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Impact of GA_3, NAA and KNO_3 on Growth and Physico - Chemical Attributes of Strawberry (*Fragaria X annaassa*. Duch.) cv. Camarosa under Sub - Tropical Conditions of Punjab

Mahabir Singh Sandhu

Ph. D Agri. Horticulture (Fruit Science), Department of Agriculture, Sri Guru Granth Sahib World University, Fatehgarh Sahib (140406), Punjab, India
Email id– *mahabirsandhu90[at]gmail.com*
Mobile - 8198002922

Abstract: ***The study entitled Impact of GA_3, NAA, and KNO_3 on growth and physico - chemical attributes of strawberry (Fragaria X annaassa. Duch.) cv. Camarosa under sub - tropical conditions of Punjab. The present investigation was carried out at the Experimental Farm, Department of Agriculture, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab during the rabi season of 2020 - 2021, to find out the suitable treatment for improving the perishability and quality of strawberry fruit. The runners of strawberry cv. Chandler was planted in the second fortnight of October with a spacing of 30 x 30cm. The experiment was laid out under Randomized Block Design (RBD) with three replications. The Experiment consists of 6 treatments, Significant differences were observed among the T_1 - GA_3[at]45ppm, T_2 - GA_3[at]85ppm (gibberellic acid), T_3 - NAA[at]25ppm, T_4 - NAA[at]75ppm (naphthalene acetic acid), and T_5 - KNO_3[at]1%, T_6 - KNO_3[at]1.5% (potassium nitrate) were sprayed on the different stages of crop growth. . The present experiment revealed that the T_4 KNO_3[at]1.5% had recorded maximum crown diameter (13.62 cm), leaf area (1409.35 cm2), and total dry matter production per plant (25.11 g - 1), and root length (15.85 cm2). T_2 GA_3[at]85 ppm recorded. Results also showed that T_2 treatment (GA_3[at]85 ppm) was the remarkable treatment for physicochemical properties of TSS (8.05°Brix), total sugars (9.17%) reducing sugars (4.85%) ascorbic acid content (65.74mg/ 100g) and minimum acidity (0.58%).***

Keywords: Strawberry, PGRs, KNO_3, fruit quality, TSS, ascorbic acid

1. Introduction

Strawberry (Fragaria annassaDuch) is one of the most attractive, delicious, soft, and refreshing fruits in the world. In India, strawberry cultivation is mainly confined to Dehradun, Nanital (Uttarakhand), Solan, Kullu (Himachal Pradesh), Srinagar (Jammu and Kashmir), and the hills of Darjeeling (West Bengal). It is an herbaceous crop with a prostrate growth habit, which behaves as an annual in the sub - tropical region and perennial in the temperature region. Strawberry requires an optimum day temperature of 220Cto230C and a night temperature of 70C to 130C for maximum growth and development. Frost, as well as winter injury, reduces the yield of berries. Plant performs well in sandy loam soil with a pH range of 5.5 to 6.5. Nutrient composition of fresh strawberries are as follows: Nutrient Per100 g Proximate Water 90.95%, Energy 32 (kcal), Protein 0.67 (g), Ash 0.40 (g), Total lipid 0.30 (g), Carbohydrate 7.68 (g), Dietary fiber 2.0 (g), Sugars 4.89 (g), Sucrose 0.47 (g), Glucose 1.99 (g), Fructose 2.44 (g), Calcium 16 (mg), Iron 0.41 (mg), Magnesium 13 (mg), Phosphorus 24 (mg), Potassium 153 (mg), Sodium 1 (mg), Zinc 0.14 (mg), Copper 0.048 (mg), Manganese 0.386 (mg), Selenium 0.4 (µg), VitaminC 58.8 (mg), Thiamin0.24 (mg), Riboflavin0.022 (mg), Niacin 0.386 (mg), Pantothenic acid 0.125 (mg), Vitamin B6, Vitamin B12, Vitamin A, Vitamin E, α - tocopherol (Sharma and Sharma, 2004). Albinism is a physiological disorder that affects the yield and quality of berries caused to certain climatic conditions. The berries are non - fat, low in calories, and rich in iron, potassium, folic acid, vitamin B6, vitamin C, and fiber (Bhautkar., 2001). The berries are valued for low - calorie carbohydrates. It is a good source of natural antioxidants (Heinonen et al 1998). Strawberry cultivars like chandler, sweet Charlie, and Tiogra are available in India. Camarosa cultivar recently developed in California has become popular nowadays because it is highly productive, stress - tolerant, and bear a flower even at high temperature (320). Plant growth regulators have improved the growth, yield, and quality of fruits through various physiological and metabolic processes Asadi et al (2013).

