Effect of plant growth regulator, Applin on growth, yield and quality of Royal Delicious apple

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ABSTRACT

Fruit size is one of the important quality parameters of apple to enhance the economic value in terms of yield and consumers preference. In the year of heavy crop load of apple tree, the fruit remains undersized which reduces the market value after harvesting. To overcome this problem, the use of gibberellins and cytokinins plant growth regulators to maintain the proper size of fruits under heavy crop load is an alternative way. The present study was carried out to know the effect of Applin (gibberellin and cytokinin) on growth, yield and quality of Royal Delicious apple. Maximum shoot growth, fruit length, fruit diameter, fruit weight, yield and ascorbic acid content were recorded in plants treated with 0.5 ml/l of Applin and with 1.0 ml/l of Wetcit. The overall results of this study showed that the application of plant growth regulator at the concentration significantly increased the size, quality and shelf-life of apple during the year of high crop load.

Keywords: Apple; Royal Delicious; Applin; growth; yield; quality

INTRODUCTION

Apple is one of the important economic fruit crops among temperate fruit crops in Kashmir due to its higher returns and prevailing climatic conditions which are suitable for its cultivation. It is mainly grown in Jammu and Kashmir, Himachal Pradesh and Uttarakhand where the chilling requirements are met for its successful fruitfulness. The production of apple in Jammu and Kashmir is 18,82,319 MT over an area of 1,64,742 ha with productivity of 11.42 MT/ha (Anon 2019).

As one of the most widely consumed fruits in the world, apples play a vital role in human diet by contributing to health and well-being. It is a good source of sugars, minerals and dietary fibre. In addition, apples are a good source of biologically active substances such as vitamin C, flavonoids and phenolic compounds which act as antioxidants (Gonzalez-Aguilar et al 2008).

Plant growth regulator is an organic compound that modifies, promotes or inhibits morphological and physiological processes of plants at low concentrations (Cato et al 2013). The plant growth regulators can be applied directly to plant parts causing changes in physiological processes which in turn increase crop production and quality and facilitate harvesting, flowering and fruiting (Castillo et al 2005). The use of growth regulators has become an important component of agricultural technology for most of the cultivated plants especially for fruit plants. Plant hormone acts as signal molecule at very low concentration to determine the formation of flowers, stems and leaves, shedding of leaves, fruit development and ripening of fruits (Sebastian et al 2019).

Plant growth regulators increase productive system with the goal of modifying physiological process in plants to optimize productivity (Yakhin et al 2017). Application of gibberellins is an effective way for

elongation of grape berries in order to accelerate the cell elongation and cell division in the sub-apical meristem regions (Kumar et al 2017). Gibberellins are highly distributed in plants and involved in physiological processes participating in seed germination, stem growth and transition from flowering to fruit development (Giovanaz et al 2016). Gibberllic acid CPPU improves size with superior quality fruits in pear (Niu et al 2015). Gibberellins contribute to the stem elongation and increase in fruit weight if given after flowering in strawberries. A mixture of GA_{4+7} and BA at different doses increased the fruit size and improved shape of apple cv Red Delicious (Milosevic et al 2014).

Cytokinin is plant hormone known to be key regulator of various aspects of plant growth and development including cell division, leaf senescence, nutrient mobilization and apical dominance (Mazid et al 2011). Cytokinins are plant growth regulators that are important plant hormones and regulate various processes of plant growth and development through cell division and differentiation (Sardoei 2014). Buban (2000) reported that the response of plant growth regulators is determined by the physiological age of trees, environmental conditions and application methods. The aim of this research was to study the effect of plant growth regulator, Applin on growth, yield and quality of apple.

MATERIAL and METHODS

The present investigations were carried out during 2019 in a private apple orchard near Krishi Vigyan Kendra, Balpora, Shopian, Jammu and Kashmir. It is located at an altitude of 2,146 m amsl having latitude of 33.72° N and longitude of 74.83° E. Climate of this area is generally temperate with cold winters.

