International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

# Foliar application of Plant Growth Regulators Influences the Growth, Yield and Quality in Kiwifruit cv. Hayward

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## ABSTRACT

*An experiment was conducted on 11-year-old vines of kiwifruit cv. Hayward grown on a T-bar trellis system for two years to study the influence of foliar application of plant growth regulators on growth, yield and quality. Four different plant growth regulators viz., $GA_3$ (25 and 50 $mgL^{-1}$), BA (10 and 20 $mgL^{-1}$), 2, 4-D (10 and 25 $mgL^{-1}$), TRIA (10 and 20 $mgL^{-1}$) and a natural extract (4$gmL^{-1}$) were sprayed four weeks after full bloom. All the growth regulators proved effective in influencing the different traits of kiwifruit. Plants treated with 50 $mgL^{-1}$ of $GA_3$ resulted in significantly higher plant volume. Number of leaves per shoot (32.50 and 33.20) and leaf area (190.25 $cm^2$ and 188.34 $cm^2$) was highest with 25 $mgL^{-1}$ of $GA_3$. Treatment ($T_6$) 10 $mgL^{-1}$ 2, 4-D recorded highest fruit retention (86.19 % and 81.06 %), yield per vine (57.98 kg and 54.82 kg) and fruit zinc content (6.88 and 6.67 ppm).Physiological loss in weight was lowest with the application of 25 $mgL^{-1}$ $GA_3$. Among all the treatments, application of 25 $mgL^{-1}$ $GA_3$ followed by 10 $mgL^{-1}$ 2, 4-D proved to be more effective in improving fruit characteristics viz., fruit firmness , total soluble solids and total sugars content. It was concluded that application of 25 $mgL^{-1}$ $GA_3$ and lower concentration of 2, 4-D i.e. 10 $mgL^{-1}$ improved growth, yield and quality of kiwifruit.*

***Key words: Plant growth regulator, growth, kiwifruit, chemical parameters.***

## I.INTRODUCTION

Kiwifruit (*Actinidia deliciosa* Chev.), a newly introduced fruit crop has great potential in temperate fruit growing areas of India. The fruit is very much acclaimed for its nutritive and medicinal value. It is rich is ascorbic acid, vitamin E and minerals like K, P and Ca. The important advantage of cultivation of this fruit is that it is available for marketing during October to December months when other fruits are rarely available and therefore fetches good price. Therefore large numbers of orchardists are now interested towards the cultivation of this fruit. Of few cultivars, the most common kiwifruit cultivar 'Hayward' accounts for 75 per cent of the global kiwifruit production due to its internal green colour, superior flavour and storage life. Use of synthetic growth regulators and natural plant extract viz. gibberellic acid, 6-benzyl aminopurine (BA), 2,4-D, triacontanol etc. are known to influence various plant processes such as water and nutrient uptake and thus increase the

growth and quality. Therefore the present studies were undertaken to test the influence of different growth regulators on growth, production and quality of kiwifruit cv. Hayward.

## II.MATERIALS AND METHODS

Investigations were carried out on 11-year-old Hayward kiwifruit vines spaced at 6mx5m. Canopies of the vines were trained on T-bar system. The vines were irrigated using drip irrigation system. All the vines were managed according to uniform agronomic practices. There were ten treatments viz. Gibberellic acid @50 mg/litre ($T_1$), Gibberellic acid @25 mg/litre ($T_2$), Benzylaminopurine (6-BA) @ 20 mg/litre ($T_3$), Benzylaminopurine (6-BA) @ 10 mg/litre ($T_4$), 2, 4-Dicholorophenoxyacetic acid @25 mg/litre ($T_5$), 2, 4-Dicholorophenoxyacetic acid @10 mg/litre ($T_6$), Triacontanol (TRIA) @ 20 mg/litre ($T_7$), Triacontanol (TRIA) @ 10 mg/litre ($T_8$), Natural extract (Auxin + Cytokinin + $GA_3$) ($T_9$) and control (water spray) ($T_{10}$). The treatments were applied foliarly 4-weeks after full bloom. Treatments were replicated thrice with a plot size of 2 plants/treatment and the experiment was laid in Randomized Block Design (RBD). The average plant volume for each treatment was calculated from height and spread measurements according to the formula given by Westwood (1993) and expressed in $m^3$. Total number of leaves per shoot was counted by selecting four shoots in different directions and the average leaf number per shoot was calculated. Area of the leaves collected during the month of July was measured with the help of LICOR-Model 3100 leaf area meter and expressed in square centimeter. The total number of fruits retained on the tagged branches was counted at the time of harvest and percentage of fruit retained was calculated on the basis of total number of fruits at the time of fruit set and expressed in per cent (Westwood, 1993). The yield of fruits under different treatments was determined on the basis of total weight of fruits harvested from the vine under each treatment and average yield per vine was calculated and expressed in kilograms per vine (kg/vine). Total number of fruits were counted at the time of harvest and expressed as number of fruits per vine. The weight of ten randomly selected fruits per vine was taken on a top pan balance and average weight was expressed in grams (g). The pressure required to force a 8 mm plunger into the kiwifruit flesh was recorded as a measure of fruit firmness using digital fruit pressure tester (Toshiba-India make). Observations were taken on diagonal sides of each fruit after peeling flesh of one square inch and results expressed in Newton (N). Total sugars content were determined as per the method described by Ranganna (1986). Fruit TSS was measured with a hand refractometer (Tanco-0 to 50% range) by placing few drops of juice from stem and stylar end of each fruit on the prism and taking the readings. Zinc content in fruit was determined using Atomic Absorption Spectrophotometer (AAS 4141). Physiological loss in weight, was measured by taking a sample of 30 fruits with 10 fruits in each replication were kept separately in 3 boxes where each box represented a replication. The weight of the fruit after 20 days of storage under ambient conditions was recorded and per cent physiological loss in weight (PLW) was calculated by subtracting the final weight of fruit from initial weight as per the following equation:

