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Research Article

Effect of Plant Growth Regulator on Growth, Yield and Quality of Apple (*Malus x domestica* Borkh.) cv. Royal Delicious

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ABSTRACT

The present study was conducted at a full bearing orchard of apple at Wathoo, Shopian near KVK Balpora, Jammu and Kashmir, India. This investigation was done to study the effect of plant growth regulator on growth, yield and quality of apple cv. Royal Delicious during the year 2019. The results reviled that maximum shoot growth (29.75 cm), leaf chlorophyll content (49.60 SPAD), fruit length (78.01 mm), fruit diameter (76.32 mm), fruit volume (242.67 cm3), fruit weight (213.46 g), Fruit yield (203.10 Kg/tree) and fruit specific gravity (0.93) were observed in T_5 (Kromolin 1.0 ml/L with wetcit). However, the maximum fruit firmness (5.86 kg/cm^2) recorded in T_2 (Kromolin 0.5ml/L without wetcit). While, there was no significant effect of the fruit colour through application of Kromolin, but numerically the maximum fruit colour (4%) was recorded under T_2 (Kromolin 0.5ml/L without wetcit). Similarly, there was no significant effect in the chemical parameters vis (TSS, TSS/acid ratio, total sugar, reducing sugar) with different concentration of kromolin but numerically the highest T.S.S. (13.53 ^{o}Brix), TSS/ Acid ratio (56.36), total sugar (9.21 mg/100g), reducing sugar (6.39 mg/100g and lowest acidity (0.24 %) registered in T_5 (Kromolin 1.0 ml/L with wetcit). However, a significant effect in fruit ascorbic acid (3mg/100g) has been recorded in T_5 (Kromolin 1.0 ml/L with wetcit) as compared to control.

Keywords: *PGR, Kromolin, Royal Delicious apple, Gibberellin, Cytokines, Leaf chlorophyll*

INTRODUCTION

Apple (*Malus* × *domestica* Borkh.) is cultivated in worldwide. It belongs to family Rosaceae sub family Pomoideae and originated in the temperate region of the Western Asia between black and Caspian Sea. Apple is rich source of carbohydrates, proteins, minerals and Vitamin-C (Banday, 2015). The leading apple producing country in the world is China with an annual production of 41.0 million tons followed by United States of America with 4.7 million tons, Turkey with 3.0 million tons and India ranks 5th with 2.4 million tone annual production (Anonymous, 2019).

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Apple is one of the dominant fruit crop among the temperate fruit crops in Kashmir due to higher returns and suitable climate for its cultivation. It is mainly grown in Jammu and Kashmir, Himachal Pradesh, Uttrakhand where the chilling requirements met for its successful fruitfulness, which accounts for over 90 percent of the total production of the country. Jammu and Kashmir is predominantly a horticultural state and economy of the state, especially rural areas which account for 75 per cent of the state's population, sustains on temperate fruit cultivation. 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 (Anonymous, 2019). Plant growth regulator is an organic compound other than nutrients that promotes, inhibits or modifies morphological and physiological processes of the plant when applied at low concentrations (Cato et al., 2013). These substances can be applied directly on plants (leaves, fruits, seeds) causing changes in structural and functional processes, in order to increase production, improve quality and facilitate harvesting. The plant growth regulators's regulated some processes in plants, such as 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 and especially for fruit plants. Plant hormone acts as signal molecule at very low concentration to determine the formation of flowers, stems, leaves, shedding of leaves, development and ripening of fruits Sebastian et al. (2019). Active gibberellins show many physiological effects, each depending on the type of gibberellin present as well as the species of plant. Application of GA3 on lentil shoot (Richards, 2001). Many scientific proves stated that GAs, originally obtained from the cultures of the fungus Gibberella fujikuroi, is present in different parts of higher plants. It induces internode extension, apical dominance, breaks dormancy, increases dry weight brings about flowering long day plants even when kept in short day conditions and replaces vernalisation. Cytokinins (CKs) are plant hormones known to be key regulators of various aspects of plant growth and development, including cell division, leaf senescence, apical dominance, lateral root formation, stress tolerance, and nutritional signaling. In plants, endogenous cytokinins content is known to be spatially and temporally regulated by a fine balance between synthesis and catabolism.

