest in the month of January. All the pruned shoots were weighed using manual platform weighing scale and represented as pruning wood weight (kg/tree).

Fruit number from each replicated unit was counted in the month of July. Fruit yield (kg/plant) was calculated from product of average fruit weight and number of fruits/ plant. Return bloom (average number of flowers/meter shoot) in control and treated trees were evaluated during following season. After harvesting, the sample of twenty fruits from each replication was subjected to fruit quality analysis. Fruit length and diameter were measured using digital vernier calipers (Mitutoyo, Japan). TSS content was measured by digital hand refractometer (Atago, Japan). Fruit firmness was recorded from the peeled surface of fruit using stand mount fruit penetrometer (Model FT-327, USA) and Newton (N). Titratable acidity of fruit was expressed as malic acid (%) measured by titrating fruit juice against 0.1 N NaOH. The percent reducing sugars in pear fruit were estimated using the method given by AOAC (1). Leaf nutrient estimation for primary macro-nutrients was done from the leaves sampled during August from the middle of the shoots. Total nitrogen (N), phosphorus (P) and potassium (K) contents in the leaves were determined by Micro Kjeldahl's method (Issac and Johnson, 9), Vanado-molybdo phosphoric yellow colour method (Chapman and Pratt, 5) and Flame photometer (Jackson, 10), respectively. The experiment was laid out in Randomized Block Design. Each treatment unit contained three replications. The data recorded were analyzed by the ANOVA method using SAS 9.3 software. The mean separation was done by LSD ($p \leq 0.05$).

RESULTS AND DISCUSSION

The effect of plant bio-regulators on different vegetative parameters, fruit yield and return bloom of 'Patharnakh' pear is presented in Fig.1. The application of PBRs significantly reduced the number of shoots in the 'Patharnakh' pear plants. The number of shoots were reduced up to 23 % in Pro-Ca 200 and 400 ppm treated pear trees as compared to the control. Chlormequat chloride treated trees was statistically at par with control. Similar reductions in shoot number have also been reported in apple and pear (Hawerroth *et al*., 8; Rademacher,14). Internodal length of shoots was also affected by different treatments, and minimum internodal length (4.18 cm) was noticed in Pro-Ca 400 ppm treatment, which was statistically at par with Pro-Ca 200 ppm treatment. The number of shoots in control trees was found and have the highest inter-nodal length (5.37 cm), which proved statistically at par with CCC 250 ppm treatment. The internodal length of the pear plant shoots was reduced by 22.16 % with the application of Pro-Ca 400 ppm. Reduction in the internodal length represents the GA inhibiting action of plant bio-regulators. Similarly, Medjdoub *et al*. (13) and Lal *et al*. (12) obtained shorter internodes in Pro-Ca treated apple and pear trees, respectively.

Weight of pruned wood of pear tree was significantly reduced with PBR treatments (Fig. 1). Pro-Ca 200 and 400 ppm reduced pruning wood weight of pear by ~35 % as compared to control. The pruning wood weight recorded in CCC 250,500 and 1000 ppm treatments was statistically at par with control plants. Reduction in weight of pruned shoots in pear trees with Pro-Ca treatments had also been reported by Hawerroth *et al*. (8) which ultimately minimized the need for winter pruning. The spur length was not affected by any growth regulator treatment. However, minimum spur length (4.95 cm) was recorded in Pro-Ca 200 ppm treatment and it was maximum in control plants. The PBRs did not have any effect on the return bloom on pear trees (Fig.1). However, the highest return bloom was observed with Pro-Ca 400 ppm, while it was found to be the lowest with CCC 500 ppm treatment. Treatments that resulted in higher yields during previous year had no effect on return bloom in next year. Our findings in case of return bloom are in the conformity with those of Asin *et al*. (3) in pear trees.

The number of fruits/ plant increased significantly with the use of tested PBRs (Table 1). Overall, Pro-Ca was more effective in improving fruit number/ plant than CCC application. Highest number of fruits/plant was obtained under Pro-Ca 400 ppm treatment, which was closely followed by Pro-Ca 200 ppm application. The fruit number/plant recorded in pear trees with CCC treatments was statistically at par with control. Rademacher *et al*. (14) also reported that the Pro-Ca applications improved fruit set and ultimately the number of fruits/plant in apple. The maximum fruit length (8.04 cm) was recorded in pear trees treated with Pro-Ca 400 pm which was significantly superior to CCC 250 ppm and control treatments, but was at par with other CCC treatments. Pro-Ca 400 ppm application increased fruit yield/plant by ~ 36.5 % as compared

