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Sarita Paikra
Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur, Chhattisgarh, India

Hemant Kumar Panigrahi
Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur, Chhattisgarh, India

Sangeeta Chandrakar
Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur, Chhattisgarh, India

Correspondence
Sarita Paikra
Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur, Chhattisgarh, India

Effect of NAA and GA_3 spray on quality parameters of strawberry (*Fragaria* x *ananassa* Duch.) cv. Sabrina under net tunnel

Sarita Paikra, Hemant Kumar Panigrahi and Sangeeta Chandrakar

Abstract
The experiment entitled "Effect of NAA and GA_3 on quality parameters of strawberry (*Fragaria* × *ananassa* Duch.) cv. Sabrina under net tunnel" was conducted at Research Farm of Centre of Excellence on Protected Cultivation and Precision Farming under net tunnel, College of Agriculture, IGKV, Raipur (C.G.) during the year 2017-18. The experiment was conducted with eleven treatments and three replications in Randomized Block Design (RBD). The treatment consisted eleven different concentrations of plant growth regulators along with recommended dose of fertilizers *viz*., T_0: RDF + Control (Water spray), T_1: RDF + GA_3 25 ppm, T_2: RDF + GA_3 50 ppm, T_3: RDF + GA_3 75 ppm, T_4: RDF + GA_3 100 ppm, T_5: RDF + GA_3 125 ppm, T_6: RDF + NAA 10 ppm, T_7: RDF + NAA 20 ppm, T_8: RDF + + NAA 30 ppm, T_9: RDF + NAA 40 ppm, T_{10}: RDF + NAA 50 ppm.
The quality parameters of fruit in terms of total soluble solids (9.91%), TSS: acid ratio, total sugar (18.02), reducing sugar (5.71%), non-reducing sugar (3.21%) and ascorbic acid content (65.05 mg/100 g) was proved to be best showing a higher status with the treatment T_3 (RDF + Gibberellic acid 75 ppm), while the acidity (0.55%) of fruit decreased by the application of same treatment.

Keywords: Strawberry, NAA, ga_3, quality parameters and Sabrina

Introduction
Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most attractive, nutritious, delicious and refreshing fruit of the world. It belongs to family Rosaceae and the most of cultivated varieties are octaploid (2n= 56). The strawberry is widely grown hybrid species of the genus *Fragaria* (collectively known as strawberries). The fruit is widely appreciated for its characteristics aroma, bright red colour, juicy texture, delicate flavour and sweetness. Strawberry thrives best in temperate climatic regions and it is grouped into short day plants on the basis of their behavior and life-cycle. Strawberry is a temperate fruit and cultivated in plains as well as in the hills but the fruit quality is found excellent in hills. Presently in India strawberry is grown in 1000 ha area with production of 5000 million tons (Anon, 2016) [2]. In India, it is mainly grown in Maharashtra and in hills of Himachal Pradesh, J & K and Uttarakhand. In Himachal Pradesh, it is being grown on limited scale in Kullu, Kangra, Sirmour, Solan and Shimla districts and occupies an area of 55 ha with annual production of 354 MT (Anon, 2014) [1].
Strawberry is a shallow rooted, herbaceous plant of which 50-90 per cent of the root system is confined to upper 15 cm of soil (Galletta and Bringhurst, 1990) [3]. Therefore, fertility, moisture, drainage and microbial status of upper layer of soil have a great impact on growth, development, fruit yield, quality and production of runners.
Strawberries are rich in good amount of vitamin 'C' (30-120mg/100 g of fruit) and ellagic acid. Strawberries can reduce the risk of developing cancer by 50% due to higher levels of vitamin-C can increase the flow of blood and oxygen to the muscles by 7% due to nitrates. Plant growth regulators (PGR's) are plant hormones enhancers or disruptors. They can be man-made or naturally derived. The plant growth regulators like naphthalene acetic acid (NAA) and gibberellic acid (GA_3) have been found important to alter the growth, yield and quality parameters of strawberry fruit. Naphthalene acetic acid is an auxin, which is very effective in controlling and directing a number of plant metabolic processes. Foliar sprays of NAA have been found to control pre-mature drop of fruit and increasing size of fruit in strawberry. The effect of growth regulators in strawberry on number of fruits, fruit yield, weight of fruit, diameter of fruit and quality parameters *i.e.* total soluble solids, ascorbic acid, acidity and sugar content have been studied by several workers. Gibberellic acid plays an important role in increasing the quality parameters of strawberry fruit.