MATERIALS AND METHODS

The experiment was conducted in a full bearing orchard of apple at Wathoo, Shopian near KVK Balpora, Jammu and Kashmir. The laboratory studies were conducted in Horticulture lab of the School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, India. The research was conducted on 25 years old apple orchard of cv. Royal delicious. fifteen bearing trees with uniform size and vigour and planted at an orchard spacing of 7 x 7 m were randomly selected for study. All plants were given uniform cultural practices during the investigation. The present study comprised of 5 treatments, which consisted of Kromolin (combination of Gibberellin and cytokines) and Wetcit, and their combinations as follow

T_1	Control
T_2	Kromolin 0.5 ml/L without wetcit
T_3	Kromolin 1.0 ml/L without wetcit
T_4	Kromolin 0.5 ml/L with wetcit
T_5	Kromolin 1.0 ml/L with wetcit

The data obtained were subjected to analysis of variance. The data analyzed using MS-excel and OPSTAT as per the design of experiment. Means were compared using RBD test with level of significance at 5 %. During the current study, standard methodology was adapted for estimation of different parameters which are described as under:

Vegetative growth and leaf chlorophyll content

vegetative growth was measured by selected two randomly scaffold branches in opposite direction in each replication were used for the observation and the average annual extension growth (cm) of the current season were

recorded in the year following leaf drop and the average was calculated in cm. leaf chlorophyll content was measured by five normal leaves per plant were collected from current season's shoots randomly selected from all sides of the tree. the ccm-200 model of chlorophyll content meter (chlorophyll SPAD meter) device was used to determine the chlorophyll content of leaves which five SPAD measurements were taken per leaf and averaged and the readings recorded by SPAD meter.

Physical parameters:

The fruit size in terms of length and breadth of ten randomly selected fruits per replication was recorded with a digital Vernier calliper (Mitutoyo, Japan). The volume of fruits was measured by water displacement method ten selected fruits taken for measuring size and weight were immersed in a measuring cylinder filled with water up to a certain graduation. Weight of each fruit was recorded with the help of electronic balance and measured in grams, fruit yield was recorded as total fruits harvested in kg/plant. The specific gravity was calculated by dividing the fruit weight with fruit volume. Fruit firmness was determined by removing 1 cm 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 in Kg/cm^2. Similarly, colour intensity was measured by comparing the coloured surface of fruit with the colour chart and expressed in percent.

Chemical parameters

The TSS content was directly read on Zeis's hand refractrometer by putting a drop of fruit juice on prism and reading as Brix^o at 20^{o}C. Acidity of collected and pro-cessed fruit was determined by diluting a known volume of fruit juice and titrating against 0.1 N sodium hydroxide solutions, using phenolphthalein as an indicator, and expressed as percent of malic acid. The ratio was obtained by dividing the corresponding value of total soluble solids to the titrable acidity. Ascorbic acid, total sugar and reducing sugar was estimated by titration method using 2, 6-dichloro indophenol as suggested by Ranganna (1986).

RESULTS AND DISCUSSION

Experimental results revealed that all the parameters studied during the course of investigation differed statistically in different concentration of kromolin.

Annual shoot growth: The maximum shoot growth (29.75 cm) was recorded with the treatment T_5 (Kromolin 1.0 ml/L with wetcit) which was statistically at par with T_3 (Kromolin 1.0 ml/L without wetcit). While the minimum annual shoot growth (19.05 cm) was recorded under T_1 (control). The improvement of annual shoot growth by the application of treatment Kromolin + witcet, may be due to an exogenous application of gibberellin through Kromolin, in which the gibberellic acid enhanced both cell division and cell elongation as well as it grates role in activating in the biosynthesis of protein RNA and DNA (Pant, 2015). Basically, cytokine through kromolin, might act early cell division in the tree in which led to an improvement to the annual shoot growth. These results are in conformity with findings of Pant (2015) in Red Delicious apple.