The trees were 15 years old planted at a spacing of 7 m x 7 m. The experiment consisted of twenty bearing trees with uniform size and vigour selected and laid out in a randomized block design. Each treatment was replicated four times. All plants were applied with uniform cultural practices during the period of investigations. The Applin (gibberllin + cytokinin) was applied individually or in combination with Wetcit (surfactant) at different concentrations. The treatments used were T_1(Control: trees sprayed with tap water), T_2 (Applin 0.5 ml/l), T_3 (Applin 0.1 ml/l), T_4(Applin 0.5 ml/l + Wetcit 1.0 ml/l) and T_5 (Applin1.0 ml/l + Wetcit 1.0 ml/l).

The growth regulator (Applin) with or without surfactant was applied once on 15 April early in the morning when fruits reached the size of about 15 mm diameter. Ten current year branches were selected at different directions and the average annual extension growth was averaged and calculated. For leaf chlorophyll content, five normal leaves per plant were collected randomly from current season's shoots from all sides of the tree. The CCM-200 model of chlorophyll meter (Chlorophyll SPAD meter) device was used to determine the chlorophyll content of leaves at which five SPAD measurements were taken per leaf and averaged.

The fruit size in terms of length and breadth of ten randomly selected fruits per replication was recorded with a digital vernier calliper. The fruit index ratio was obtained by dividing the corresponding value of length of fruit to the diameter of fruit. Ten selected fruits were taken for recording the fruit weight on electronic balance. The yield of fruits under different treatments was recorded at the time of harvest by weighing the total fruits on top pan balance. The colour rating of the selected fruits from each treatment was counted on four-point scale suggested by Blanpied et al (1975).

Fruit firmness was determined by removing thin peel at three places and the 11 mm plunger of Effegi model penetrometer FT-3-27 was inserted in the fruit to record fruit firmness. The specific gravity was calculated by dividing the fruit weight in air with water displaced by fruit in a beaker. Ten fruits were selected for measuring volume with a measuring cylinder filled with water up to a certain graduation. The difference between the initial and final readings gave the measure of volume of fruit samples which was averaged. The total sugar was estimated by titrating a boiling mixture of 5 ml each of Fehling A and B solutions against aliquot using methylene blue as an indicator. The end point was noted upon obtaining brick red colour and total sugar content was taken (Ranganna 1986).

Ascorbic acid and titratable acidity were estimated by titration method using 2, 6-dichloro indophenol and 0.1 N NaOH solutions as suggested by Ranganna (1986). The total soluble solids of fruits were determined by hand refractometer. Physiological loss in weight (PLW) was calculated from ten fruits of each treatment and weighed before and after the

storage period (10, 20 and 30 days) by using the formula:

$$PLW\ (\%) = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Data were analysed by using one-way analysis of variance followed by Duncan's multiple range test to determine the level of significance at 5 per cent level of significance.

RESULTS and DISCUSSION

Annual shoot growth of apple in the present experiment was affected by the application of Applin (cytokinin+ gibberellin) with or without surfactant (Table 1). Growth regulator (0.5 ml/l) with Wetcit was found to be highest effective in increasing size of shoots than all other treatments. The increase in shoot growth attributed with Applin might be due to its cytokinin like action which leads to rapid cell division and cell elongation (Thomas and Katterman1986). Application of GA_3 as a foliar spray alone or in combination with cytokinin resulted in larger plants with response to GA_3 that might have occured as a consequence of cell elongation (Leite et al 2003)

Leaf chlorophyll content was significantly affected Applin. The maximum leaf chlorophyll content was recorded in the treatment Applin (0.5 ml/l) and (1.0 ml/l) with Wetcit which were at par, whereas, the minimum was observed in control. The potential influence of cytokinins brings down the senescence, retards the degradation of chlorophyll and enhances the rate of chlorophyll synthesis (Zubo et al 2008).

