**Effect of Gibberellic Acid and Naphthalene Acetic Acid on Growth, Yield and Quality of strawberry (*Fragaria× ananassa* Duch) cv. Winter Dawn under controlled condition.**

**ABSTRACT**

The experiment conducted with the help RBD (Randomized Block Design) with 8 treatmentsviz., T1:GA350ppm, T2:GA3100ppm, T3:NAA20ppm, T4:NAA40ppm, T5:GA350ppm+NAA20ppm, T6:GA350ppm+NAA40ppm, T7:GA3100ppm+NAA20ppm&T8:GA3100ppm+NAA40ppm& 3 replications. In context of maximum Plant height (23.10cm), leaves per plant(22.27), flowers per plant(19.43), no. of runners per plant(9.65),and spread in E-W(23.09cm) and N-S(23.99cm) Direction were obtained under T8 at 90DAT. Whereas maximum fruit length (53.54mm), weight (14gm), maximum no. of fruits per plant(21.78), yield per plant (304.70gm) and yield per hectare (253.54q/ha) were obtained withT8 where as maximum TSS (9.60°B) and ascorbic acid (60.26mg/100g) were obtained under T8. Total sugar content (8.54%) was maximum in T6. The finding revealed that Highest cost of cultivation (17,54,741.0Rs/ha), net profit (53,44,379Rs/ha) and B:C (3.0) were maximum under T8.

**KEY WORD :-**GA3 , NAA , Growth, Quality , Protected , Cultivation ,Flowers ,Yield ,Cost Benefit-ratio, Net profit ,Strawberry ,Winter Dawn.

**INTRODUCTION**

 Strawberry is important major crop which is self-pollinated and perishable in nature and developed by hybridizationbetween two wild species*Fragaria virginiana and Fragaria chiloensis.* Strawberry comes under Rosaceae family . Strawberry’s eatable part is called thalamus. It is bisexual plant which contains fibrous and shallow root system. It contains five sepals ,five petals ,20-30 stamens and 4 type of pistils and flowers are in white colour. Due to anthocyanin content strawberry’s berries have red colour. It flourishes in all type of climatic conditions and all type of soil. but sandy loamy soil and ph should be 5 to 6.5 suitable for their cultivation .It’s had ideal range of temperature for day is 22 to 23 °c and 7 to 13 °c at night for their survival .It comes under accessory fruit and false berry which developed by without fertilization. Inflorescences of strawberry are thyrses which contains two branching system – monopodial primary axis and sympodial lateral branches It is low growing cash crop which cultivated throughout the world because of it heigh net profit potential in short period under small area.

It’s containing large number of vitamins, minerals ,fibers .It’s had medicinal properties which help to maintain daily nutritional requirement of body. It’s containing large quantities of antioxidants ,anti-cancerous component like ellagic acid, and flavonoids(Roussos *et al*. 2009) .

According to U.S.D.A (2019) 100gram of raw strawberry contains: Total Sugar(5.3gm),dietry-Fiber(1.8g),Protein(0.7gm),Vit.C(56mg),Manganese (0.28mg),Fructose(2.84g),Glucose(2.39g),Calcium(12mg),Phosphorus(20g),Magnesium(0.28mg),Potassium(89mg),Na(10mg),Vit.A(1µg),Totallipids(0.22g)Riboflavin(0.016mg),Sucrose(0.11mg).

According to NHB reports Mahabaleshwar (MH)is referred as the strawberry capital of India and Haryana ranks 1st is strawberry production in India.In 2022-23 the total area contributed to strawberry cultivation in India was 2 thousand hectares and production of strawberry is 19 thousand MT and in 2024-25 Maximum production was17 thousand MT in 2-thousand-hectare lands contribute 30% in total world production. the United State of America is largest producer of strawberry.

World population review revealedthe data that China has held the leading position in strawberry production since 1994. In 2023. Securing second place, the United States yielded 1,055,963 tons of strawberries. Egypt narrowly surpassed Mexico for third place, with each growing 597,029 and 557,514 tons of strawberries respectively. Turkey is not far behind with 546,525 tons of strawberries this year. Spain, Brazil, Russia, Poland, and Morocco all rank lower, contributing between 272,550 to 166,955 tons of strawberries.