Leaf chlorophyll (SPAD): chlorophyll content of leaves significantly effect by different concentration of kromolin. The maximum leaf chlorophyll content (49.60 SPAD) was observed in T_5 (Kromolin 1.0 ml/L with wetcit) Whereas, the lowest leaf chlorophyll content (47.45 SPAD) recorded in control. The increase in chlorophyll content of leaf in might attributed to the fact that cytokines prevent chlorophyll degradation in the leaves (Prajapati et al., 2014) or may be due to the positive interaction of cytokinin in delaying senescence process which help in retention of chlorophyll in the leaf (Kundu et al., 2013). Kinetin treatment postponed the senescence of leaves through improving RNA synthesis followed by protein synthesis, thus resulted the increase of chlorophyll content of leaves (Bisht et al., 2014). The role of gibberellin in increasing the chlorophyll content of leaves might be due to increasing the PAL (Phenylalanine ammonia-lyase) activity and anthocyanin content in the apple fruit. It also be concluded that PAL activity

and anthocyanin content high in red ripen stage. Thus, it can be concluded that GA_3 treatment are promising for enhancing the chlorophyll fluorescence, protein content and increasing the PAL activity and anthocyanin content of wax apple fruit under field conditions (Khandaker et al., 2015), this finding are in conformity with the findings of (Kundu et al., 2013) in pear.

Table 1: Effect of plant growth regulator on leaf chlorophyll content of apple tree content of apple cv. Royal Delicious

Treatments combination		Annual shoot growth (cm)	Leaf chlorophyll (SPAD)
T_1	Control	19.05	47.61
T_2	Kromolin 0.5ml/L without wetcit	22.25	48.96
T_3	Kromolin 1.0 ml/L without wetcit	24.35	49.33
T_4	Kromolin 0.5 ml/L with wetcit	22.1	46.69
T_5	Kromolin 1.0 ml/L with wetcit	29.75	49.60
C.D $_{0.05\%}$		4.76	**2.91**

Physical parameters: as the data reviled that kromolin (gibberellin + cytokines) had a significant effect of fruit physical characteristics throughout the parameters as compared with control.

Fruit Length: The result of effect of Kromolin treatments of fruit length are presented in Table 2, the result indicates that the fruit length significantly increased over control. The maximum fruit length (78.01 mm) was recorded in T_5 (Kromolin 1.0 ml/L with wetcit). Which was found statistically at par with the treatments T_3 (Kromolin 1.0 ml/L without wetcit) and T_4 (Kromolin 0.5 ml/L with wetcit). However, the lowest fruit length (71.54 mm) was observed in the control.

Fruit diameter: The maximum fruit diameter (76.32 mm) was recorded in T_5 (Kromolin 1.0 ml/L with wetcit). Which was found statistically at par with the treatments T_3 (Kromolin 1.0 ml/L without wetcit) and T_4 (Kromolin 0.5 ml/L with wetcit). However, the lowest fruit diameter (70.50 mm) was observed in the control

Fruit volume: The result of effect of Kromolin treatments of fruit volume are presented in Table 2, the result indicates that the data in the treatment T_5 increased the fruit volume significantly as compared to other treatments and control. The maximum fruit volume (242.67 cm3) was recorded in T_5 (Kromolin 1.0 ml/L with wetcit). However, the lowest fruit volume (188.52 cm3) was observed in control.

Fruit weight: the result in table 2 indicated that kromolin at higher concentration had a significant effect on fruit weight of fruit. Maximum fruit weight (213.46 g) was observed in T_5 (Kromolin 1.0 ml/L with wetcit). Which is significantly at par with T_3 (Kromolin 1.0 ml/L without wetcit) and T_4 (Kromolin 0.5 ml/L with wetcit) whereas, the lowest fruit weight (165.14 g) was observed in control.