Many plants' growth - regulating compounds (auxins, cytokinins, and gibberellins) have been used in various crops in order to achieve larger fruit sizes (Guardiola and Garcia - Luis, 2000 Stern et al., 2007). Although the efficacy of such product applications is quite easily evaluated based on fruit enlargement, this does not apply to biochemical quality characteristics. The role of auxin in strawberry fruit development has long been recognized, as it is responsible for receptacle enlargement and therefore fruit size growth.

Objectives:

1) To study the impact of GA_3, NAA and KNO_3 on vegetative growth of strawberry cv. Camarosa.
2) To study the impact of GA_3, NAA and KNO_3 on bio - chemical attributes of strawberry cv. Camarosa.

2. Materials and Methods

The experiment was carried out during the year 2020 - 2021 in the Experimental Farm, Department of Agriculture, Sri

Guru Granth Sahib World University, Fatehgarh Sahib, Punjab. The climatic condition of Fatehgarh Sahib district is sub - tropical with three distinct seasons i. e. winter, summer, and rainy. During the winter months (December - January) temperature falls 8 - 12^{0}C or even low, while in the summer months (May - June) it reaches as high as 38 - 45^{0}C. Occasional spells of frost and precipitation may be during winters. The experiment was laid out with three replications. The whole field was first divided into three main blocks and each block represented one replication. Further, each block was divided into 5 equal 0.5 x 6 m - sized beds, each representing one treatment. With an objective to evaluate the performance of the strawberry cultivar Camarosa, Vigorous, healthy, free from insect pests, and well - rooted plants were selected for planting. The seedlings were planted in November 2021. A unit of twenty runners comprising a treatment was planted in each replication at a spacing of 30 X 30 cm on the raised beds taking care that the crown of the runners lies just at the surface of the soil. All plants were kept with uniform cultural practices, i. e. fertigation, irrigation, etc. The treatment was allocated to each replication randomly. The treatment comprised five different concentrations of PGRs such as GA_3[at]45ppm, $GA_{3[at]}$85ppm, NAA[at]25ppm, NAA[at]75ppm, KNO_3[at]1%, and KNO_3[at]1.5% foliar application on 30, 60 and 90days after transplanting (DAT).

2.1 Soil Analysis

The samples of soil from the experimental field were taken from 10 - 15 cm depth before planting the strawberry runners and these samples were thoroughly mixed and composite prepared samples were subjected to mechanical and physicalanalysis in the Laboratory of Soil Science, Department of Agriculture, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab. The results recorded during the analysisis given below:

Table 2.1: Mechanical analysis of soil components

Component	Percentage	Method used
Sand	54.43	International pipette method
Silt	16.27	
Clay	28.96	
Texture	-	Sandy loam

Table 2.2: Physical analysis of soil components

Components	Value
Field capacity	23.47
Water holding capacity (%)	39.54
Permanent wilting point (%)	5.76
Bulk density (g/cm^2)	2.69

2.3 Statistical analysis

The treatments were laid out in a Randomized Block Design (CRD) with three replications and five plants per replicate. The overall significance of difference among the treatments was tested, using critical differences (C. D.) at a 5% level of significance. The results were statistically analyzed with the help of a windows - based computer package OBSTAT (Sheoran, 2004).