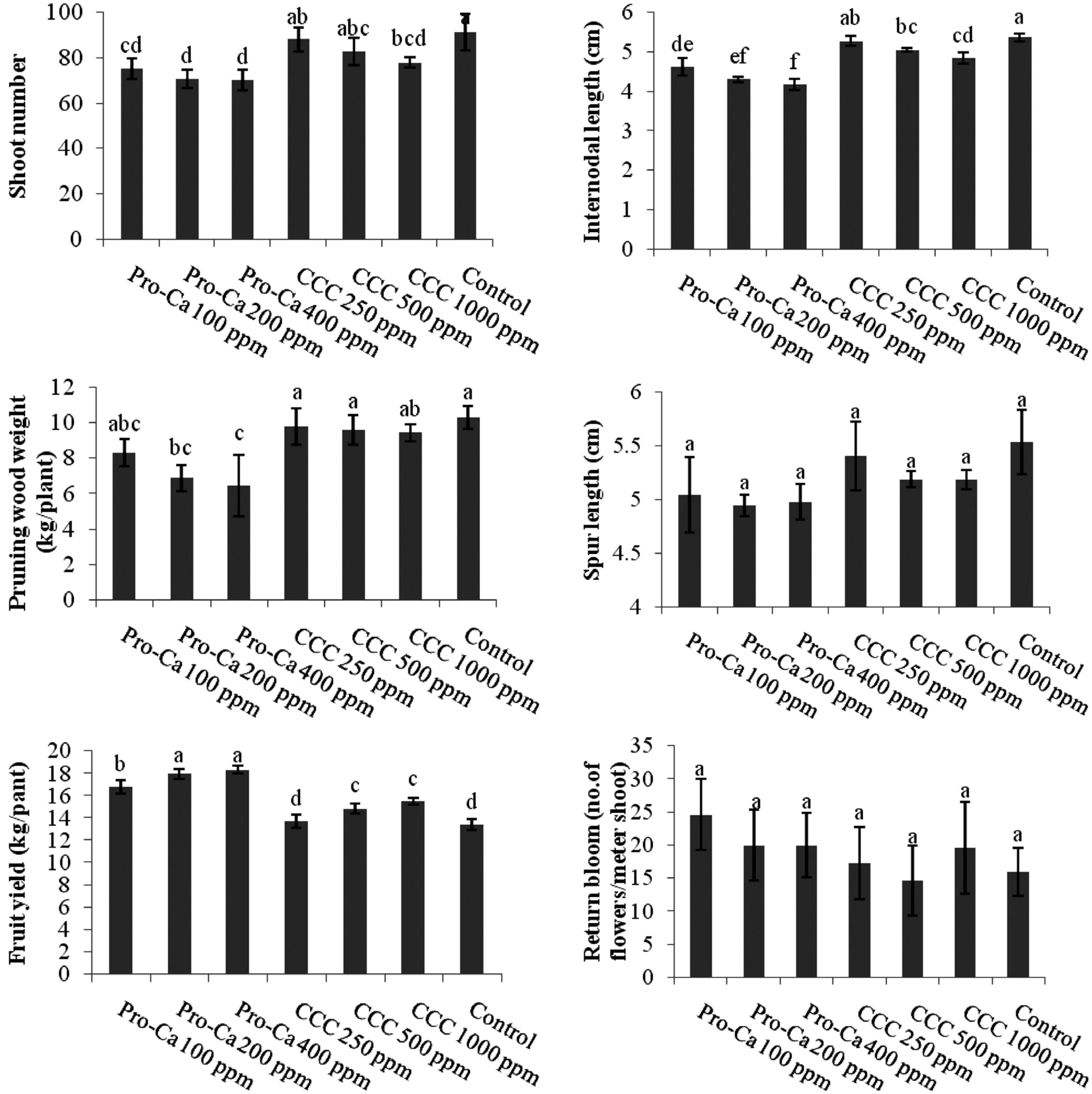

Fig. 1. Effect of plant bio-regulators on the shoot number, internodal length, pruning wood weight, spur length, fruit yield and return bloom. Vertical bars represent standard deviation of mean and alphabetical letters represent significant mean separation at LSD (*p≤0.05*).

to control. Among the CCC treatments, the highest (15.52 kg/plant) and the lowest (13.75 kg/plant) fruit yields were recorded in CCC 1000 ppm and CCC 250 ppm treatments, respectively. Increase in fruit yield with Pro-Ca treatment had also been reported by Lal *et al*. (12). However, fruit diameters were not affected by any treatment although maximum (7.51 cm) and minimum (6.71cm) fruit diameter was recorded with Pro-Ca 400 ppm and CCC 250 ppm treatments, respectively. These findings are similar to the findings of Medjdoub *et al*. (13), observed in apple.

Pro-Ca 400 ppm resulted in largest fruits of 'Patharnakh' pear as compared to other treatments (Table 1).The increase in fruit size may be attributed to the reduction in competition between the vegetative and reproductive sinks due to application of growth retardants (Costa *et al*. 6). In accordance with

Table 1. Effect of plant bio-regulators on the number of fruits/ plant, fruit size and fruit quality of 'Patharnakh' pear.