Applin (0.5 ml/l) in combination with Wetcit also resulted in maximum fruit length in comparison to all other treatments. Increased fruit size by the application of synthetic cytokinin could be due to strong growth regulation and was found very effective in accelerating fruit size. Sharma et al (2018) studied the effect of GA_{4+7} + BA and CPPU on fruit retention, yield efficiency and fruit size in apple cv Scarlet Spur II. Curry and Greene (1993) also reported that CPPU applied at 0, 5, 10, 15, or 20 mg/l to Spur Delicious trees at king bloom resulted in increased fruit length and diameter at all doses.

It is evident from the data that Applin at different concentrations significantly affected fruit volume. The maximum fruit volume was recorded in Applin (0.5 ml/l) and (1.0 ml/l) with Wetcit which were at par. Fruit weight of apple was also found significantly distinct by the application of growth regulator. The maximum fruit weight was observed in Applin (0.5 ml/l) in combination with Wetcit, whereas, the minimum fruit weight was observed in control. The application of Applin at petal fall significantly increased the fruit weight. This may be increased endogenous cytokinin level that resulted in cell division and further increased the development of fruits. Similar responses in fruit weight were observed by Banyal et al (2013). The fruit yield was also influenced significantly by the application of Applin. The maximum fruit yield was recorded in the treatment Applin (0.5 ml/l) combined with Wetcit while the minimum was recorded in control. The findings of this study agree with those of Pramannik et al (2015) in kiwi fruit. They found higher yield by dipping the fruits in CPPU @ 10 ml + pinching $1/5^{th}$ at petal fall at one-month interval.

Treatments showed no significant effect on fruit firmness, fruit colour and fruit acidity (Table 2). The results are in line with the findings of Cruz-Castillo et al (2014) and (Miceli et al 2019). Application of Applin (cytokinin + gibberellin) on apple cv Royal Delicious had significant effect on specific gravity. The maximum specific gravity was recorded in the treatment Applin (1.0 ml/l with Wetcit) followed by Applin (0.5 ml/l +Wetcit), whereas, the minimum was in control. The increase in specific gravity of fruits by the application of Applin after fruit set might be due to increase in weight of fruits. Thus pre-harvest application of plant growth hormones reduced the weight loss and respiration losses which resulted in maintaining higher value of specific gravity (Singh et al 2017).

It is evident from the data that Applin (0.5 ml/l) and (1.0 ml/l) with Wetcit exhibited a significant effect on total soluble solids (TSS) which were at par. Minimum TSS was recorded in control. The findings are in conformity with earlier study of Kim et al (2006) who reported increased fruit TSS content and decreased level of acidity in kiwifruit. The higher TSS content might be attributed to a higher rate of photosynthates assimilation as cytokinins are known to influence mobilization of metabolites and nutrients

Table 1. Effect of plant growth regulator on tree and fruit attributes of apple cv Royal Delicious

Treatment	Annual shoot growth (cm)	Leaf chlorophyll (SPAD)	Fruit length (mm)	Fruit diameter (mm)	Fruit volume (cm^3)	Fruit weight (g)	Yield (kg/tree)
Control	19.42[a]	46.36[a]	74.15[a]	71.45[a]	199.38[a]	188.75[c]	152.75[a]
Applin (0.5 ml/l)	22.67[b]	48.11[b]	74.65[ab]	75.30[b]	216.30[b]	164.60[a]	172.05[bc]
Applin (1.0 ml/l)	24.15[b]	48.69[b]	75.75[b]	75.65[b]	209.25[ab]	177.95[b]	169.75[b]
Applin (0.5 ml/l) + Wetcit (1.0 ml/l)	29.42[c]	50.55[c]	77.65[d]	76.75[c]	230.49[c]	200.45[d]	195.47[d]
Applin (1.0 ml/l) + Wetcit (1.0 ml/l)	23.17[b]	49.21[bc]	75.65[bc]	75.25[b]	219.65[bc]	188.65[c]	183.22[c]

