

Effect of some plant bioregulators on fruit yield and quality characteristics of Apple cv. Red Delicious.

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ABSTRACT

An investigation was carried out at a commercial orchard in Pulwama district of J&K, India during the year 2016 to study the suitability of chemical sprays in improving the apple (*Malus x domestica* Borkh 'Red Delicious') fruit set *vis a vis* yield, in consequence of the climatic factors particularly during the bloom, and lack of proper pollination and pollinizers. The treatments applied were: GA₃ (Progibb); Cytokinin + Enzymes (Poushak); GA₄₊₇ + 6-benzyladenine (Promalin); Hand Pollination; and *o*-naphthalene acetic acid (Agronaa), and control (water spray). Hand pollination (proper pollination) and GA₄₊₇ + 6-BA (Promalin), proved to be best for setting 14.33% and 11.67%, and retaining 20.66% and 24% of apple fruit respectively over control. Further, GA₄₊₇ + 6-BA (Promalin) enhanced the fruit size (length: 6.66 cm; diameter: 7.03 cm) and weight (263 g) significantly over all other treatments. Implying Promalin can be used to boost the yields in unfavorable fruit setting conditions.

Keywords: Red Delicious, Fruit Set, Fruit Retention, Weight, Kashmir, Bioregulators

INTRODUCTION

Apple is the predominant temperate fruit crop of India which accounts for about 10 % of the total fruit production of the country (Gautam *et al.*, 2004). At present these Delicious group cultivars mainly Red Delicious, Royal Delicious and Starking Delicious constitute nearly 80 % of apple trees. The cropping of apple (*Malus x domestica* Borkh 'Red Delicious'), the main desert cultivar grown in the Kashmir, is not only irregular, but the yield is also low as compared to the cultivars grown in other regions. Several factors like inadequate pollinizer proportion, reduction in natural population of pollinating agents, inadequate winter chilling, occurrence of spring frost *etc.* have been attributed as the main factors leading to poor fruit set.

In conventional orchards apple fruit set is promoted by cross-pollination achieved by inter-planting the main varieties with other compatible cultivars. Golden delicious and Red gold are the predominant pollinizing cultivars being used, and have attained biennial bearing tendency, thus providing the pollinizing services only during the 'on' years. Transfer of pollen is often facilitated by hived bees

placed in orchards, the positioning of pollinizer trees being arranged to take advantage of the preferred flying patterns of bees. The population of natural pollinators has gone down due to indiscriminate use of pesticides and the deterioration of the ecosystem. Managed bee pollination is very limited and available bee hives during bloom hardly meet 2-3 % of the demand (Gautam *et al.*, 2004). However cold or overcast weather or high winds during the flowering period can greatly reduce bee activity, while low temperatures can slow pollen tube growth so much that embryo sac degeneration can occur before fertilization has been affected. Thus, efforts made to achieve a satisfactory initial set fail due to unfavorable weather. The situation thus encourages diverting to the chemical methods for improving the fruit set in apple.

Gorter and Visser (1958), showed that mature fruit could be developed from unpollinated flowers (parthenocarpy), with the application of synthetic auxins in apple and pear. There was an increase in initial fruit set with some cultivars, but obtained little improvement in the number of harvested fruit. Later the treatments with gibberellic acid (GA₃)

by Luckwill (1960), could stimulate parthenocarpy in some pear and apple cultivars, but could attain the fruits of half the size as that of seeded fruits. The use of plant growth regulators such as NAA, GA₃ and indole-3-butyric acid (IBA) by many researchers have shown reduced flower drop, high flower retention, increased yield and fruit quality in various fruit species such as citrus, apple, mango and guava (El-Shewy, 1999; Iqbal *et al.*, 2009). Watanabe *et al.*, (2008), in their study on apple observed 60% fruit set in GA₃ treated 'Ohrin' cultivar and about 7% in 'Fuji'. Moreover, GA₃ + 2,4-DP + CPPU treated 'Ohrin' apple showed the highest fruit set percent of 89.3. These researches have put the corner stones for the fruit production through chemical means even under the unfavorable conditions.

As apple trees bloom during a cool period and also suffer from self-incompatibility, any factor that can improve pollination, pollen germination and pollen tube growth or extend the effective pollination period, such as the application of plant bioregulators, should be beneficial for fruit production. Thus an investigation was conducted to explore the effectiveness of various chemical sprays in improving the apple fruit yield.