Treatment	Fruit number/ plant	Fruit length (cm)	Fruit diameter (cm)	TSS (°Brix)	Fruit firmness (N)	Titratable acidity (%)	Reducing sugars (%)
Pro-Ca 100 ppm	80.33[bc]	7.77[a]	7.11[a]	11.87[abc]	56.57[bc]	0.38[a]	6.44[ab]
Pro-Ca 200 ppm	82.33[ab]	7.63[ab]	7.27[a]	12.10[ab]	59.98[ab]	0.36[a]	6.82[a]
Pro-Ca 400 ppm	83.00[a]	8.04[a]	7.51[a]	12.33[a]	62.94[a]	0.34[a]	7.00[a]
CCC 250 ppm	78.33[c]	7.12[bc]	6.71[a]	11.30[cd]	52.34[cd]	0.40[a]	4.70[cd]
CCC 500 ppm	78.33 [c]	7.57[abc]	6.81[a]	11.47[bcd]	53.82[cd]	0.40[a]	5.50[bc]
CCC 1000 ppm	79.00[c]	7.68[ab]	7.05[a]	11.57[bcd]	54.86[c]	0.38[a]	6.18[ab]
Control	78.00[c]	7.03[c]	6.71[a]	11.07[d]	49.72[d]	0.42[a]	4.19[d]

Alphabetical letters denote significant mean separation at LSD (*p≤0.05*).

present findings, Medjdoub *et al*. (13) reported a positive deviation in fruit size in Pro-Ca treated 'Smoothe Golden Delicious' apple trees. Our results showed that the highest dose of Pro-Ca increased fruit yield in pear plants by 1.44 times over the untreated plants. Fruit quality was significantly improved with the PBR treatments (Table 1). The highest (12.33 °Brix) and lowest (11.07 °Brix) TSS were obtained in fruits of trees treated with Pro-Ca 400 ppm and control, respectively. Among the CCC treatments, highest (11.75 °Brix) and lowest (11.30 °Brix) TSS were observed in the fruits of trees treated with CCC 1000 ppm and CCC 250 ppm, respectively, which were at par with control. The firmness of pear fruits was maximum (62.94 N) in the Pro-Ca 400 ppm treated plants as compared to all treatments, except Pro-Ca 200 ppm treatment. Reducing sugars content in fruits was also found higher under Pro-Ca 400 ppm (7.00 %) followed by Pro-Ca 200 ppm (6.82 %) treatment. Fruit acidity was nonsignificantly affected by the treatments. Pro-Ca 400 ppm treatment resulted in less acidic (0.34%) fruits, where control treated tended to produce fruits with high acid content (0.42%). Similar to our results, Lal *et al*. (12) had also reported that Pro-Ca resulted in the production of firmer fruits with increased TSS and fruit sugars with no effect on acidity.

Estimation of primary leaf macro-nutrients revealed that the leaf N, P and K contents were altered by the PBR treatments over control (Table 2). In general, leaf N content decreased, and P and K tended to increase with PBR treatments. Leaf N content was reduced by ~15 %, and its lowest value was obtained in trees treated with Pro-Ca 100, 200 or 400 ppm treatments. The maximum leaf N content was recorded in CCC 250 ppm treated trees, which was statistically at par with CCC 500 ppm and control treatments. There was ~7% increase in leaf P content incurred by the Pro-Ca 200 or 400 ppm treatments. Similarly, leaf K content was significantly increased under Pro-Ca 100, 200 or 400 ppm as compared to control and CCC 250 ppm treatment, but proved similar statistically at par with other treatments. The changes in leaf macro nutrient contents with PBR treatments had also been reported by Javaid and Misgar (11) in apple.

Table 2. Effect of plant bio-regulators on the leaf nutrient content of leaves of 'Patharnakh' pear.

Treatment	N (%)	P (%)	K (%)
Pro-Ca 100 ppm	1.96[c]	0.181[b]	1.1[a]
Pro-Ca 200 ppm	1.94[c]	0.185[a]	1.1[a]
Pro-Ca 400 ppm	1.86[c]	0.186[a]	1.1[a]
CCC 250 ppm	2.26[a]	0.176[cd]	0.8[b]
CCC 500 ppm	2.17[ab]	0.178[bc]	0.9[ab]
CCC 1000 ppm	2.11[b]	0.179[bc]	0.9[ab]
Control	2.27[a]	0.173[d]	0.7[b]

Alphabetical letters denote significant mean separation at LSD (*p≤0.05*).

It can be summarized that the application of Pro-Ca 400 ppm to 'Patharnakh' pear trees proved most effective in overall growth management, and higher yield of good quality fruits. A reduction in vegetative growth and improved fruit yield was also observed with 1000 ppm chlormequat chloride, however, no significant effect of this treatment was observed on fruit quality parameters.

AUTHORS' CONTRIBUTION

Conceptualization of research (Kaur S. and Singh M.); Designing of the experiments (Singh M. and Gill P.P.S.); Contribution of experimental materials (Kaur S. and Singh N.); Execution of field/ lab experiments and data collection (Kaur S. and Singh M.); Analysis of data and interpretation (Kaur S. and Singh N.); Preparation of the manuscript (Kaur S., Singh M. and Gill P.P.S.).

DECLARATION

The authors declare no conflict of interest.

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