Values carrying different alphabets within columns indicate significant differences ($\leq$0.05) using DMRT

Table 2. Effect of plant growth regulators on physico-chemical characters of apple cv Royal Delicious

Treatment	Fruit firmness (kg/cm^2)	Fruit peel colour (%)	Specific gravity (g/cc)	TSS (%)	Total sugar (%)	Ascorbic acid (mg/100 g)	Titratable acidity (%)
Control	5.84[a]	87.61[a]	0.73[a]	12.5[a]	7.85[a]	5.60[a]	0.55[a]
Applin (0.5 ml/l)	5.73[a]	82.83[a]	0.80[b]	13.5[a]	9.08[cd]	5.72[b]	0.40[a]
Applin (1.0 ml/l)	5.45[a]	73.37[a]	0.80[b]	13.2[a]	8.53[b]	5.92[c]	0.52[a]
Applin (0.5 ml/l) + Wetcit (1.0 ml/l)	5.86[a]	76.58[a]	0.87[c]	14.6[b]	9.27[d]	6.65[e]	0.57[a]
Applin (1.0 ml/l) + Wetcit (1.0 ml/l)	5.56[a]	73.86[a]	0.93[d]	13.8[ab]	8.72[bc]	6.22[d]	0.57[a]

Values carrying different alphabets within columns indicate significant differences ($\leq$0.05) using DMRT

Table 3. Effect of plant growth regulator on physiological loss in weight of apple cv Royal Delicious

Treatment	Per cent physiological loss in weight after (days)			Mean
	10	20	30	
Control	4.89	5.40	5.23	5.20
Applin (0.5 ml/l)	4.98	3.47	3.44	3.96
Applin (1.0 ml/l)	2.12	2.09	2.32	2.18
Applin (0.5 ml/l) + Wetcit (1.0 ml/l)	2.64	2.71	4.51	3.28
Applin (1.0 ml/l) + Wetcit (1.0 ml/l)	3.67	3.99	4.06	3.91
Mean	3.66	3.53	3.91	

$CD_{0.05}$
Treatments: 0.55
Days: 0.36
Treatments × Days: 0.95

to the cytokinin-treated portion of the plant (Leopold and Kriedemann 1975).

Total sugar content of fruits was significantly influenced by different concentrations of Applin. Total sugar was found significantly highest by the application of Applin (0.5 ml + Wetcit) and Applin (0.5 ml) which were at par while the lowest was found in control. The results of this study are in agreement with the findings of Khandaker et al (2013) who reported that GA_3 treatments had a significant influence on the total sugar content of the apple fruits. They reported highest total sugar content of 6.24 g in the treatment 50 mg GA_3/l.

The application of Applin significantly affected the accumulation of ascorbic acid in fruits. Maximum ascorbic acid was observed with the treatment Applin (0.5 ml/l) with Wetcit and the minimum in control. The ascorbic acid content increase might be due to the reason that cytokinin assists in translocation of nutrients which are further redistributed in different biochemical processes. Similar results were reported by Sharma (2018) in apple.

The highest weight loss was recorded in fruits under control after storage under ambient temperature (Table 3). The fruits which were treated with Applin (1.0 ml) recorded minimum fruit weight loss as compared to other treatments. The rate of change in weight loss was significantly lower in fruits sprayed with growth regulator than in control. The interaction between the treatments and days was also found to be significant. The results are in line with the work of Duguma et al (2014) who suggested that energy released during respiration process in the form of heat from the fruit by evaporation of water ultimately leads to weight loss. The increase in the membrane permeability following the respiratory climacteric can result in loss of moisture through the peel (Siriboon and Banluslip 2004).

CONCLUSION

From the results it can be concluded that the size of the tree and the fruits with minimum loss of weight is significantly affected by the application of growth regulator, Applin when applied at the fruit size of 15 mm diameter which may economically benefit the orchardists in the year of high crop load of apple.

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