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Effect of plant bio-regulators on fruit growth, quality and productivity of pear [*Pyrus pyrifolia* (Brum.) Nakai] cv Gola under *tarai* condition

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Abstract

Pear (*Pyrus* spp.) mainly cultivated in the temperate Himalayan region of India, is an important fruit crop. Although, it is a temperate fruit but *tarai* region of northern India have great potential for growing different low chilling cultivars of this fruit. But the main problem of these low chill cultivars in this area is vigorous growth with shy bearing habit with heavy fruit drop and poor fruit growth resulting very low yield with much inferior fruit quality as compared to fruits produced in temperate region. Plant bio-regulators have the great potential to boost up reproductive growth resulting higher yield with better quality fruits under *tarai* region. Hence, a field experiment was conducted to study the role of different plant bio-regulators (PBRs) to prevent fruit drop and to improve fruit growth, quality and the productivity of low chill pear cv Gola. Fifteen years old Gola trees were foliar sprayed or soil drenched with different PBRs *viz.,* gibberellin (GA_3), benzyl adenine (BA) and paclobutrazol (PP_{333}) at petal fall (PF) stage followed by two and four weeks after PF or at late fall stage. The results indicate that different treatments had significant effect on all the parameters studied. Minimum fruit drop and maximum productivity was depicted in foliar and soil application of PP_{333} followed by foliar spray of GA_3. However, fruit growth (length and width) and volume at maturity and total sugar content was recorded maximum in combined application of GA_3 and BA. Foliar as well as soil application of PP_{333} was also found effective for increasing the sugar content of the fruit while maximum TSS to acid ratio was also recorded in these two treatments. Based on results, it could be said that the foliar as well as the soil application of PP_{333} is highly effective for controlling shy bearing problem with minimal fruit drop and improved fruit quality resulting higher productivity of marketable fruits of better quality.

Key words: Pear, plant bio-regulators (PBRs), trunk soil line pore (TSLP), productivity, total sugar content, TSS to acid ratio.

Introduction

Among temperate fruits, pear ranks second, next to apple with respect to global importance, diversity of existence, acreage and production. About 109.62 million tonnes of pears are now produced annually around the world, of which 0.382 million tonnes are produced in India. In India, pear cultivation is mainly confined to the temperate Himalayan mountains which have ideal conditions to grow European (*Pyrus communis* L.) and oriental [*P. pyrifolia* (Burm.) Nakai] pear. However, selection and development of low chill pear cultivars (Janick, 1991) had made its cultivation possible in *tarai* regions of Uttar Pradesh, Punjab and Uttarakhand which receives sufficient amount of cold in winters, necessary for meeting the chilling requirement and mild temperature, suitable for flowering and better fruit set. Among different low chill cultivars of pear, cultivation of Gola pear has been a unique success in the *tarai* region of North India (Bist, 1990) due to its hardy nature. Moreover, it can flourish even on inferior lands with relatively less care and also can withstand in temporary water logged conditions where most of the other fruit trees cannot survive. However, the cultivar has typical problem of shy bearing habit with excessive fruit drop and poor fruit growth which results in very low yield. Moreover, the harvested fruits are less sweet and more acidic as compared to fruits grown in temperate region. If these aforesaid problems are overcome, then the cultivar may give higher yield with better quality fruits thus enhancing the productivity of pear under *tarai* region. Since, the availability of suitable rootstocks to overcome the problems, are very less and if available, most of the rootstocks show either graft incompatibility or delayed incompatibility. On the other hand, exogenous application of various plant bio-regulators has been found effective in reducing fruit drop and stimulation of fruit growth and maturity. Higher yield with improved fruit quality by the use of plant bio-regulators has been reported in mango (Wahdan *et al*., 2011), citrus (Gonzales and Borroto, 1987), apple (Turk and Stopar, 2010) and other fruits. Exogenous application of PBRs has also been reported to improve the endogenous levels of phytohormones (Al-Duljaili *et al*., 1987), mineral nutrients (Bist, 1990) which stimulate the growth, flowering and fruiting of different fruit crops (Al-Duljaili *et al*., 1987; Randhawa *et al*., 1959). Exogenous application of growth promoters namely Promalin, a combination of GA_{4+7} and BA (Montalti *et al*., 1984), Paturyl, BA (Wertheim and Estabrooks, 1994) and GA (Higazi *et al*., 1983) have been shown to have effective role on improving the yield, productivity and fruit quality in apple and pear. Paclobutrazol also play vital role in prevention of fruit drop resulting higher yield of better quality fruits. Hence, in absence of suitable rootstocks and limitation in breeding programme under *tarai* region, the problem can be tackled by using plant bio-regulators (PBRs). Keeping these roles of PBRs in mind, the present investigation, therefore, was conducted with the hypothesis that PBRs could improve the productivity and quality of Gola pear by improving fruit growth and reducing fruit drop under *tarai* condition.