Fruit Yield: The result of presented study in table 2 indicated that higher concentration of Krolomin+wetcit had a significant on fruit yield during the research period. However, the maximum Fruit yield (203.10 Kg/tree) was recorded in T_5 (Kromolin 1.0 ml/L with wetcit) which was found statistically at par with T_3 (Kromolin 1.0 ml/L without wetcit). While the lowest (175.49 kg/tree) fruit yield was observed in T_1 (control).

Fruit specific gravity: The result of presented study in Table 2 indicated that different concentration of Kromolin had a significant effect on fruit specific gravity. The maximum specific gravity (0.93) was recorded in T_5 (Kromolin 0.5 ml/L with wetcit), which was found statistically at par with treatments T_3 (Kromolin 1.0 ml/L without wetcit). However, the minimum specific gravity (0.73) was recorded in control.

Fruit Firmness: The result of presented study in Table 2 indicated that there was no significant effect of different concentration of kromolin on fruit firmness. However,

numerically the maximum fruit firmness (5.86 kg/cm^2) recorded in T_2 (Kromolin 0.5ml/L without wetcit). However, the minimum fruit firmness (5.23 kg/cm^2) was recorded in T_3 (Kromolin 1.0 ml/L without wetcit).

Fruit colour: The result of presented study in Table 2 indicated that there was no significant effect of different concentration of kromolin on fruit colour during. However, numerically the maximum fruit colour (4%) respectively recorded in T_2, T_3, T_4 and T_5. However, the minimum fruit colour (3%) was found in control.

The improvement of fruit length, diameter, weight, volume, specific gravity and yield by the application of treatment Kromolin + witcet may be due to an exogenous application of cytokine through kromolin which acts early cell division in the fruit and also on subsequent growth. Thus, fruit becomes bigger in size due to efficient cells because the cells have been able to attract more water, minerals and carbohydrates that enable the fruit to expand to large size (Kulkarni, 2017). The role of gibberellin through the Kromolin had a positive effect in fruit size, weight, volume, specific gravity and yield which this improvement might be due to the positive action on enhancing both cell division and cell elongation as well as it grate role in activating in the biosynthesis of protein RNA and DNA (Pant, 2015). These results are in conformity with findings of Pant (2015) in Red Delicious, Lal and ahmed (2012), Digrase et al. (2016) in pomegranate and Shukla et al. (2011) reported the same result through application of GA_3. However, Martin et al. (1970) and Basi et al. (1993) claimed the same result in apple fruits through application of synthetic cytokines source (CPPU).

Table 2: Effect of Plant growth regulator on physical characteristics of apple cv. Royal Delicious

Treatments combination		Fruit length (mm)	Fruit diameter (mm)	Fruit volume (cm^3)	Fruit Weight (g)	Yield (kg/tree)	Specific gravity (g/cm^3)	Fruit Firmness kg/cm^2	Fruit colour (%)
T_1	Control	71.54	70.50	188.52	165.14	175.49	0.73	5.75	3
T_2	Kromolin 0.5 ml/L without wetcit	73.81	71.22	202.73	179.80	182.20	0.80	5.86	4
T_3	Kromolin 1.0 ml/L without wetcit	74.69	75.04	218.72	189.51	194.89	0.88	5.23	4
T_4	Kromolin 0.5 ml/L with wetcit	75.57	73.93	220.60	187.47	190.50	0.80	5.73	4
T_5	Kromolin 1.0 ml/L with wetcit	78.01	76.32	242.67	200.46	203.10	0.93	5.56	4
C.D $_{0.05\%}$		**4.02**	**2.82**	**7.51**	**13.26**	**8.22**	**0.11**	**N/A**	**N/S**

CHEMICAL PARAMETERS:

TSS: The data regarding T.S.S. content of the fruits has been presented in Table 3. The results revealed that application of Kromolin at different concentration had no significantly effect on the T.S.S. of apple fruit. However, numerically highest T.S.S. (13.53 ^{o}Brix) was found in T_5 (Kromolin 1.0 ml/L with wetcit). While the lowest T.S.S. (12.35 ^{o}Brix) recorded in control.