Strawberry is mainly used for making value added products like pickles and chutney, kimchi, desserts, cakes, juice, jelly, ice cream and sorbets etc.

There are many plant growth regulators like -GA3, NAA etc. who affect the growth stage, yield, quality attributes of the strawberry plant. foliar treatment of plant growth regulators shows positive effect on growth yield and quality characters of strawberryplant which is reported by Vishal*et al. (*2016). GA3 application on strawberry help to increaseplant vegetative growth like plant height, leavesper plant, plant spread, runner and also ascorbic acid while NAA treated plant show highest number of flowers per plants reported by Plaei *et al. (*2016). the combine use of GA3ppm and NAA ppm helps to increase overall plant growth, flowering fruit set percentage, increase size, yield and fruit quality reported by Bhople *et al*. (2019).

**MATERIAL AND METHODS: -**

The field study titled “Effect of Gibberellic Acid and Naphthalene Acetic Acid on Growth, yield and Quality of strawberry (*Fragaria × ananassa* Duch.) cv. Winter Dawn under controlled condition” was conducted at Horticulture Research Farm of Rama University, Kanpur (U.P). All accommodations to accomplish the experiment was available at department of Horticulture, Rama University Kanpur (U.P). the experimental site is located at25.25 and 26.58 North latitude and 79.32 - 80.34 East longitude. It is located at an elevation of 125.9 meter above mean sea level.

 The strawberry crop with Winter Dawn variety was grown in RBD with three replication and eight treatments. Treatments details wereT1:GA350ppm, T2: GA3 100ppm, T3:NAA20ppm, T4:NAA40ppm, T5:GA350ppm+NAA20ppm,T6:GA350ppm+NAA40ppm,T7:GA3100ppm+NAA20ppm&T8:GA3100ppm+NA40ppm. Each plot comprised of 1.2m2area with spacing 40 ×30cm. Each plot contains 10 plant per plot. The foliar application of GA3 and NAA alone and in combine way recommended dose applied at 30,60 and 90 days after transplanting. The observation was recorded at 30 ,60 and 90 days after transplanting. Plant growth, yield and quality parameters of strawberry ex: plant height (cm), No. of leaves per plants, No. of flowers per plants, No. of runners /plant, Plant spread(cm). fruit length(mm)**,** Fruit weight (gm),No. of fruit per plant, Yield /plant (gm),Yield per hectare (q)**,**TSS (°B),Total Sugar(%),Ascorbic Acid (mg/100g) also economic parameters ex- .Cost of cultivation(Rs/ha),Net profit(Rs/ha),Benefit -cost ratio were analyzed .The five healthy representative plants are selected from each treatment for collecting data . Plant height and plant spread were measured by meter scale while length was measure by vernier calipers, weighting machines was used for calculating fruit weight( gram and quintal per hectare).TSS was measured by hand refractometer and total sugar was calculated by method describe by Lane and Eynon (AOAC,1965).and ascorbic acid was determined by Dichlorophenol -indophenol dye method and statistical analysis as per the methodology described by Sukhatme and Panse( 1995).

**RESULT AND DISCUSSION**

The obtained result of current study title “Effect of Gibberellic Acid and Naphthalene Acetic Acid on Growth ,Yield and Quality of strawberry (*Fragaria×ananassa* Duch) cv. Winter Dawn under controlled condition” is briefly discussed and presented in Table 1,2&3. This research was done for examine the

effectiveness of Gibberellic acid and Naphthalene acetic acid on growth, yield and quality of strawberry under controlled condition.

**GROWTH PARAMETERS**

In context of growth parameter as plant height (cm),No. of leaves per plants, No. of flowers per plants, No. of runners per plant and Plant spread(cm) was maximum in plant who received GA3100ppm+NAA40ppm(T8) foliar application. The Data related to plant growth parameters illustrated in Table 1 .