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

The data generated were subjected to statistical analysis as per the procedures described by Gomez and Gomez (1983).

## III.RESULTS AND DISCUSSION

Tree volume , leaf area, number of leaves per shoot and fruit retention of kiwifruit cv. Hayward were significantly influenced by exogenous application of plant growth regulators (Table1).Maximum Tree volume was recorded with the application of 50 mg $l^{-1}$ $GA_3$ ($T_1$) (11.99 $m^3$ during 2011 and 11.76$m^3$ during 2012) which was significantly superior over rest of the treatments. Lowest tree volume was recorded in control ($T_{10}$) (10.45 $m^3$ during 2011 and 10.31$m^3$during 2012). Maximum number of leaves per shoot was observed with ($T_2$) 25 mg $l^{-1}$ of $GA_3$ (32.50) during 2011 and (33.20) during 2012.Maximum leaf area (190.25 $cm^2$ during 2011 and 188.34 $cm^2$ during 2012) was recorded in vines which received 25 mg $l^{-1}GA_3$ ($T_2$) in comparison to other treatments under study. However lowest leaf area was observed in control ($T_{10}$) (170.57 $cm^2$ during 2011 and 173.62 $cm^2$ during 2012). The promotion of growth in terms of increase in tree volume and leaf area has been attributed to increasing plasticity of the cell wall followed by hydrolysis of starch to sugars which lowers the water potential of cell, resulting in the entry of water into the cell causing elongation. These osmotic driven responses under the influence of gibberellins might have attributed for increase in photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products, thus resulting in increased cell elongation and rapid cell division in the growing portion. The results are in conformity with the findings of Xin *et al.* (1994). Increase in the number of leaves due to $GA_3$ might be due to additional availability of GA in seed which might have increased the level of amylase in the aleurone tissues of seed for better conversion of complex starch into simple sugars for providing energy for growth (Asrey *et al.,* 2001).Fruit retention was highest with 10 mg $l^{-1}$ 2, 4-D ($T_6$) (86.19% during 2011 and 81.06 % during 2012) in comparison to other treatments. However lowest per cent fruit retention was recorded in control ($T_{10}$) (63.71% during 2011 and 60.92 % during 2012). These results are in agreement with the finding of Ghosh and Chattopadhyay (1994).Retention or abscission of flower and fruit are influenced by combination of endogenous as well as environmental factors. Plant hormones such as auxin, gibberellin and ethylene are among the endogenous factors controlling abscission of organs, including flowers, and fruits (Taiz and Zeiger, 2002).Reduction in fruit drop as a response of gibberellic acid may also be due to an increase in initial growth of ovaries which ultimately reduce the magnitude of peak of abscission (Agusti, 2003).The results are also in conformation to the findings of Rani and Brahmachari (2004).