Materials and methods

The present investigation was carried out during the year 2017-18 at the Research Farm of Centre of Excellence on Protected Cultivation and Precision farming under net tunnel, College of Agriculture, IGKV, Raipur (C.G.). Raipur is situated near the central part of Chhattisgarh and lies at 21°25' N latitude and 81° 63' E longitude at an altitude of 298.15 meter above the mean sea level. Raipur district comes under dry, sub-humid agro-climatic region. Healthy tissue cultured saplings of strawberry cv. Sabrina transplanted on raised beds of size 2.0 m x 1.0 m. planting of strawberry was done at spacing of 30 x 30 cm distance with the help of Khurpi on 4th December 2017. The experiment was laid out in Randomized Block Design (RBD) composed by 11 treatments and each replicated thrice. The treatments consisted eleven different concentrations of plant growth regulators along with recommended dose of fertilizers viz., T_0: RDF + Control (water spray), T_1: RDF + Gibberellic acid (GA_3) 25 ppm, T_2: RDF + Gibberellic acid (GA_3) 50 ppm, T_3: RDF + Gibberellic acid (GA_3) 75 ppm, T_4: RDF + Gibberellic acid (GA_3) 100 ppm, T_5: RDF + Gibberellic acid (GA_3) 125 ppm, T_6: RDF + Naphthalene acetic acid (NAA) 10 ppm, T_7: RDF + Naphthalene acetic acid (NAA) 20 ppm, T_8: RDF + Naphthalene acetic acid (NAA) 30 ppm, T_9: RDF + Naphthalene acetic acid (NAA) 40 ppm, T_{10}: RDF + Naphthalene acetic acid (NAA) 50 ppm. The plant growth regulators applied at 30th and 45th days after planting on strawberry cv. Sabrina. The required quantity of gibberellic acid and naphthalene acetic acid was measured by measuring cylinder and dissolved in a small quantity of absolute ethyl alcohol and NH_4OH, respectively and then the final volume was made up to one liter with distilled water. The stock solution of the chemicals was diluted with tap water for preparing the required strength of the foliar spray. The chemical were sprayed upper surface of the plant thoroughly with the help of knap sack sprayer with fine nozzle having mist droplets.

Results and discussion

Total soluble solids (%)

The maximum total soluble solids (9.91%) was recorded under the treatment T_3 (RDF + GA_3 75 ppm), which was found at par with T_9 (9.84%). while the minimum total soluble solids (7.53%) were registered under T_0 (RDF + Control). The treatment T_1 & T_8 and T_{10} & T_2 having respective total soluble solids of 8.75 & 8.79 and 8.93 & 8.98 per cent found statistically at par with each other. Moreover the treatments T_5, T_6, T_7 and T_4 having respective total soluble solids of 9.46, 7.75, 9.71 and 9.30 per cent observed significant differences with each other. In conformity of this similar observations were reported by Kumar and Tripathi (2009) [6], Kumar *et al.* (2012, a) [5] and Thakur *et al.* (2015) [10] in strawberry.

Acidity (%)

The results obtained for the acidity under present experiment indicated that the acidity was significantly affected by the application of plant growth regulators. The treatment T_3 (RDF + GA_3 100 ppm) recorded minimum fruit acidity (0.55%), which was found at par with the treatments T_2 and T_7 having respective acidity percentage of 0.59 and 0.56, while the maximum acidity (0.79%) was recorded under treatment control. These findings are in close agreement with the findings of Singh and Singh (2009), Singh and Tripathi (2010) [9] and Thakur *et al.* (2015) [10] in strawberry.

TSS: Acid ratio

Application of RDF + GA_3 75 ppm (T_3) recorded highest TSS: Acid ratio (18.02), followed by T_7 having TSS: Acid ratio of 17.34. The minimum TSS: Acid ratio (9.53) was registered under T_0 (RDF + Control). The treatments T_9, T_8 & T_5 and T_1, T_4, T_{10}, T_9 & T_8 having respective TSS: Acid ratio of 13.48, 13.52 & 14.33 and 12.87, 13.10, 12.94, 13.48 & 13.52 showed non-significant differences with each other at 5% level of significance. Similar findings are also reported by Kumar and Tripathi (2009) [6] and Thakur *et al.* (2015) [10] in strawberry.