**Table (1). Effect of Gibberellic Acid and Naphthalene Acetic Acid on and NAA on Growth parameter of strawberry (*Fragaria× ananassa* Duch) cv. Winter Dawn under controlled condition**.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plant height (cm)** | **Number of leaves** | **No. of Flowers per plant** | **Runners per plant** | **Plant spread (cm)** |
| **E-W** | **N-S** | **E-W** | **N-S** | **E-W** | **N-S** |
| **Treatment** | **30DAT** | **60DAT** | **90DAT** | **30DAT** | **60DAT** | **90DAP** | **30DAT** | **60DAT** | **90DAT** |
| **T1** | 6.86 | 13.56 | 18.33 | 6.09 | 11.04 | 16.30 | 17.03 | 4.44 | 9.97 | 10.42 | 14.7 | 15.16 | 20.19 | 20.69 |
| **T2** | 7.90 | 15.56 | 20.36 | 7.81 | 12.55 | 19.68 | 17.83 | 6 | 10.94 | 11.09 | 17.35 | 17.72 | 21.18 | 22.43 |
| **T3** | 5.60 | 9.60 | 15.10 | 3.43 | 7.13 | 10.83 | 15.19 | 3.64 | 8.73 | 8.80 | 12.38 | 12.93 | 15.39 | 16.06 |
| **T4** | 6.80 | 11.80 | 15.77 | 4.90 | 8.41 | 11.66 | 15.88 | 3.43 | 9.20 | 9.81 | 15.20 | 15.86 | 19.30 | 19.67 |
| **T5** | 7.36 | 13.60 | 16.40 | 5.66 | 11.27 | 14.07 | 16.37 | 5.34 | 10.05 | 10.28 | 16.34 | 16.47 | 20.32 | 20.47 |
| **T6** | 8.00 | 14.03 | 17.20 | 6.85 | 12.03 | 16.23 | 16.44 | 6.66 | 10.35 | 10.95 | 16.72 | 17.97 | 20.56 | 20.83 |
| **T7** | 8.26 | 14.63 | 18.15 | 7.92 | 13.70 | 20.09 | 18.13 | 7.65 | 11.19 | 11.22 | 17.95 | 18.62 | 21.29 | 21.95 |
| **T8** | 9.53 | 16.13 | 23.10 | 8.40 | 15.42 | 22.27 | 19.43 | 9.65 | 12.03 | 12.23 | 19.05 | 19.17 | 23.09 | 23.99 |
| **CD** | **0.54** | **0.73** | **1.00** | **0.73** | **0.97** | **1.15** | **0.88** | **0.7** | **1.14** | **1.16** | **1.23** | **1.33** | **1.38** | **1.54** |
| **SE. m** | **0.17** | **0.23** | **0.32** | **0.23** | **0.31** | **0.37** | **0.28** | **0.2** | **0.37** | **0.38** | **0.40** | **0.43** | **0.45** | **0.50** |

The maximum plant height at 30,60,90 DAT (9.53,16.13&23.10cm)was recorded inT8 and minimum plant height (5.60,9.60 &15.10cm) was recorded in NAA20ppm(T3).This increase due to PGR whereas the plant height which was closely associated with the finding of Paikra *et. al* (2018),Maya Lamba *et al.* (2024) & Choudhari *etal.* (2015).

Similarly maximum leaves per plant (8.40 ,15.42, and 22.27) was obtained under T8 whereasminimum (3.43,7.13&10.83) was found under T3. These finding aligns with finding of Kumar *etal.*(2012a) and Vishal *et. al* (2023).The maximum no. of leaves per plant occur may be due to increase in length of epidermal cell or cell division in strawberry plants.

Maximum number of flowers per plant (19.43) was found under T8,whereas lowest no. of flowers (15.19) was recorded under NAA20ppm (T3) .The obtained result is closely related with finding of Kaveri and Mishra (2023) & Bhople *et.al* (2019) ,they revealed that combine use of GA3 along with NAA at different con. affect the growth, parameter of strawberry plant due to complimentary effect of PGRs.

