Research Article

Strawberry Yield and Yield Attributes after Application of Plant Growth Regulators and Micronutrients on Cv. Winter Dawn

Indira Yadav*[1], Jitendra Singh[1], Bharat Meena[2], Pravin Singh[2], Sanjay Meena[3], Shraddha Neware[4] and D. K. Patidar[2]

[1]Department of Fruit Science, College of Horticulture and Forestry (Agriculture University, Kota) Jhalarapatan, Jhalawar-326 023 Rajasthan, INDIA
[2]Department of Vegetable Science, College of Horticulture and Forestry (Agriculture University, Kota) Jhalarapatan, Jhalawar-326 023 Rajasthan, INDIA
[3]Department of Genetics & Plant Breeding, Institute of Agricultural Science, Banaras Hindu University, Banaras- 221005 Uttar Pradesh, INDIA
[4]Department of Fruit Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, 413 722, District Ahmednagar, Maharashtra, INDIA

Abstract

There are many factors which influence plant health. PGR_S and micronutrients are such type of input factors. With the aim to understand the effect of foliar application of growth regulators and micronutrients on production of Strawberry (Fragaria x ananassa Duch) cv. Winter Dawn under open field condition this experiment was carried out at the Department of Fruit Science and the Protected Cultivation Unit, College of Horticulture & Forestry, Jhalrapatan city, Jhalawar (Rajasthan) during the year 2014-15 and result found that treatment- GA_3 75ppm resulted in the earliest initiation of flowering (23.50 days), the minimum time (29.34 days) for first fruit set, first harvest (53.15 days), maximum harvesting duration (96.00 days), number of pickings (34.17), fruit length (4.91cm), length:diameter ratio (1.92) whereas Maximum fruit diameter (4.20cm) was reported in treatment T14-Boric acid 0.4% and Maximum fruit weight-fresh weight (28.09g) as well as dry weight (2.05g) were found in treatment T_{16}- Zinc sulphate 0.4%. The result of the study showed that foliar spray of T_6- GA_3 75ppm after 45 days of transplanting was found superior over all other treatments with respect to production parameters to enhance strawberry yield under Jhalawar condition.

Keywords: Strawberry, growth regulators and micronutrients, production

***Correspondence**
Author: Indira Yadav
Email: indirayadav999@gmail.com

Introduction

Strawberry is one of the most delicious, attractive, nutritious and refreshing soft fruits of the world. The cultivated strawberry (*Fragaria x ananassa* Duch.) is a hybrid of two native American sp; *F. chiloensis* and *F. virginiana*. Strawberries are good source of natural anti-oxidant [8]. Owing to its medicinal properties (anticarcinogenic, antidiabetic and antioxidant), strawberry is gaining popularity among all age group consumers. Strawberries are good source of natural anti-oxidant [21]. In India, it is mainly grown in Maharashtra and in hills of Himachal Pradesh, J&K and Uttarakhand.

The main objective of the strawberry growers is to produce a fruit with appealing appearance (size, color and shape) not necessary accompanied by the same appealing tasteful characteristics [2]. In order for the farmers to achieve such fruit growth enhancement, they often use plant growth regulating compounds. Plant growth regulators (PGR_S) have proven their role in augmenting yield and quality in many fruits. Some of plant bio-regulators are synthesized endogenously, but occasionally they are needed to get supplemented exogenously for additional stimulus for short duration crop like strawberry, which require quick response for increased growth, fruit set and yield. Use of plant bio-regulators plays an important role in vegetative growth, flowering, yield and quality.

Use of GA_3 in strawberry has been reported in early flowering, increased duration of flowering, harvesting and yield. It increases yield and quality of fruits, helps in cell elongation and cell enlargement, increases vegetative growth and minimizes time of maturity and increases fruit set [14].

Application of NAA increases fruit size and delays ripening and increases anthocyanin accumulation in strawberry fruits. It also increases duration of flowering, improves yield and quality of fruits [12].