MATERIALS AND METHODS

The experiments was initiated on mature 'Red Delicious'/ seedling apple growing at a commercial orchard in Pulwama district of J&K, India (latitude 33°48'38"N – longitude 74°51'12" E) during the year 2016. Normal control and cultural management practices were used during the course of the experiment. Eighteen 20-year-old 'Red Delicious' apple trees were selected for the study in such a way that each six trees representing the six treatments of a replication were equidistant from pollinizer tree at the center. Two limbs on each tree were selected and tagged prior to flowering and the total number of flower clusters and the flowers counted. The treatments as described in Table 1 were applied during the full bloom. The observations, Percent fruit set and fruit retention were recorded 20 days after petal fall and at harvest respectively. Fruit length and diameter were measured using digital vernier calliper, and the weight using digital balance.

The experiment was conducted according to Randomized Complete Block Design (RCBD) by

using six treatments, each comprising of three replications. Statistical analysis of the data was performed by using Analysis of Variance (ANOVA) technique and difference among treatment means were compared by the Duncan's Multiple Range (DMR) test at 1% level of probability (Steel *et al.*, 1997).

RESULTS

Fruit set

The results of the treatments applied at full bloom on fruit set in Red Delicious apples at 50 days after flowering can be seen in Table 2. The treatments sprayed achieved significantly higher levels of fruit set than control except NAA, which recorded the lowest fruit set of all (51.67%). The highest percentage of fruit set was achieved in hand pollinated apple flowers followed by Promalin and GA₃ (Progibb) sprayed apple flowers with the fruit set of 84.33%, 81.67% and 77% respectively. Poushak sprayed flowers with the fruit set of 76% did not differ significantly with control (70%).

Fruit retention

Significantly highest fruit retention percentage was recorded in Promalin sprayed flowers with 75.67% followed by hand pollinated trees with 72.33%. And the lowest fruit retention percentage of 48% and 51.67% were recorded in NAA sprayed and control respectively. Poushak and GA₃ applied fruits recorded 60.33% and 63% of fruit retention respectively.

Fruit length

All the treatments applied recorded significantly higher fruit length than control. Promalin applied fruits had highest fruit length of 6.66 cm followed by GA₃ with 6.23 cm. No significant difference in fruit length was observed between the Hand pollinated and Poushak applied fruits and recorded 6.08 cm and 5.99 cm of length respectively. Agronaa (NAA) applied fruits recorded the mean fruit length of 5.8 cm.

Fruit diameter

The treatments applied significantly affected the fruit diameter of the fruit. The highest fruit diameter

of 7.03 cm was recorded in Promalin applied fruits, followed by GA₃ and Hand pollinated fruits with 6.84 cm and 6.70 cm respectively. Poushak and NAA applied fruits were at par with each other with the diameters of 6.53 cm and 6.50 cm respectively.

Fruit weight

Fruit weight was significantly affected by the treatments applied. The highest fruit weight of 263 g was observed in Promalin treated fruits and the lowest 176 g in control fruits. However, treatments which did not differ significantly among themselves were GA₃, Hand pollinated, Poushak and NAA applied with the mean fruit weight of 225 g, 220.67 g, 219.33 g and 213 g respectively.

DISCUSSION

Improving fruit set is a useful way to increase yield. As evident from the results, partial pollination (Control) set 70% fruit, while as, hand pollination proved the best for setting fruit followed by Promalin application. Since up to 30% of ovules in Delicious become nonfunctional and degenerate within 72 hours following bloom. Also, the apple pollen being relatively large in size and not getting carried away by wind can be the reason for low fruit set in control. Therefore, for good fruit set adequate pollination is required immediately after bloom. Thus, hand pollinated flowers showed the highest fruit set by ensuring sufficient pollination. The results are in accordance with the earlier researches and holds true for most of the crops cultivated (Can-Medrano and Darnell, 1998; Chauta-Mellizo, 2012). Moreover, pollen germination and pollen tube growth are key events in the sexual reproduction of plants (Wu *et al.*, 2008). Seeds are usually formed, and the ovary and receptacle enlarge if pollination and fertilization occur normally in apples. Simultaneously, seeds produce indole-3-acetic acid, gibberellins and cytokinins during growth. These plant growth regulators apparently control fruit growth. Currently, it is accepted that both fruit set and fruit development are regulated by the coordination action of hormones produced in the ovary after pollination or fertilization (Mariotti *et al.*, 2011). Pollination and subsequent fertilization lead to a strong shift in the balance of phytohormones and development of the ovule (Obroucheva, 2014).

Exogenous application of gibberellins have been reported to promote pollen germination and increase pollen tube length in vitro in apricot (Bolat and Pirlak, 1999). The active components of Promalin (GA₄₊₇ + 6-BA) operate as growth promoters at cellular level and improve the development of fruitlets immediately after flowering (Vilardell *et al.*, 2008). This validates the significantly higher fruit sets in the treatments, Promalin and GA₃, next to the hand pollinated treatment.