The maximum no. of runners (9.65) per plant was obtained in (T8)while as minimum number of runners(3.43) was obtained under (T4).these finding aligns with finding of Bhople *et al.* (2019).

The maximum plant spread at 30,60 & 90DAT in E-W (12.03 ,19.05&23.09cm) and N-S (12.23,19.17&23.99cm) direction, recorded under T8  while minimum(8.73,12.38&15.39cm)in E-W and (8.80,12.93 & 16.06cm) in N-S direction was recorded with (T3).These finding closely aligns with finding of Vishal *et al.*(2023) and Maya Lamba *et al.(*2024). Maximum plant spread occurs in T8 due to combine use of GA3 and NAA at suitable concentration.

**YIELD PARAMETER**

The Data related to plant yield like -fruit length (mm)**,** Fruit weight (gm),No. of fruit per plant, Yield per plant (gm) and Yield per hectare (q) was illustrated in Table2.

The maximum fruit length (53.54mm) was obtained with T8and minimumlength (21.50mm)was observed with NAA20ppm (T3)**.**These results align with finding from Vishal *et al.*(2023).

Maximum fruit weight(14g) is obtained from under T8 plant. while minimum (9.80g) found under T3.This result aligns with finding of Singh *et al.* (2022) and Bhople*et al.* (2019).

The maximum no. of fruits (21.78) per plant was obtained under T8and minimum (15.11) fruits per plant was observed with T4. Whereas these finding aligns with the finding of Kharjana *et al*. (2022) &Kaveri and Mishra *etal*. (2023) .

While minimum yield per plant (156.01g) was obtained with T3 and maximum fruit yield (304.70g) obtained from T8 . Maximum yield per plant was obtained due to the higher amount fruit set and size. These finding is closely with result ofKriti *et al.* (2016) & Bhople *et al*.(2019).

Similarly maximum yield per hectare 253.54 quintal per hectare was recorded under (T8) and minimum (129.33q/ha) recorded under NAA20ppm (T3). these finding aligns with the finding of Singh *et al.*(2022)& Kriti *et al.* (2016).

**QUALITY PARAMETERS**

The data related to quality parameters ex-TSS, TS and Ascorbic Acid were presented in Table2. Table data related to quality parameter showthat plants,who received T8 gave highest TSS (9.60°B) and T3 contain minimum TSS (6.37°B) . These finding closely align tofinding of Rathod *et al*.(2021)& Kumar *etal.***(**2012a).

While T6 recorded maximum total sugar (8.54%) & minimum (5.13%) under T2 . These finding closely aligns with finding of Rathod *et al*. (2021).

Highest ascorbic acid (60.26mg/100g) found under T8 , while minimum ascorbic acid (53.54mg/100g) was obtained from T3.These obtained results are similarly aligning with finding of Vishal *et al.* (2023)& Kriti *et al.* (2016).

**ECONONMIC PARAMETERS**

The data table related to finding of4current study on economic parameter like total cost of cultivation, net profit and benefit -cost ratio was illustrated in Table 2. The plant under (T8 ) have highest total cost of cultivation(1754741.0Rs/ha) , net profit (53,44,379 Rs/ha ) and B:C ratio (1:3.0) while minimum total cost of cultivation (17,52,474.0Rs/ha), net profit(18,68,766) and B:C (1:1) were calculated under T3. the obtained result is aligned with Singh *et al*.(2022) &Rathod *et al.* (2024).

**Table (2):- Effect of Gibberellic Acid and Naphthalene Acetic Acid on and NAA on yield,quality and economic parameter of strawberry (*Fragaria×***