BA, as a plant growth regulator enhances the size and shape of fruits, lateral bud break and lateral shoot growth, leading to improved branching in fruit trees and flowering [17]. BA increases fruit size and delay chlorophyll breakdown and fruit ageing. BA also decreases loss in firmness, delay ethylene production, decreases respiration rate and induces mechanical resistance which reduces senescence rate after harvest.

Morphactins are a group of substances which act on morphogenesis and modulate the expression of plants. Chemically they are methyl 2- chloro-9-hydroxyfluorene-9-carboxylate. In the presence of other natural hormones, morphactins exhibit both synergistic and antagonistic effects. However, the effect depends upon the relative concentrations. Its role has been observed in mango Cv. Kensington Pride for increasing flowering and reduces vegetative growth of plant [5].

Micronutrients forming constituent part of plant are considered essential for the plants. Zinc (Zn) is an essential micro element for plants. It is involved in many enzymatic reactions. Zinc is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory factor of a large number of enzymes. Zn is essential for carbon dioxide evolution and utilization of carbohydrate and phosphorus metabolism and synthesis of RNA [15].

Boron is a heavy non-metal micronutrient. It is absorbed by plant in the form of boric acid (H_3BO_3). For translocation of sugar; reproduction of plants and germination of pollen grains boron is necessary. The above explanation clearly highlights the effectivity of PGR_S and micronutrients on intensifying crop's productivity. Hence, there is a need to conduct research aimed to quantify their effect on strawberry culture and experiment was conducted.

Materials and Methods

Experimental design

The present investigation was carried out at Department of Fruit Science and the Protected Cultivation Unit, College of Horticulture & Forestry, Jhalrapatan city, Jhalawar (Rajasthan) India during 2014-15 as Randomized Block Design (RBD) with seventeen treatments. The treatments consistent different growth regulators and micronutrients viz. Control (T_0), NAA 5ppm (T_1), NAA 10ppm (T_2), NAA 15ppm (T_3), GA_3 25ppm (T_4), GA_3 50ppm (T_5), GA_3 75ppm (T_6), BA 5ppm (T_7), BA 10ppm (T_8), BA 15ppm (T_9), Morphactin 25ppm (T_{10}), Morphactin 50ppm (T_{11}), Morphactin 75ppm (T_{12}), Boric acid 0.2% (T_{13}), Boric acid 0.4% (T_{14}), Zinc sulphate 0.2% (T_{15}) and Zinc sulphate 0.4% (T_{16}).

Planting system and crop management

Plants were planted at a spacing of 60 x 30 cm on drip during 18 October, 2014, each treatment with three replications consisting 51 beds (1.5x1.2 m) in which strawberry cultivar 'Winter Dawn'. Each treatment consisted of three plants. Recommended dose of NPK (19:19:19) as liquid fertilizers were applied through fertigation machine.

Plant sampling and laboratory procedures

The observations were recorded on nine characters namely days taken to first flower initiation, days taken to first fruit set, days taken to first harvest, days taken to final harvest, number of pickings, fruit length (cm), fruit diameter (cm), length and diameter ratio and fruit weight (g).

Production parameters like days taken to first flower initiation, days taken to first fruit set, days taken to first harvest, days taken to final harvest, number of pickings are taken by counting days for each observation from date of transplanting. Fruit length (cm), fruit diameter (cm), length:diameter ratio are taken by using digital vernier caliper and fruit weight (g) on physical balance respectively. Analysis of variance for individual character was done on the basis of mean values as suggested by [11].

Results and Discussion

Days taken to initiate first flowering

Data presented in **Table 1** and **Figure 1** revealed that the various plant production parameters were significantly influenced by different growth regulators.