3. Results

3.1 Crown diameter

The data pertaining to the crown diameter (cm) as affected by different treatment combinations have been presented in Table 3.1 and graphically represented in Fig.3.1 It is clearly evident from the data that different treatments showed significant difference for average crown diameter and the treated plants were significantly more spread than the untreated plants. From the Table it is clear that application of KNO_3 (Potassium nitrate) [at] 1.5 % produced the plants of maximum height (13.62 cm) followed by KNO_3 (Potassium nitrate)[at]1% (12.85cm) and the minimum crown diameter was found in NAA [at] 25ppm plants (7.27cm). In which the growing temperature increases the number of runners and total dry matter by plants treated with GA_3 [at] 75ppm Increasing in crown diameter, leaf area and root length per plant with the application KNO_3 ([at]2 % during the course of investigation in accordance with the finding of Thakur et al (2015)

3.2 Leaf area

The data pertaining to the plant spread by different treatments have been presented in Table 3.2 and illustrated in Fig.3.2 It is evident from the data that different treatments strikingly reflected difference in average leaf area (cm^2) The treated plants showed significantly more spreading than the other treatments. The data clearly shows that maximum leaf area (1409.35cm^2) was found in KNO_3 (Potassium nitrate) [at]1.5 % treated plants followed by KNO_3 (Potassium nitrate) [at]1% (1283.94cm^2) The minimum leaf area was found in NAA[at] 25ppm (1276.24cm^2) followed by NAA [at] 75ppm (963.81 cm^2). These finding are in agreement with the reports of Paroussi et al. (2002) and Sharma and Singh (2009).

3.3 Root length

The plants treated with KNO_3 (Potassium nitrate)[at]1.5 % produced maximum root length (15.85cm) followed by KNO_3 (Potassium nitrate) [at] 1% (13.79cm) which were statistically at par, whereas the minimum root length was recorded under treatment of NAA[at]75ppm (9.52cm) followed by NAA [at] 25ppm (7.47cm). These results are in conformity with Saravanan et al. (2013) and El - Shabasiet al. (2008) who reported that GA3 application increases root length.

3.4 Number of runners

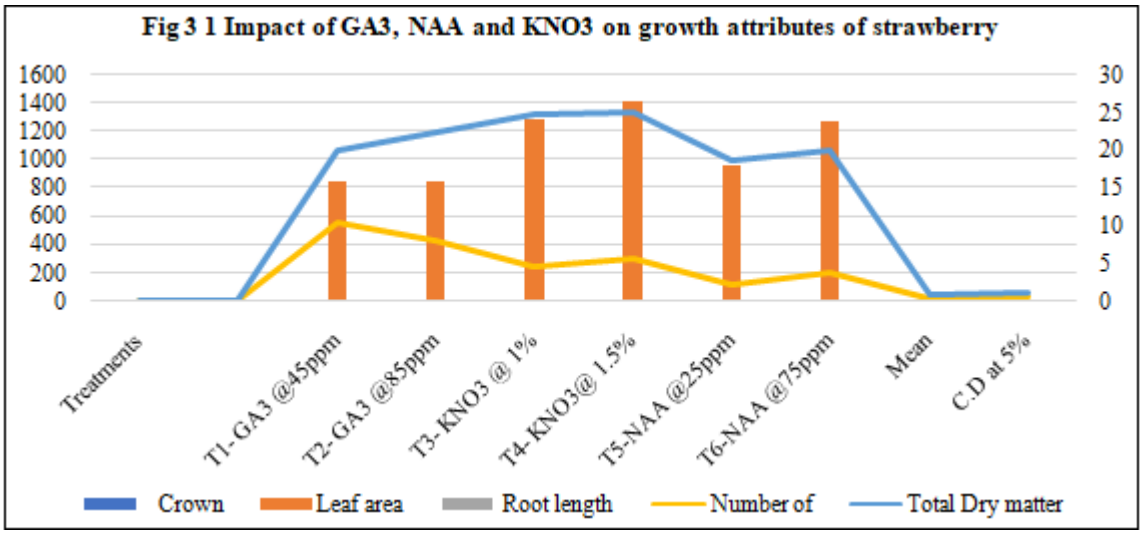
The relevant data pertaining to number of number of runners per plant as affected by different treatment combinations are presented in Table 3.1 and depicted in Fig.3.1 A perusal of the data revealed that maximum number of runners per plant (10.34) was recorded in plants treated with GA_3[at]45ppm, followed by GA_3[at]85ppm (7.88). Whereas, the minimum numberof runners was recorded in NAA[at]75ppm (3.79) followed by NAA[at]25ppm (2.17). Better development of runners is possibly due to plant nutrients and growth hormone (GA_3) (Martinez et al., 2003) which directly influence the increase in plant growth parameters.