Materials and methods

An experiment was conducted at the Horticultural Research Centre (HRC) Pattarchatta, G.B. Pant University of Agriculture and Technology on fifteen years old, low-chill pear [*Pyrus pyrifolia* (Burm.) Nakai] cv Gola trees of uniform vigour and size, growing in a compact block at 5 x 5 m spacing and having a layout of RBD. Selected Gola trees were treated with three different plant bio-regulatos, consisting seven treatment combinations namely control: no treatment (C), three sequential foliar spray of GA_3 at 250 mg L^{-1} (G), three sequential foliar spray of BA at 250 mg L^{-1} (B), three sequential foliar spray of GA_3 + BA at 250 mg L^{-1} each (GB), soil application of PP_{333} by trunk soil line pour (TSLP) at 0.2 g cm^{-1} trunk diameter of the tree (PPT), combined application of GA_3 + BA at 250 mg L^{-1} each + PP_{333} at 0.2 g cm^{-1} trunk diameter of the tree (GBPP) and three sequential foliar spray of PP_{333} at 250 mg L^{-1} (PP). Foliar sprays were done during petal fall (PF) followed by two and four weeks after PF while soil application of PP_{333} was done during the late fall stage. For measuring percentage of fruit drop per metre branch, numbers of fruits were counted at fifteen days interval on each selected branch during the whole fruit growing season. Fruit length and diameter were measured from the base of the fruit stalk to the calyx end and at the point where the fruit having maximum diameter, respectively by using digital Vernier caliper. The observations for fruit length and diameter were recorded at fifteen days interval starting after fruit attained a minimal length and diameter of four cm to till harvesting. Fruit weight and volume was measured by weighing the sample on pan balance and by water displacement method, respectively. After collecting the data on total yield per tree, productivity was calculated on the basis of total number of plants accommodated per hectar (ha). Quality parameters namely TSS, Total sugar and titratable acidity were determined as per the outline given by Ranganna (1986) and TSS to acid ratio were computed by using following formula:

$$\text{TSS acid ratio} = \frac{\text{Birx (\%)}}{\text{Acidity (\%)}}$$

To determine the differences between treatments in field experiment, data were analyzed by using OPSTAT software (OPSTAT, CSS HAU, Hisar India).

Results and discussion

Experimental results revealed that all the parameters studied during the course of investigation differed statistically in different PBRs. Foliar spray of PP_{333} was found most effective for preventing fruit drop (62.51 % less as compared to control) during the entire period of observations which was statistically at par with soil application of PP_{333} (61.03 %). Foliar spray of GA_3 alone, combination of GA_3 and BA along with PP_{333} and combination of GA_3 and BA also reduced the fruit drop significantly over control (57.07, 56.86 and 41.22 % less as compared to control). However maximum fruit drop was recorded in foliar application of BA (20.41 % more) as compared to control (Fig. 2). Prevention of fruit drop was due to higher pedicel-spur retention force. Soil and foliar spray of paclobutrazol had a synergistically higher effect in terms of increasing pedicel-spur retention force, causing minimum fruit drop (Benjawin *et al*., 2006). Fruit growth (length and diameter) followed a linear pattern of growth for all the treatments during entire fruit growing season (Fig. 1). Finally at the time of harvesting maximum fruit length and diameter was recorded in combined application of GA_3 and BA (1.15 and 1.15 fold, respectively as compared to control) which was statistically at par with foliar spray of BA alone (1.14 and 1.09 fold, respectively). Foliar spray of GA_3 alone and combination of GA_3 and BA along with