Cytokinins are plant hormones promoting cell division and differentiation (Mok and Mok, 2001). They have also been reported to influence the development of flowers and seeds, nutrient uptake and demand, and organ assimilation (Zalabak *et al.*, 2013). Also, exogenous treatment with cytokinins delay flower senescence in several plant species (Trivellini *et al.*, 2015). Bolat and Pirlak (1999) found that the exogenous application of kinetin at low concentrations in vitro improved pollen germination in apricot and significantly improved pollen tube lengths. In some species, the application of cytokinins to flowers before fertilization, originates the beginning of fruit growth (Pandolfini, 2009). However, in this experiment, Poushak treated flowers showed enhanced fruit set than control but didn't differ significantly.

The lowest fruit set was found in 'Red Delicious' apple flowers treated with auxin, NAA. The application of synthetic auxin, naphthlene acetic acid at flowering did not increase fruit set or yield significantly, as was also found in earlier studies (Vilardell *et al.*, 2008, Theron *et al.*, 2011).

Highest fruit retention percentage was observed in promalin treated fruits followed by hand pollinated ones. Whereas, the lowest retention percentage was found in NAA treated and control fruits. Gibberellins either from fruit seed or exogenously applied, have been found to intensify organ ability to function as nutrient sink and also can increase the biosynthesis of IAA in plant tissue which delays the formation of the separation layer and thus enhances fruit retention. Reports claim a correlative relationship of depleted endogenous levels of gibberellins with mango fruit abscission (Bains *et al.*, 1997; Singh *et al.*, 2010). Further findings have also indicated that foliar sprays of gibberellic acid

Table 1: Description of the treatment combinations.

Treatment	Active Ingredient	Dosage	Manufacturer
T1 Control	Water spray	-	-
T2 Progibb	Gibberellic acid 90% w/w	0.01g/l	Valent Agricultural Products
T3 Poushak	Cytokinin + Enzymes	2.5 ml/l	Krishi Rasayan Exports Pvt. Ltd.
T4 Promalin	GA ₄₊₇ 1.8% + 6- Benzyladenine 1.8%	1.5ml/l	Valent Agricultural Products
T5 Hand pollination	-	-	-
T6 Agronaa	á-Naphthelene acetic acid 4.5% w/w	0.1ml/l	Aries Agro Ltd.

Table 2: Treatment effects on yield parameters of apple cv. Red Delicious

Treatments	Fruit set (%)	Fruit retention (%)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
T1 Control	70.00c	51.67c	5.40e	6.14e	176.00c
T2 GA ₃	77.00b	63.00b	6.23b	6.84b	225.00b
T3 Poushak	76.00cb	60.33b	5.99c	6.53d	219.33b
T4 Promalin	81.67ab	75.67a	6.66a	7.03a	263.00a
T5 Hand pollination	84.33a	72.33a	6.08c	6.70c	220.67b
T6 NAA	51.67d	48.00c	5.80d	6.50d	213.00b

Mean separation within columns by Duncan's Multiple Range Test; (Pd''0.01)

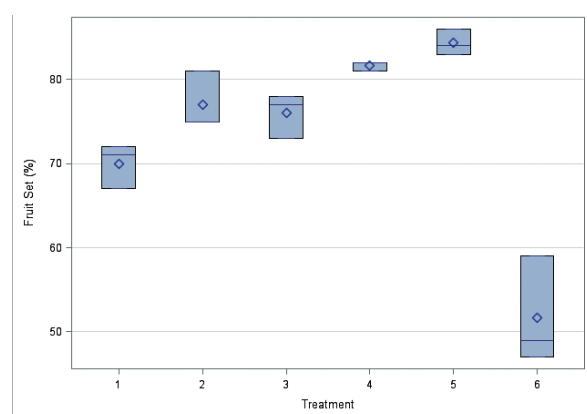


Fig.1: Distribution pattern of fruit set in apple cv. Red Delicious owing to various treatment effects.

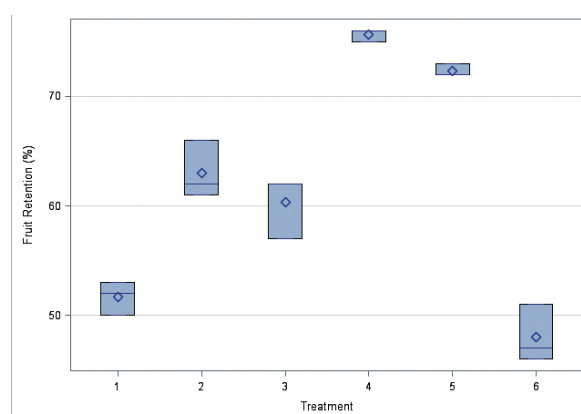


Fig.2: Distribution pattern of fruit retention in apple cv. Red Delicious owing to various treatment effects.