 ***ananassa* Duch) cv. Winter Dawn under controlled condition**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment details**  | **YIELD PARAMETER** | **QUALITY PARAMETER** | **ECONOMIC PARAMETERS** |
| **Fruit Length (mm)** | **Fruit weight****(gm)** | **No. of fruit per plant** | **Yield per plant (gm)** | **Yield per plant (q/ha)** | **Total sugar solids****(°B)** | **Total sugar content (%)** | **Ascorbic acid (mg/100g)** | **Total cost of cultivation (Rs/ha )** | **Net profit (Rs/ha )** | **B:C ratio** |
| **T1** | 51.08 | 11.26 | 16.43 | 184.86 | 154.10 | 7.50 | 5.25 | 54.41 | 17,53,436.5 | 25,61,363.5 | 1:1.4 |
| **T2** | 51.61 | 12.4 | 18.61 | 230.39 | 191.06 | 8.26 | 5.13 | 56.39 | 17,54,513.0 | 35,95,167 | 1:2.0 |
| **T3** | 21.50 | 9.80 | 15.94 | 156.01 | 129.33 | 6.37 | 6.32 | 53.54 | 17,52,474.0 | 18,68,766 | 1:1 |
| **T4** | 22.38 | 10.86 | 15.11 | 164.02 | 136.26 | 6.51 | 8.36 | 55.60 | 17,52,588.0 | 20,62,692 | 1:1.2 |
| **T5** | 51.51 | 11.8 | 16.44 | 194.08 | 161.57 | 7.70 | 5.80 | 56.48 | 17,53,550.5 | 27,70,409.5 | 1:1.5 |
| **T6** | 52.43 | 12 | 19.11 | 229.13 | 190.48 | 7.43 | 8.54 | 59.12 | 17,53,664.5 | 35,79,775.5 | 1:2 |
| **T7** | 52.34 | 13.2 | 20.44 | 269.15 | 223.20 | 8.30 | 5.75 | 57.97 | 17,54,627.0 | 44,94,973 | 1:2.5 |
| **T8** | 53.54 | 14 | 21.78 | 304.70 | 253.54 | 9.60 | 6.66 | 60.26 | 17,54,741.0 | 53,44,379 | 1:3.0 |
| **C.D** | 1.38 | 0.5 | 1.19 | 0.73 | 1.58 | 0.60 | 0.47 | 0.91 | **\_\_\_\_** | **\_\_\_\_** | **\_\_\_\_** |
| **SE. m** | 0.45 | 0.17 | 0.38 | 0.24 | 0.51 | 0.28 | 0.15 | 0.29 | **\_\_\_\_\_** | **\_\_\_\_** | **\_\_\_\_** |

**CONCLUSION**

On the basis of our finding, it is concluded that the treatment (T8)GA3100ppm+NAA40ppm gave a positive effect and found to be best in term of plant Growth parameter (plant height (cm), leaves, flowers per plants&runners spread(cm)), Yield parameter and Economic parameters.

 Similarly in relation to quality parameter, plant treated with(T8)GA3100ppm+NAA40ppm gave best result in term of higher TSS (°B) and Ascorbic acid (mg/100g) but Total sugar (%) was maximum in(T6) GA350ppm+NAA40ppm.

**REFERENCES**

Association of official Agricultural Chemists,1965. Official methods of Analysis, Washington DC.

Bhople A., A. Singh, S. K, &P. P (2019**)** Studies on impact of growth regulators on performance of strawberry (Fragaria × ananassa Duch.) variety chandler under polyhouse condition, *Plant Archives,***19(1**),555–558: 0972-5210

Choudhari. Vishal, V., Thippesha. D., & Hemala Naik B. (2015). Effect of plant growth regulators on growth, yield and quality parameters of strawberry (*Fragaria × ananassa* Duch.) under low-cost polyhouse. Master's Thesis, *University of Agricultural and Horticultural Sciences, Shivamogga (Mudigere****),*pg-142.**

Kaveri, A., and Mishra, S. (2023). Effect of Plant Growth Regulators on Growth, Yield and Quality of Strawberry *(Fragaria x ananassa* Duch.) cv. Winter Dawn. *Int. J. Plant Soil Sci,* vol 35(15):343-350

Kharjana B., K. Anita, & Topno E. Samir (2022). Effect of NAA and GA3 on Growth, Flowering, Fruiting, Yield and Quality of Strawberry *(Fragaria × ananassa Duch.*) cv. Winter Dawn, Environment *and Ecology* 40 (4): 0970-0420

Kriti, A.*et al.* (2016). Effect of GA3 and NAA on growth flowering, fruiting yield and quality of Strawberry (*Fragaria*X *ananassa* Duch.) cv. Chandler. *Master's Thesis.*

Kumar R, Bakshi M & Singh DB. (2012a.) Influence of plant growth regulators on growth, yield & quality of strawberry (*Fragaria*× *ananassa* Duch) under UP subtropics. *Asian Journal Horticulture,*7(2):434-436.