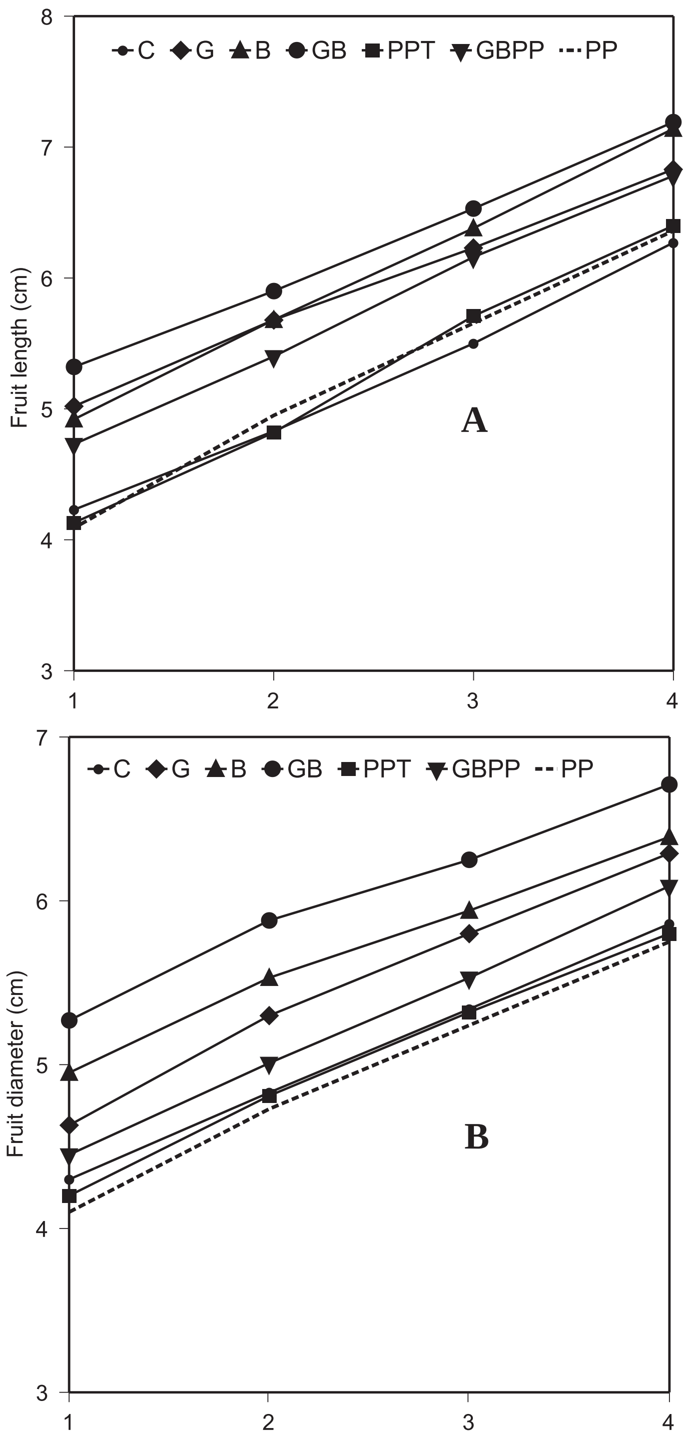

Fig. 1. Effect of different PBRs on fruit length (A) and diameter (B) of Gola pear. Horizontal axis indicate the period of fruit growth starting after fruit attained a minimal length and diameter of four cm to till harvesting at fifteen days interval. Vertical bars indicate the mean value ± standard error of mean. LSD at P=0.05 for fruit length (A) at different period of fruit growth: 0.33, 0.13, 0.15 and 0.15, respectively while LSD at P=0.05 for fruit diameter (B) at different period of fruit growth: 0.14, 0.46, 0.13 and 0.43, respectively.