**Table1.Effect of foliar application of plant growth regulators on tree volume, number of leaves per shoot, leaf area and fruit retention in kiwifruit cv. Hayward.**

| Treatments | Tree volume | | Number of leaves /shoot | | Leaf area ($cm^2$) | | Fruit retention (%) | |
|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| $T_1$ | 11.99 | 11.76 | 30.19 | 31.84 | 185.77 | 183.82 | 81.32 | 72.12 |
| $T_2$ | 11.84 | 11.57 | 32.50 | 33.20 | 190.25 | 188.34 | 85.43 | 78.75 |
| $T_3$ | 10.86 | 10.75 | 24.13 | 24.78 | 177.17 | 176.42 | 76.23 | 73.10 |
| $T_4$ | 11.01 | 10.97 | 24.75 | 21.09 | 179.18 | 177.23 | 78.64 | 70.04 |
| $T_5$ | 11.23 | 11.13 | 27.95 | 27.67 | 180.14 | 179.19 | 83.12 | 76.34 |
| $T_6$ | 11.51 | 11.29 | 28.15 | 29.84 | 184.07 | 182.46 | 86.19 | 81.06 |
| $T_7$ | 10.99 | 10.56 | 23.95 | 24.63 | 173.03 | 173.98 | 79.32 | 64.19 |
| $T_8$ | 10.41 | 10.01 | 22.10 | 22.75 | 175.13 | 174.84 | 84.19 | 78.72 |
| $T_9$ | 11.62 | 11.02 | 26.19 | 28.84 | 181.27 | 179.37 | 73.39 | 70.26 |
| $T_{10}$ | 10.45 | 10.31 | 21.65 | 21.74 | 170.57 | 173.62 | 63.71 | 60.92 |
| $CD_{(0.05)}$ | 0.13 | 0.11 | 2.41 | 1.34 | 1.41 | 1.39 | 2.01 | 2.21 |

The data on yield per vine, Fruit weight, Firmness and Total sugars are presented in table 2.Maximum yield per vine was noticed with 10 mg $l^{-1}$ 2, 4-D ($T_6$) (57.98 kg $vine^{-1}$ during 2011 and 54.82 kg $vine^{-1}$ during 2012) followed by 25 mg $l^{-1}$ 2-4-D ($T_5$) (56.18 kg $vine^{-1}$ during 2011 and 52.63 kg $vine^{-1}$ during 2012). The significantly lower fruit yield was recorded in control ($T_{10}$) (40.95 kg $vine^{-1}$ during 2011 and 39.79 kg $vine^{-1}$ during 2012). Increased number of fruits per tree and increased fruit size and weight might have contributed towards increase in yields due to growth regulators application. 2, 4-D treatments have also known to increase total yields in other fruits like Nagpur Santra (Ansari *et al.*, 2008). Fruit weight was significantly more in vines treated with 25 mg $l^{-1}$ $GA_3$ ($T_2$) (87.39 g during 2011 and 89.94 g during 2012) in comparison to other treatments

.However minimum fruit weight was recorded in control ($T_{10}$) (66.96 g during 2011 and 68.43 g during 2012). Fruit firmness was higher with the application of 25 mg $l^{-1}$ $GA_3$ ($T_2$) (7.76 N during 2011 and 7.55 during 2012). The lowest firmness was recorded in untreated fruit ($T_{10}$) (7.01 N during 2011 and 7.04 N during 2012). Choi *et al.* 2002 also reported that $GA_3$ increased fruit firmness at harvest and decreased the rate of fruit softening. Maximum percentage of total sugars was recorded with the application of 25 mg $l^{-1}$ $GA_3$ ($T_2$) (12.76% during 2011 and 12.01 % during 2012).Minimum total sugars content was recorded with 25 mg $l^{-1}$ 2, 4-D ($T_5$) (8.65% during 2011 and 9.21 % during 2012). The increase in the content of total sugars in fruits may be due to degradation of polysaccharides into simple sugars by metabolic activities, conversion of organic acids into sugars, and loss of moisture with growth regulators application (Kumar *et al.*, 2011).

**Table 2. Effect of Foliar application of plant growth regulators on yield per vine, fruit weight, firmness and total sugars in kiwifruit cv. Hayward.**

| Treatments | Yield per vine (Kg) | | Fruit weight (g) | | Fruit firmness (N) | | Total sugars (%) | |
|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| $T_1$ | 51.45 | 48.13 | 79.84 | 81.82 | 7.69 | 7.50 | 12.65 | 11.67 |
| $T_2$ | 53.29 | 49.08 | 87.39 | 89.94 | 7.76 | 7.55 | 12.76 | 12.01 |
| $T_3$ | 47.89 | 44.73 | 79.21 | 81.11 | 7.34 | 7.13 | 11.32 | 11.31 |
| $T_4$ | 48.15 | 46.99 | 78.34 | 78.74 | 7.46 | 7.25 | 12.05 | 11.58 |
| $T_5$ | 56.18 | 52.63 | 84.75 | 84.97 | 7.64 | 7.46 | 8.65 | 9.21 |
| $T_6$ | 57.98 | 54.82 | 86.24 | 87.11 | 7.53 | 7.32 | 8.91 | 9.36 |
| $T_7$ | 44.79 | 41.13 | 80.79 | 81.24 | 7.32 | 7.37 | 11.21 | 11.28 |
| $T_8$ | 46.14 | 43.29 | 78.30 | 79.99 | 7.05 | 7.07 | 10.32 | 11.34 |
| $T_9$ | 46.28 | 43.12 | 79.11 | 74.86 | 7.23 | 7.29 | 11.20 | 11.18 |
| $T_{10}$ | 40.95 | 39.79 | 66.96 | 68.43 | 7.01 | 7.04 | 9.05 | 9.17 |
| $CD_{(0.05)}$ | 1.33 | 1.09 | 0.11 | 0.04 | 0.08 | 0.04 | 0.01 | 0.32 |