Lamba Maya, Kumar S., Sharma.S., Mehta A., & D. Reenu (2024). Effect of Plant Growth Regulators on Morphology of Strawberry (Fragaria *× ananassa* Duch*)* Under Protected Cultivation. *Agriculture Association of Textile Chemical and Critical Reviews Journal*.,**12(4):**293-296.

Ministry of Agriculture & Farmers Welfare, Governmentof India. (2022*). Horticultural statistics at a glance 2022.* National Horticulture Board.

National Horticulture Board. (2024). *Horticulture statistics estimates.*  Ministry of Agriculture & Farmers Welfare, Government of India. https://www.agriwelfare.gov.in/en/StatHortEst

Paikra S, Panigrahi HK & Chandrakar S. (2018). Effect of NAA and GA3 spray quality parameters of strawberry *(Fragaria × ananassa* Duch*.)* cv. Sabrina under net tunnel. *Journal of Pharmacognosy & Phytochemistry*, **7(6):** 393-395.

Palei S., Das. A. Kumar., Sahoo A.K., Dash S.K. and Swain S. ( 2016). Influence of plant growth regulators on Strawberry *(Fragaria x ananassa)* cv. Chandler Under Odisha conditions. *International journal of Recent Scientific Research,* Vol. **7(2):** 9945-9948.

Rathod K.D., Ahlawat ,T.R., Kumar, S., Sarkar, M. and Chakraborty ,B. (2021).Effect of plant growth regulators on growth ,yield and quality of Strawberry (*Fragaria ananassa*× Duch) cv. Winter Dawn under open field conditions of south Gujarat., *Agricultural Science Digest*.**41(2):** 329-333

Rathod, Patel & Chakraborty (2024).Field assessment of growth regulators on yield and economics of strawberry: a south Gujarat perspective. *Plant Archives***24(2):**1656-1660.

Roussos P.A, Denaxa N.K. and Dam Vakaris T.(2009).Strawberry fruit quality attributes after application of plants growth stimulating compound. *Scientia Horticulturae*.**119(2):**138-146-113.

Singh Alok, Singh Dilip RK, Piloo Ng., Singh NO, Devi NS & Singh SR. (2022). Effect of GA3 and NAA on yield and benefit: cost ratio of strawberry *(Fragaria xananassa* Duch*.)* cv. Chandler under the open condition of Manipur*. Journal of Agriculture and Ecology*,**14**:93-98*;*

Sukhatme, P.V. and Panse, V.G (1995). Statistical methods of agricultural workers. Indian Council of Agriculture Research, New Delhi.

U.S. Department of Agriculture, Food and Nutrition Service. (2019). Food Data Central: Food details [Nutrient data]. Retrieved February 14, 2025. https://fdc.nal.usda.gov/fooddetails/747448/nutrients

Vishal, Bahadur V., & Manjeet. (2023). Impact of Plant Growth Regulators on Growth, Yield and Quality of Strawberry *(Fragaria × ananassa* Duch.) cv. Winter Dawn. *International Journal of Plant & Soil Science*, **35(19**): 31–36.

Vishal VC, Thippesha D., Chethana K, Maheshgowda BM, Veeresha BG, & Basavraj AK (2016). Effect of Various Growth Regulators on Vegetative parameters of strawberry (*Fragaria x* a*nanassa* Duch.) cv. Sujatha. *Research Journal of Chemical and Environmental Science* **4(4):** 68-71

World Population Review.(2024). Strawberry production by country 2024. https://worldpopulationreview.com/country-rankings/strawberry-production-by-country