3.5 Total dry matter Production per plant

Findings on total dry matter (g) as affected by different treatment combinations are presented in Table 3.1 and illustrated in Fig.3.1. The data clearly reveals that the maximum dry matter production (25.11g) was recorded with KNO_3 (Potassium nitrate)[at]1.5% treated plants which was statistically significant, followed by KNO_3 (Potassium nitrate)[at]1% (24.86g). The minimum dry matter was recorded under NNA[at]25ppm (18.66g). Increased dry mattermight have also resulted because of increase in number of crowns per plant. Similar observations are also reported by Tripathi et al. (2015) in strawberry.

Table 3.1: Impact of GA3, NAA and KNO3 on growthattributesof strawberry (*Fragaria X annaassa. Duch*.) cv. Camarosa.

Treatments	Crown Diameter (cm^2)	Leaf area (cm^2)	Root length (cm)	Number of Runners per plant	Total Dry matter Production/plant (g)
T_1 - $GA_{3[at]}$45ppm	10.05	847.50	9.64	10.34	20.15
T_2 - $GA_{3[at]}$85ppm	10.99	856.71	10.23	7.88	22.36
T_3 - $KNO_{3[at]}$1%	12.85	1283.94	13.79	4.46	24.86
T_4 - KNO_3[at]1.5%	13.62	1409.35	15.85	5.62	25.11
T_5 - NAA[at]25ppm	7.27	963.81	7.47	2.17	18.66
T_6 - NAA[at]75ppm	8.14	1276.24	9.52	3.79	20.09
Mean	0.35	0.48	0.21	0.15	0.83
C. D at 5%	0.76	0.82	0.79	0.47	1.14



3.6 TSS

Data pertaining to Total soluble solids (TSS) as affected by different treatment combinations have been presented in Table 3.2 and illustrated in Fig.3.2 The fruits of significantly higher TSS (8.05) were produced from the plants treated with GA_3 [at] 85 ppm which was statistically significant, followed by GA_3[at]45ppm (7.61). The minimum TSS was recorded in NAA [at]25ppm is (7.14) and followed by NAA[at]75ppm is (6.89). Similar results are also reported by Kumar et al. (2011) and Kumar et al. (2013).

3.7 Titratable acidity

It is evident from perusal data that minimum acidity was recorded in the fruits produced from the plants treated withGA_3[at]85ppm (0.58%) followed by GA_3[at]25ppm (0.65%) which was statistically at par. Whereas the maximum acidity was recorded under treatment with NAA [at] 25ppm (0.84%) treated plants followed by NAA [at]75ppm (0.81%) which were statistically at par. Similar findings are also reported by Singh and Singh (1999) and Kumar et al. (2012). Although, there is no report in the literature to support this contention, however many authors have corroborated with the observations of Singh et al. (2009)

3.8 Total sugars

A perusal of the data reveals that sugar content in strawberry fruits was recorded maximum in the fruits produced from the plants treated with GA_3[at]85ppm (9.17), followed by GA_3[at]45ppm (8.65) which were statistically at par. Total sugar was minimum in NAA[at]25ppm (5.23) treated plants followed by NAA[at]75ppm (6.87) which was statistically at par.

3.9 Reducing sugar

The berries of significantly higher reducing sugar (4.85 %) were produced in plants treated with GA_3[at]85ppm which was statistically significant followed byGA_3[at]45ppm (4.12 %). Whereas, the minimum reducing sugar (1.34 %) was recorded in NAA[at]25ppm plants.