Table 1. Effect of PBRs on fruit growth, quality and productivity of pear cv Gola

Treatment	Fruit volume (cc)	Fruit weight (g)	Productivity (ton/ha)	Fruit quality	
				Total sugar (%)	TSS to Acid ratio
C	158.80 ± 0.98	167.03 ± 1.20	8.48 ± 0.29	6.98 ± 0.08	17.55 ± 0.28
G	169.65* ± 2.07	173.31* ± 1.76	9.28 ± 0.38	7.39* ± 0.08	21.91* ± 0.34
B	175.57* ± 1.72	178.71* ± 0.88	9.69* ± 0.48	7.43* ± 0.06	20.45* ± 0.18
GB	182.50* ± 0.82	180.91* ± 1.16	9.78* ± 0.10	7.95* ± 0.03	23.09* ± 0.37
PPT	163.74* ± 0.57	172.49* ± 0.58	10.32* ± 0.14	7.64* ± 0.04	23.90* ± 0.22
GBPP	165.64* ± 0.52	170.83* ± 0.88	9.17 ± 0.14	7.11 ± 0.08	19.50* ± 0.25
PP	157.25 ± 0.60	173.75* ± 1.20	11.08* ± 0.27	7.19* ± 0.07	23.23* ± 0.77
$CD_{0.05}$	3.92	3.77	0.97	0.20	1.20

* significant over control at P=0.05 while value with ± symbol indicate standard error of mean (P=0.05).

C: Control, G: GA_3 at 250 mg L^{-1}, B: BA at 250 mg L^{-1}, GB: GA_3 + BA at 250 mg L^{-1} each, PPT: soil application of PP_{333} by (TSLP) at 0.2g cm^{-1} trunk diameter of the tree, GBPP: combined application of GA_3 + BA at 250 mg L^{-1} each + PP_{333} at 0.2g cm^{-1} trunk diameter of the tree and PP: foliar spray of PP_{333} at 250 mg L^{-1}.

PP_{333} also increased the fruit length and diameter significantly over control (Fig. 1A and 1B). However, PP_{333} treated trees had marginal influence on fruit length increment while fruit diameter decreased marginally under these two treatments as compared to control (Fig. 1B). Fruit weight and volume at maturity was also influenced in a similar pattern by different PBRs. Maximum fruit volume and weight was recorded in combined application of GA_3 and BA whereas minimum increase in volume and weight was observed in foliar and soil application of PP_{333} (99.02 and 103.27 % as compared to control), respectively. Basically, GA_3 and BA promote cell division in plant tissue (Gardner *et al*., 1985; Letham, 1958) which may cause the development of bigger size fruits. Endogenous level of these hormones fall much lower level within a few days after flowering (Guardiola, 1993). So, exogenous application of these hormones at petal fall and thereafter caused rapid cell division in the pericarp of the fruits. Warusavitharana *et al*. (2008) also reported that BA increased the number of cell layers in the fruit cortex while GA_3 causes cell expansion resulting bigger size fruits in grape by combined application of GA_3 and BA.