Fruit Acidiy: The data from the Table 3 revealed that, the titrable acidity (%) of fruits had significantly affect due to the application of different concentration of kromolin. The lowest acidity (0.24 %) was found in the treatment T_5 (Kromolin 1.0 ml/L with wetcit) which was statically at par with T_3 and T_4. While the highest acidity (0.30 %) was recorded under control.

TSS/acid ratio: The data regarding TSS/acid ratio content of the fruits has been presented in Table 3. The results revealed that application of different concentration of Kromolin had not significantly effect the TSS/acid ratio of apple fruit. However, numerically highest TSS/ Acid ratio (56.36) was found in T_5 (Kromolin 1.0 ml/L with wetcit). While the lowest TSS/acid ratio (42.16) was observed under treatment T_2 (Kromolin 0.5ml/L without wetcit).

Fruit Ascorbic acid: The result of presented study in Table 3 indicated that higher concentration of Krolomin+wetcit had a significant effect on Ascorbic acid during the research period. The maximum fruit ascorbic acid (3 mg/100g) was recorded in T_5 (Kromolin 1.0 ml/L with wetcit) which was found statistically at par with T_3. While the lowest fruit yield (1.6 mg/100g) was observed in T_1 (control). The perceptive increase in ascorbic acid with gibberellic acid may be due to catalytic influence of gibberellic acid on its biosynthesis from its precursor glucose6-phosphate or the inhibition of its conversion to dehydroascorbic acid by ascorbic acid oxidase or both (Hazarika, 2016). The role of witcet in here attributes to the fact that witcet enhance the absorption of Kromolin by the plant and increase the efficiency of kromolin. These are in line with the finding of Shanmugasundaram (2013) in pomegranate cv. Mridula and Jayachandran et al. (2005) in guava cv. Lucknow-49 through application of GA_3, the same result claimed by Sharma (2009) in strawberry through application of GA_3.

Total Sugar: The data regarding total sugars has been presented in Table 3. The significant differences were not observed with respect to total sugar content of the fruits due to the application of different concentration of Kromolin. However, numerically the highest total sugar (9.21 mg/100g) was registered in the treatment T_5 (Kromolin 1.0 ml/L with wetcit). While the lowest total Sugar (8.45 %) was recorded under T_1 (control).

Reducing sugar: there was no significant effect with respect to reducing sugar due to the application of different concentration of kromolin. However, numerically the highest reducing sugar (6.39 mg/100g) was found in the treatment T_5 (Kromolin 1.0 ml/L with wetcit) which is followed by T_4 and T_3). However the lowest reducing sugar (5.32) was found in T_2 (Kromolin 0.5ml/L without wetcit).

Table 3: Effect of Plant growth regulator on chemical characteristics of apple cv. Royal Delicious

Treatments combination		Fruit TSS (^{o}Brix)	Acidity (%)	TSS/ acid ratio	Ascorbic acid (mg/100g)	Total sugar mg/100g	Reducing sugar mg/100g
T_1	Control	12.35	0.30	46.06	1.61	8.45	5.34
T_2	Kromolin 0.5 ml/L without wetcit	12.73	0.29	42.16	1.80	8.49	5.32
T_3	Kromolin 1.0 ml/L without wetcit	13.47	0.27	50.35	2.50	8.83	5.56
T_4	Kromolin 0.5 ml/L with wetcit	13.00	0.27	43.81	2.00	8.74	5.80
T_5	Kromolin 1.0 ml/L with wetcit	13.53	0.24	56.36	3.00	9.21	6.39
C.D $_{0.05\%}$		N/S	0.03	N/S	0.41	N/S	N/S

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CONCLUSION

The result can be concluded that fruit of apple cv. Royal Delicious significantly affect through all the treatments, treatment (Kromolin 1.0 ml/L with wetcit) indicated maximum vegetative growth and chlorophyll content of leaf, fruit physical parameters, fruit colour, TSS, TSS acid ratio, ascorbic acid, total sugar, reducing sugars and lowest acidity, while the highest firmness was recorded

through the treatment (Kromolin 0.5ml/L without wetcit) as compared to control.

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