Treatment- $GA_3$75ppm resulted in the earliest initiation of flowering (23.50 days),whereas, it took more number of days (37.40 days) for initiation of flowering in treatment T_{12}- Morphactin 75ppm. Minimum days required to initiate

flower with treatment T_6- $GA_3$75ppm may be due to its effect to cause rapid growth of flower primordium. Its role has been well proven in enhancing flowering in short day plants growing under inducive conditions [18]. Gibberellin is known to overcome endogenous dormancy factors and promote flowering. Similar findings in earlier flowering due to GA3 were reported in rose and strawbeery respectively [4, 20].

Table 1 Effect of growth regulators and micronutrients on days taken to first flower initiation to final harvest and number of pickings of strawberry (*Fragaria x ananassa* Duch.) cv. Winter Dawn

Treatments	Days taken to first flower initiation	Days taken to first fruit set	Days taken to first harvest	Days taken to final harvest	Number of pickings
T_0- Control	34.33	43.67	62.10	85.83	21.18
T_1- NAA 5ppm	32.36	40.61	59.67	89.14	23.07
T_2- NAA 10ppm	31.77	40.80	58.16	89.48	25.73
T_3- NAA 15ppm	31.42	40.10	57.16	90.89	26.84
T_4- GA_3 25ppm	27.40	34.82	54.94	89.67	28.12
T_5- GA_3 50ppm	26.75	34.39	54.51	92.89	28.95
T_6- GA_3 75ppm	23.50	29.34	53.15	96.00	34.17
T_7- BA 5ppm	33.04	39.67	60.35	90.69	27.88
T_8- BA 10ppm	31.07	38.05	58.85	92.29	28.28
T_9- BA 15ppm	30.35	36.19	57.28	92.69	29.17
T_{10}-Morphactin 25ppm	32.05	41.16	64.50	85.71	23.48
T_{11}-Morphactin 50ppm	35.47	43.03	67.33	84.30	21.07
T_{12}-Morphactin 75ppm	37.40	47.07	71.00	81.82	18.86
T_{13}- Boric acid 0.2%	34.16	43.30	60.44	90.19	27.50
T_{14}- Boric acid 0.4%	31.18	40.26	59.26	91.37	29.78
T_{15}- Zinc sulphate 0.2%	33.70	41.74	60.34	91.44	29.78
T_{16}- Zinc sulphate 0.4%	33.80	41.34	59.15	92.21	28.89
CD at 5%	3.26	2.70	2.09	2.91	3.09
SEm±	1.60	1.40	1.05	1.31	1.52