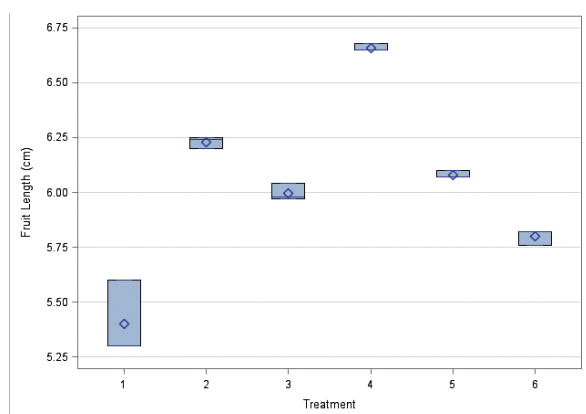


Fig.3: Distribution pattern of fruit length in apple cv. Red Delicious due to various treatment effects.

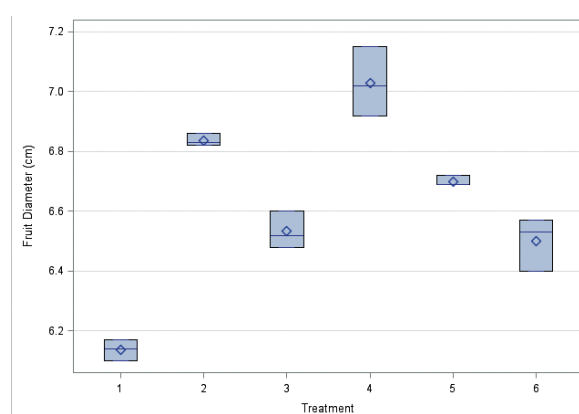


Fig.4: Distribution pattern of fruit diameter in apple cv. Red Delicious due to various treatment effects.

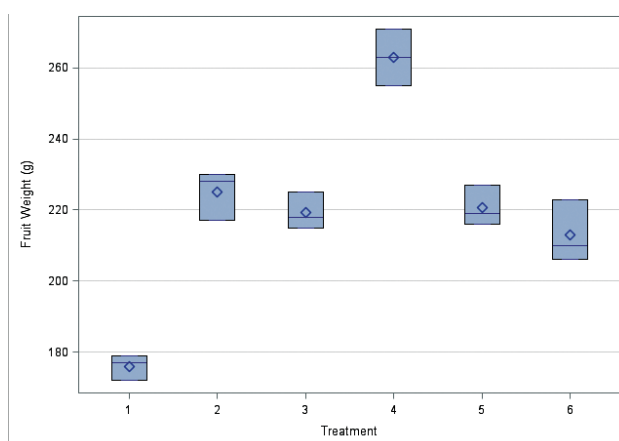


Fig.5: Distribution pattern of fruit weight of apple cv. Red Delicious owing to various treatment effects.

resulted in higher fruit retention (Wally *et al.*, 1999).

Size of the fruit is one of the main quality factors which determine the price and marketability, especially for those which are intended for fresh consumption. In this experiment, the size and subsequently the weight of the Red Delicious apple fruits were significantly enhanced with all the treatments as compared to control. The maximum size and weight among the treatments was found in Promalin treated fruits followed by GA₃ treated. Bengerth and Schroder (1994) reported an increase in length to diameter ratio in parthenocarpic apple fruits induced by CPPU + GA. Early application of GA₃ reduced seed number and increased fruit

length in 'Conference' pear (Vercammen and Gomand, 2008). GAs are synthesized in seeds, young leaves and roots and function at cellular level by elongating and expanding cells at the whole plant level (Brock and Kaufman, 1991).

NAA treated fruits also showed significantly enhanced size and weight, which can be attributed to thinning effect. As reported by Shargal *et al.* (2006), the two commercial practices commonly applied to enlarge the fruit are: reducing the competition between fruits for assimilates by thinning flowers or fruitlets; and by directly enhancing fruit size by stimulating and extending cell division, e.g. application of synthetic cytokinins.

CONCLUSION

It is apparent from the results that pollination and pollinizers if properly maintained may result in better fruit set and fruit retention. However, during unfavorable weather conditions or when proper pollination is hindered, GA₄₊₇ + 6-benzyladenine (Promalin) application may turn helpful in improving the fruit set and yield.

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