Total soluble solids, zinc content in fruits and physiological loss in weight is presented in table 3.Total soluble solids were found to be highest with foliar application of 25 mg $l^{-1}$ $GA_3$ ($T_2$) (12.91 $^0$B during 2011 and 13.32 $^0$B during 2012). Increase in total soluble solids might be due to conversion of carbohydrates into simple sugars with $GA_3$ applications (Rub *et al.*, 2010). Clayton *et al.* (2006) also reported that $GA_3$ sprays increased fruit soluble solids in sweet cherry. Plants treated with 10 $mgL^{-1}$ 2, 4-D ($T_6$) recorded higher fruit Zn content 6.88 ppm during 2011 and 6.67 ppm during 2012. The results are in accordance with the findings of Marschner (1995) and (Hassan *et al.*, 2010). Per cent weight loss of Hayward fruit during storage was significantly influenced by different growth hormones during both the years of study. There was a gradual increase in per cent physiological loss in weight of Hayward fruits during storage period of 20 days irrespective of treatments. All the treatments had great influence in reducing the physiological loss in weight during storage as compared to control. Physiological loss in weight was significantly lowest with the application of ($T_2$) 25 mg/litre $GA_3$ (3.13 and 3.17%) followed by ($T_1$) 50 mg/litre $GA_3$ (3.34 and 3.49%) and ($T_6$) 10 mg/litre 2,4-D (3.41 and 3.99%) than all other treatments. The control recorded significantly higher physiological loss in weight (5.24 and 6.02%) during both the years. Physiological loss in weight of fruit is mainly due to evaporation, respiration and degradation process occurring during post-harvest handling of fruits (Haard and Salunkhe 1975). It has been suggested that $GA_3$ influences cuticle thickness and dimensions of the epidermal cells (Mohamed *et al.*, 2007). The results are inconformity with the findings of Marzouk and Kassem (2011).

**Table 3.Effect of foliar application of plant growth regulators on total soluble solids, fruit zinc and physiological loss in weight (%) in kiwifruit cv. Hayward.**

| Treatments | **T.S.S. ($^o$Brix)** | | **Zn (ppm)** | | **Physiological loss in weight (%)** | |
|---|---|---|---|---|---|---|
| | **2011** | **2012** | 2011 | 2012 | **2011** | **2012** |
| $T_1$ | 12.80 | 13.11 | 6.51 | 6.50 | 3.34 | 3.49 |
| $T_2$ | 12.91 | 13.32 | 6.47 | 6.48 | 3.13 | 3.17 |
| $T_3$ | 12.29 | 12.45 | 6.85 | 6.07 | 3.50 | 4.25 |
| $T_4$ | 12.42 | 12.84 | 6.75 | 5.95 | 3.48 | 4.21 |
| $T_5$ | 12.65 | 12.98 | 6.62 | 6.61 | 3.45 | 4.02 |
| $T_6$ | 12.78 | 13.23 | 6.88 | 6.67 | 3.41 | 3.99 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $T_7$ | 12.11 | 12.65 | 6.42 | 6.45 | 3.52 | 4.56 |
| $T_8$ | 11.93 | 12.87 | 6.47 | 6.47 | 3.50 | 4.49 |
| $T_9$ | 11.10 | 12.11 | 6.44 | 6.45 | 3.51 | 4.52 |
| $T_{10}$ | 11.25 | 11.32 | 4.23 | 4.38 | 5.24 | 6.02 |
| $CD_{(0.05)}$ | 0.51 | 0.07 | 0.015 | 0.014 | 0.17 | 0.29 |

From the above discussion it may be concluded that growth regulators viz., 25 mg/L $GA_3$ and 10 mg/L 2, 4-D may be used for enhancing the plant growth and yield of better quality kiwifruits.

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