Total Sugar (%)

The treatment T_3 (RDF + GA_3 75 ppm) recorded maximum total sugar (8.92%), followed by T_{10} having total sugars of 8.03%. The minimum total sugar (6.7%) was noticed under T_0 (RDF + Control), which was recorded lowest from rest of the treatments under present investigation. The treatments T_{10}, T_8 and T_7 having total sugar percentage of 8.03, 7.67 and 7.44, respectively registered statistically at par with each other. Similar results were also observed by Sharma and Singh (2009) [7] and Thakur *et al.* (2015) [10] in strawberry.

Reducing sugar (%)

The treatment T_3 (RDF + GA_3 75 ppm) recorded maximum reducing sugar (5.71%), followed by T_7 having reducing sugar per cent of 5.33, while the minimum reducing sugar per cent (4.43) was noticed under T_0 (RDF + Control). The treatments T_4, T_7, T_9, T_{10}, T_1 and T_5 having reducing sugar of 5.28, 5.33, 5.24, 5.17 and 5.04 per cent, respectively registered statistically at par with each other. Similar results were also observed by Khunte *et al.* (2014) [4] and Thakur *et al.* (2015) [10] in strawberry.

Non-reducing sugar (%)

The treatment T_3 (RDF + GA_3 75 ppm) registered maximum non-reducing sugar (3.21%), followed by T_8 (2.89%). The treatments T_9 (2.27%), T_1 (2.03%) & T_2 (1.97%) and T_4 (1.98%), T_6 (2.51%) & T_7 (2.43%) found statistically at par with each other. The minimum non-reducing sugar (1.87%) was noticed under T_0 (RDF +Control). Similar results are agreement with the results of Kumar *et al.* (2012, a) [5], Khunte *et al.* (2014) [4] and Thakur *et al.* (2015) [10] in strawberry.

Ascorbic acid (mg/100 g)

The treatment T_3 (RDF + GA_3 75 ppm) recorded maximum ascorbic acid (65.05 mg/100 g) which was found statistically at par with the treatments T_2, T_8, T_9, T_{10} and T_4 having respective ascorbic acid content of 63.99, 62.74, 63.80, 63.47 and 64.87 mg/100g under present investigation. However the minimum ascorbic acid content (56.52 mg/100 g) was noticed under T_0 (RDF + Control). Similar findings were also reported by Kumar and Tripathi (2009) [6] and Thakur *et al.* (2015) [10] in strawberry.

Table 1: Effect of NAA and GA_3 spray on quality of strawberry (*Fragaria x ananassa* Duch.) cv. Sabrina under net tunnel

Treatments	TSS (%)	Acidity (%)	TSS: Acid ratio	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (mg/100 g)
T_0 -RDF + Control (Water spray)	7.53	0.79	9.53	6.70	4.43	1.87	56.52
T_1 -RDF + GA_3 25 ppm	8.75	0.68	12.87	7.07	5.04	2.03	59.19
T_2 -RDF + GA_3 50 ppm	8.98	0.59	15.22	6.81	4.84	1.97	63.99
T_3 -RDF + GA_3 75 ppm	9.91	0.55	18.02	8.92	5.71	3.21	65.05
T_4 -RDF + GA_3 100 ppm	9.30	0.71	13.10	7.26	5.28	1.98	64.87
T_5 -RDF + GA_3 125 ppm	9.46	0.66	14.33	6.84	4.96	1.88	57.33
T_6 -RDF + NAA 10 ppm	7.75	0.70	11.07	7.08	4.57	2.51	61.92
T_7 -RDF + NAA 20 ppm	9.71	0.56	17.34	7.44	5.33	2.43	59.36
T_8 -RDF + NAA 30 ppm	8.79	0.65	13.52	7.67	4.50	2.89	62.74
T_9 -RDF + NAA 40 ppm	9.84	0.73	13.48	7.11	5.24	2.27	63.80
T_{10} -RDF + NAA 50 ppm	8.93	0.69	12.94	8.03	5.17	2.86	63.47
SE(m)±	0.04	0.02	0.29	0.22	0.13	0.30	0.99
C.D. at 5%	0.12	0.07	0.87	0.66	0.40	0.89	2.94

Conclusion

On the basis of experimental findings, it is concluded that application of plant growth regulators (RDF + GA_3 75 ppm) was found to be best for increasing the quality parameters *i.e*. total soluble solids, TSS: acid ratio, total sugar, reducing sugar, non-reducing sugar and ascorbic acid content as compared to control, while the acidity of fruit decreased by the application of same treatment. Hence the application of Gibberellic acid @ 75 ppm is recommended for better quality fruits under Chhattisgarh region.

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