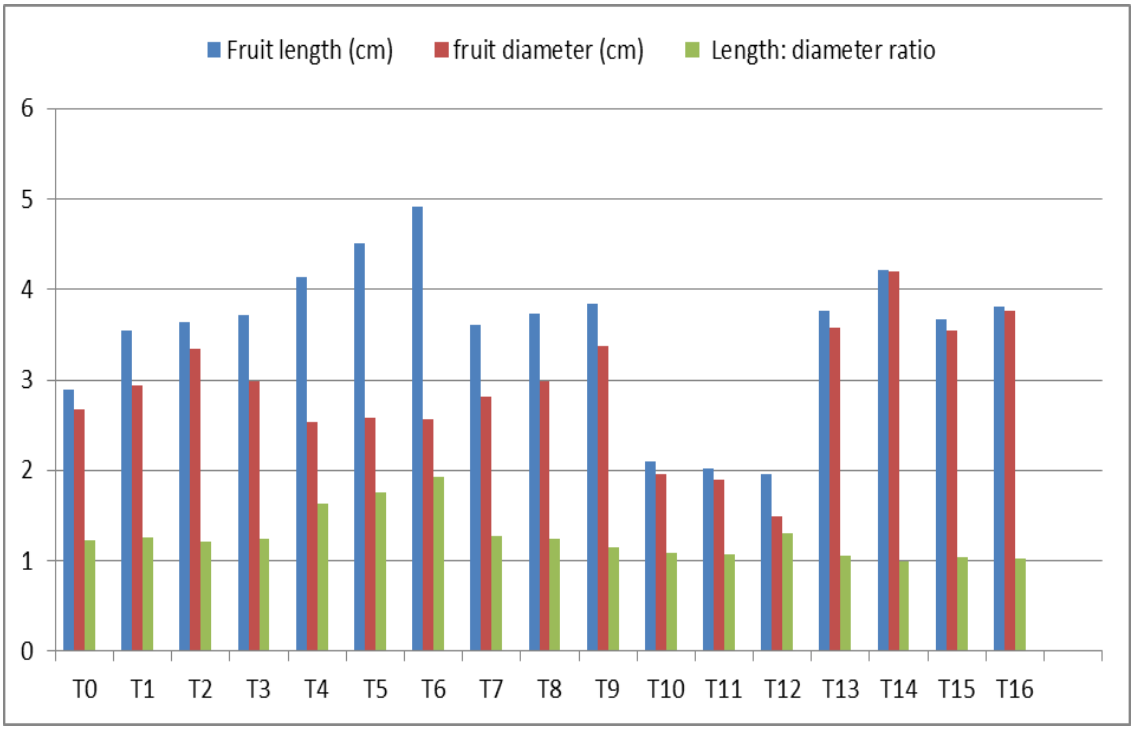

Figure 1 Effect of growth regulators and micronutrients on fruit length, fruitdiameter and length:diameter ratio of strawberry (*Fragaria x ananassa* Duch.) cv.Winter Dawn

Days taken to initiate first fruit set and harvesting

Minimum time (29.34 days) for first fruit setand first harvesting (53.15 days), were observed in T_6- GA_3 75ppm, while maximum time for fruit set (47.07 days) and first harvest (71.00 days) in T_{12}-Morphactin 75ppm. It might be due to the fact that exogenous application of GA_3 application increases the level of endogenous gibberelins and plays an important role in breaking dormancy which ultimately took fewer days to first fruit set and first harvesting. Similar findings reported in strawberry cv. 'Confitura' and 'Brighton' with 40ppm $GA_3$and [3, 9].

Days taken to final harvest and number of pickings

Maximum harvesting duration (96.00 days) and number of pickings (34.17) in $GA_3$and minimum productive period (81.82 days) and minimum number of pickings (18.86) recorded in treatment T_{12}- Morphactin 75ppm. Maximum harvesting duration and number of pickings in GA_3might be due to fact that by following use of GA_3, days to first fruit set and first harvesting are minimum so ultimately days taken to final harvest and number of pickings will be maximum [20].

Fruit length (cm)

Maximum fruit length (4.91cm) recorded in GA_3 75ppm and minimum (1.96cm) length of fruit was recorded in treatment T_{12}- Morphactin 75ppm.Increase in fruit length following use of GA might be due to its effect in cell division and cell elongation. GA is also reported to promote growth by increasing plasticity of cell wall followed by hydrolysis of starch into sugar which reduces cell wall potential, resulting in the entry of water into the cell and causing its elongation [13, 19].

Length:diameter ratio

GA have effect in cell division and cell elongation in strawberry fruit so length of fruit increases linearly but not diameter, hence maximum length:diameter ratio (1.92) was recorded in GA_3 75ppm and minimum (1.00) was in treatment T_{14}- Boric acid 0.4%. [12].

Fruit diameter (cm)

The findings presented through Figure 1 and **Figure 2** revealed that micronutrients had significant effect on characters such as fruit diameter and fruit weight.