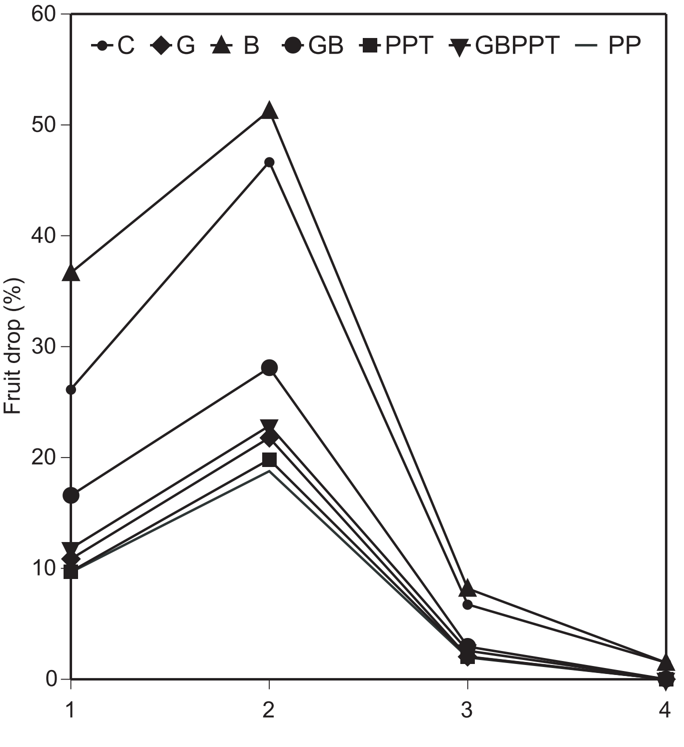

Fig. 2: Effect of different PBRs on prevention of fruit drops of Gola pear during the whole fruit growing season at fifteen days interval. Vertical axis indicates the fruit drop percentage. Horizontal axis indicates the period of fruit growth during whole fruit growing season. LSD at P=0.05 for fruit drop at different period of fruit growth: 0.66, 0.21, 0.46 and 0.21, respectively.

Productivity increased significantly in all the treatments as compared to control (Table 1). Maximum productivity was recorded in foliar application of PP_{333} (1.31 fold higher than control) which was statistically at par with soil applied PP_{333} (1.22 fold higher). Combined application of GA_3 and BA and foliar application of BA alone also increased the productivity significantly (1.16 fold and 1.13 fold). Higher productivity by foliar as well as soil applied PP_{333} was due to production of maximum number of flowers and fruits (data not shown) and minimum fruit drop during the entire period of fruit growth (Fig. 1) which confirmed the earlier findings of Jindal and Chandel (1996).

Total sugar content increased significantly in all the treatment as compared to control. However, maximum sugar was found in combined application of GA_3 and BA (13.9 % higher than control) followed by soil application of PP_{333} (TSLP) (9.46 % higher) and foliar application of BA (6.45 % higher). Foliar application of GA_3 alone, PP_{333} alone and combination of GA_3 and BA along with PP_{333} also increased total sugar content significantly over control. Maximum accumulation of sugar into the fruits by combined application of GA_3 and BA may be due to the positive interaction of cytokinin in delaying senescence process which help in retention of chlorophyll in the leaf (Sharma, 1974) and role of GA_3 in increasing vegetative growth (Leopold, 1964). Combination of these two plant hormones leads the movement of photosynthates, produced in the leaves, into the fruit sink at higher rate. On the other hand, TSS to acid ratio increased significantly in all the treatment as compared to control and recorded maximum in soil application of PP_{333} (TSLP) which was statistically at par with foliar application of PP_{333} alone (1.36 fold and 1.32 fold, respectively as compared to control). This was due to reduced titratable acidity present in the fruits of paclobutrazol treated trees as compared to other treatments which confirm the earlier finding of Khader (1990) in Dashehari mango by the application of paclobutrazol.

Present findings confirm that the soil and foliar applications of paclobutrazol were superior to all other treatments for improving fruit growth as well as prevention of fruit drop resulting in higher yield and productivity of marketable fruits. Moreover, these two treatments also produced fruits with higher sugar content and high TSS to acid ratio. Thus these two treatments can be used as effective tool for successful cultivation of Gola pear in *tarai* region of north India for improving productivity and quality. However, further studies are needed to investigate the effect of paclobutrazol on storage life, shipping quality as well as cost benefit ratio in that particular region, before making any generalized conclusion.

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