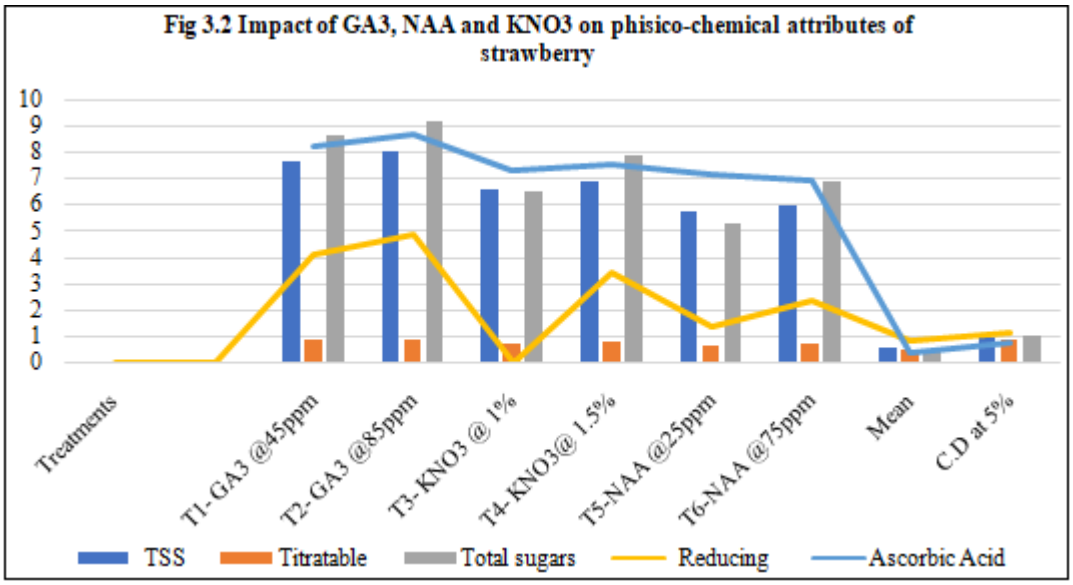
3.10 Ascorbic acid (mg /100 g pulp)

The corresponding data on ascorbic acid contentas influenced by treatment combinations are presented in Table 3.2 and illustrated in Fig.3.2. It is evident from the data that significantly maximum ascorbic acid content in berries were recorded under plants treated with GA_3[at]85ppm (65.74 mg/100 g pulp), followed by KNO_3[at]1.5% (65.07 mg/100g

pulp) which was statistically at par. Plants which were NAA [at] 25ppm had produced minimum ascorbic content (57.68 mg/100g pulp) followed by KNO_3[at]1% (58.16mg/ 100gpulp) treated plants which were statistically at par. Similar findings were also reported by Kumar et al. (2012).

Table 3.2: Impact of GA_3, NAA and KNO_3 onphyisico - chemical attributesof strawberry (*Fragaria X annaassa. Duch.*) cv. Camarosa

Treatments	TSS (°Brix)	Titratable acidity (%)	Total sugars (%)	Reducing Sugar (%)	AscorbicAcid (mg/ 100g)
T_1 - $GA_{3[at]}$45ppm	7.61	0.65	8.65	4.12	64.27
T_2 - $GA_{3[at]}$85ppm	8.05	0.58	9.17	4.85	65.74
T_3 - $KNO_{3[at]}$1%	6.53	0.73	6.47	2. .76	58.16
T_4 - KNO_3[at]1.5%	6.85	0.69	7.84	3.42	65.07
T_5 - NAA[at]25ppm	5.72	0.84	5.23	1.34	57.68
T_6 - NAA[at]75ppm	5.97	0.81	6.87	2.37	59.53
Mean	0.57	0.43	0.49	0.85	0.38
C. D at 5%	0.94	0.86	0.97	1.15	0.73



4. Conclusion

From the results obtained during the present investigation with different treatment of GA_3, $KNO_3$and NAA on vegetative growth and quality of strawberry cv. Camarosa, it is concluded that plants treated with ppm significantly KNO_3[at]1.5 increased the crown diameter, leaf area and root length. Total sugar of fruits treated with GA_3[at]85ppm were higher than the other treatments. Minimum titrable acidity were recorded in plants treated with GA_3[at]85ppm, whereas, the maximum titrable acidity were recorded in plants treated with NAA[at]25ppm. Maximum Ascorbic acid content was recorded in plants treated with GA_3[at]85ppm

On the basis of the above findings it may be concluded that for getting substantial higher yield of quality berries with more propagating materials and earn higher profit in the market, the plants of strawberry should be treated with GA_3[at]85ppm and KNO_3[at]1.5% in the sub - mountain reagon of Fatehgarh Sahib, India.

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Transplanting the runners and immidetly irrigated the experimental area

Root of transplanting material

Flowering of strawberry plant

Inspection of experimental area and identification of maturity of plants

Fruit setting of strawberry plants

Ripening of the fruit

Fruit anaysis in labouratry