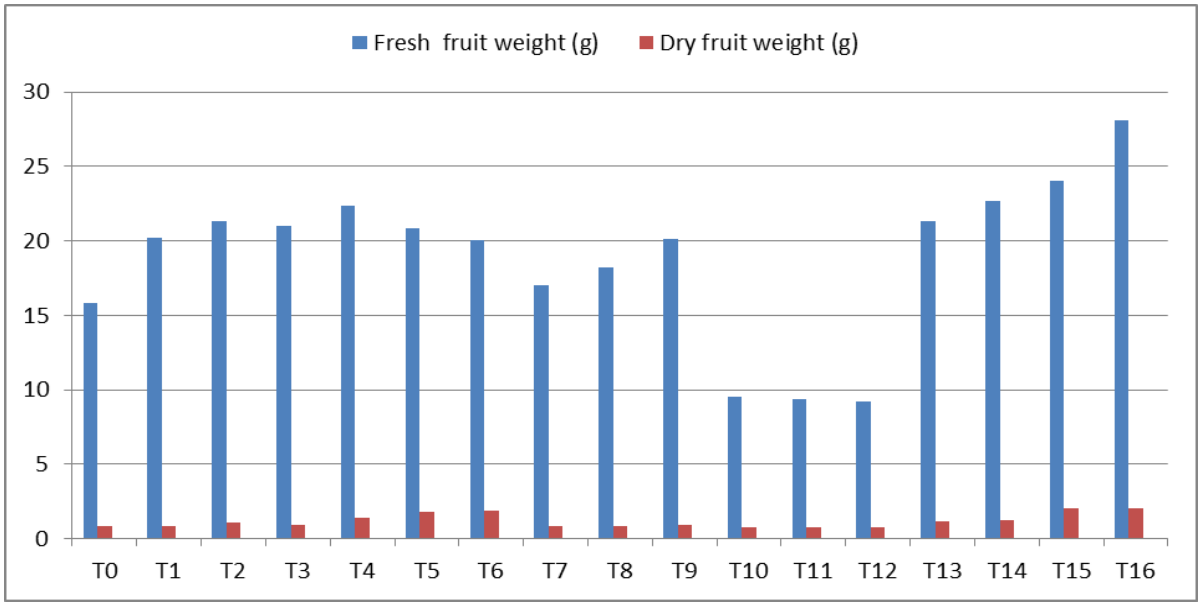

Figure 2 Effect of growth regulators and micronutrients on fresh weight and dry weight of fruit of strawberry (*Fragaria x ananassa* Duch.) cv. Winter Dawn

Maximum fruit diameter (4.20cm) was reported in treatment T_{14}-Boric acid 0.4%, while minimum (1.49cm) in T_{12}-Morphactin 75ppm. Increment in fruit diameter in treatment T_{14}- Boric acid 0.4%, might be due to its role in plant metabolism [7] in terms of better supply of water, nutrients and other compounds vital for their proper growth and development [6]. Results are in close proximity with [1, 19].

Fruit weight (g)

Maximum fruit weight- fresh weight (28.09g) as well as dry weight (2.05g) were found in treatment T_{16}- Zinc sulphate 0.4%, whereas minimum fresh weight (9.17g) as well as dry weight (0.72g) in treatment T_{12}- Morphactin 75ppm. It may be due to the fact that zinc has been identified as a component of almost 60 enzymes and it has a role in synthesis of growth promoter hormone (auxin) which may be found directly associated with improvement of fruit weight [16, 10].

Conclusion

Thus the results of this study suggested that growth regulators and micronutrients have a great potential to affect plant growth and yield of strawberry. Therefore, these can be utilized for sustainable and ecological fruit production and the use of chemical fertilizers can be reduced to a great extent.

Acknowledgment

The authors are grateful to the Dean and all staff of College of Horticulture and Forestry, Jhalawar, for providing the necessary research facilities.

References

[1] Abdollahi M, Eshghi S and Tafazoli E, Interaction of Paclobutrazol, Boron and Zinc on vegetative growth, yield and fruit quality of Strawberry cv. Selva. Journal of Biological environment science, 2010, 4(11), p 67-75.
[2] Azodanlou R, Darbellay C, Luisier JL, Villettaz JC and Amado R, Quality assessment of strawberries (Fragaria species). J. Agric. Food Chem, 2003, 51, p 715–721.
[3] Bandey FA, Sofi SA and Hafiza A, Effect of growth regulators on physicochemical characters and yield attributes of strawberry. Applied Biological Research, 2005, 7(1/2), p 27-30.
[4] Bhattacharjee SK, Influence of boron on growth, flowering and post harvest life and nutrient remobilization in Raktagandha roses. Indian J. Hort., 1996, 53(2), p 155-159.
[5] Blakie SJ, Kulkarni VJ and Muller WJ, Effects of morphactin and paclobutrazol flowering treatments on shoot and root phenology in mango cv. Kensington Pride. Scientia Horticulture, 2004, 101(1/2), p 51-68.
[6] Datta P and Banik AK, Effect of foliar feeding of nutrients and plant growth regulators on physic-chemical quality of sardar guava grown in red and lateritic tract of Bengal. Acta Hortic., 2007, 735.
[7] Dixit A, Shaw SS and Pal V, Effect of micronutrients and plant growth regulators on fruiting of litchi. HortFlora Research Spectrum, 2013. 2(1), p 77-80.
[8] Heinonen MI, Meyer AS and Frankel EN, Antioxidant activity of berry phenolics on human low-density lipoprotein and liposome oxidation. Journal of Agricultural and Food Chemistry, 1998, 46, p 4107-4112.
[9] Islam MS, Islam MO, Alam MN, Ali MK and Rahman MA, Effect of plant growth regulator on growth, yield and yield components of onion. Asian Journal of Plant Science, 2007. 6(5), p 849-853.
[10] Kazemi M, Influence of foliar application of iron, calcium and zinc sulphate on vegetative growth and reproductive characteristics of strawberry cv. Pajaro. Trakia Journal of Sciences, 2014, 12(1), p 21-26.
[11] Panse VG and Sukhantme PV, Statistical methods for agricultural workers. Published by ICAR, New Delhi, 1967.
[12] Mir MM, Barche S and Singh DB, Effect of plant growth regulators on growth, yield and quality of strawberry (Fragaria x ananassa Duch.) cv. 'Sweet Charlie'. Applied Biological Research, 2004, 6(1/2), p 48-51.
[13] Richard M, How to grow big peaches. Dep.of Hort. Virginia Tech. Blacksberg, VA 24061. Internet, www. Rce. Rutgers.edu. 8 pages, August, 2006.
[14] Sharma RR and Singh R, Gibberellic acid influences the production of malformed and button berries, fruit yield and quality in strawberry (Fragaria × ananassa Duch.). Scientia Horticulture, 2009, 119(4), p 430-433.

[15] Sharma J, Gupta AK, Kumar C and Gautam RKS, Influence of zinc, calcium and boron on vegetative and flowering parameters of gladiolus cv. Aldebran. The Bioscan, 2013. 8(4), p 1153-1158.
[16] Shivanandam VN, Pradeep SL, Rajanna KM and Shivappa, Effect of zinc sulphate on growth and yield of mango varieties and hybrids. J. Soil Crops, 2007. 17, p 225-229.
[17] ShouMing S, GuoJie L, ShaoHua L. and PengFei M, Effects of IAA, GA3 and 6-BA applied in autumn on plant quality of strawberry. Journal of Fruit Science, 2007. 24(4), p 545-548.
[18] Singh J 2012. Basic Horticulture, Third edition, Kalyani Publishers,Ludhiana, p. 143.
[19] Tripathi HP, Singh G, Kumar S and Pandey AK, Effect of growth regulators on growth, yield and quality of Ber cv. Banarasi Karaka. International Journal of Agricultural Science and Technology, 2011, 2(1), p 22-27.
[20] Tripathi VK and Shukla PK, Influence of plant bio-regulators and micronutrients on flowering and yield of strawberry cv. Chandler. Annals of Horticulture, 2008. 1(1), 45- 48.
[21] Wang H, Cao G and Prior RL, Total antioxidant capacity of fruits. Journal of Agricultural and Food Chemistry, 1996, 44, p 701-705.

Publication History
Received 12th Mar 2017
Revised 20th Mar 2017
Accepted 20th Mar 2017
Online 30th Mar 2017