Effect of plant growth regulators and mulches on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler

THESIS

Submitted to Babasaheb Bhimrao Ambedkar University
(A Central University)
Lucknow

For the Degree of

Doctor of Philosophy
In
HORTICULTURE

Supervisor
Prof. Sanjay Kumar
Head & Dean

Co-Supervisor
Dr. R. S. Verma
Assistant Professor

Submitted By:
Lalit Kumar
Enrollment No. 868/17

DEPARTMENT OF APPLIED PLANT SCIENCE (HORTICULTURE)
SCHOOL FOR BIOSCIENCES & BIOTECHNOLOGY
BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY
(A Central University)
Vidya- Vihar, Rae-Bareli Road, Lucknow- 226025 India

2022

Dedicated to

Beloved Parents

DECLARATION

I, **Lalit Kumar**, Enrolment No.-868/17, hereby declare that I am a candidate for the degree of **Doctor of Philosophy in Horticulture**, Department of Applied Plant Sciences (Horticulture), Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar, Rae Bareli Road, Lucknow-226025 (U.P.), India and have carried out my research work entitled **"Effect of plant growth regulators and mulches on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler".**This submitted for the award of the degree of Doctor of Philosophy in Horticulture is my original research work.

Lalit

(Lalit Kumar)

Date: 31-01-2022

Place: Lucknow

CERTIFICATE

This is to certify that the thesis titled **"Effect of plant growth regulators and mulches on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler"** Submitted by **Mr. Lalit Kumar**, Enrolment No.-868/17 is an original research work and has not been previously submitted in part or full for the award of any other degree or diploma to this or any other university.

The thesis submitted to Babasaheb Bhimrao Ambedkar University, Lucknow satisfies all the requirements as stipulated in the Doctor of Philosophy (Ph.D.) regulations- 1999 as amended in 2008/2010/2013 and it is fit for submission and evaluation for the award of the degree of Doctor of Philosophy of the University.

Date: 31-01-2022

Place: Lucknow

31/01/2022
Supervisor

31/01/2022
Co-Supervisor

31/01/2022
Head of the Department

HEAD
Department of Horticulture
School of Agricultural Sciences and Technology
Babasaheb Bhimrao Ambedkar University, Lucknow

ACKNOWLEGMENT

With limitless humility, I bow head to almighty, merciful compassionate and supreme power "God" who showed his mercy on me and blessed with the favourable circumstances to go through this gigantic task. Acknowledgement for a few might be just a trifle written on piece of paper. But in its true essence it gives us an opportunity to remember and express our feeling for their whom me is love and shares our secrets to with them. I got a chance to express my taken of thanks to people who have touched me in one way or the other by this small thinks, words are not enough to express my feeling which comes straight from heart.

First and foremost I express my deep sense of gratitude to my supervisor ***Prof. Sanjay Kumar Head Department of Horticulture and Dean, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University Lucknow,*** *who is not only my teacher and guide to me, but my mentor and well-wisher too. His persistent encouragement, perpetual motivation, everlasting patience, constructive criticism and valuable technical inputs in research have benefitted me to an extent which is beyond expression. He not only trained me in science but in all aspects of life.*

I emphatically express my thanks to co-supervisor ***Dr. Ravi Shankar Verma*** *for the kind co-operation and impeccable guidance during course of study, Research work. It is my deep sense to express my heartiest gratitude to* ***Prof. R. B. Ram, Prof. Deepa H. Dwivedi, Dr. M. L. Meena, Dr. Sutanu Maji*** *and* ***Dr. Rubee Lata*** *Department of Horticulture, for their encouragement and help during the course of study.*

Uncountable words of cordial veneration and gratitude are dedicated from the deepest part of my heart to my affectionate and beloved father ***Srhi Brajmohan Lal*** *and mother* ***Smt. Ganga Devi*** *for their never ending blessing, inspiration and constant encouragement moral support throughout out my academic life.*

In my opinion, it is the almighty before which should please for providing me courage and zeal to complete this manuscript by showering the endless blessing, with a world full of cheer, clam and peace.

I would like to take this opportunity to extend my gratitude to my seniors ***Mr. Amit Kumar Bhargav, Dr. Pradeep Kumar, Dr. Ram Vilas Gautam, Mr. Rajiv Kumar*** *and* ***Mr. Prem Kumar*** *for their timely advices, encouragement, guidance and good will which enable me to start and successfully complete my work.*

I express my heartiest thanks to my batch mates ***Mr. Viplaw Kumar, Mr. Mata Prasad, Mr. Bhag Chand Shiivran, Mr.SomPrakash*** *and* ***Mr.Harvindra Pal.***

I also express my deep sense to my juniors ***Mr.ShatrunjayYadav, Mr.ShrikantMaurya, Mr.Vipnesh Singh Yadav, Mr.Rajmani Singh, Mr.Mohit Kumar, Mr.Mayaram, Mr.Razauddin,*** *and* ***Mr.Rajnish Kumar*** *for supporting me at every stage of my research work.*

I am also grateful to Central Institute of Temperate Horticulture, Srinagar (Jammu & Kashmir) for providing strawberry runners for my research.

Who directly or indirectly, gave encouragement and humorous company at BBAU, Lucknow. I am also thankful to all departmental staff members, especially ***Mr. Vinay Kumar.*** *Office Assistant, Department of Horticulture BBAU,* ***Mr. Sahab Saran Verma,*** *Laboratory Assistant and* ***Ms. Munni Devi*** *and finally, I thank the Almighty for leading me all the ways towards successful completion of this work.*

I am also thankful to library section for the providing the facility of library during my research period and plagiarism.

Lalit

Lalit Kumar

Date: 31-01-2022
Place: Lucknow

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

ANOVA	:	Analysis of variance
CD	:	Critical Difference
cm	:	Centimeter
CV	:	Coefficient of variation
per se	:	As such with mean
et al.	:	and others
Fig	:	Figure
g	:	Gram
Kg	:	Kilogram
m	:	Meter
ha	:	Hectare
mg	:	Milligram
SE (d)	:	Standard error difference
S.E (m)	:	Standard error mean
df	:	Degrees of freedom
RBD	:	Randomized Block Design
Vit-C	:	Ascorbic Acid
viz.	:	Namely
vs	:	Against
No.	:	Number

CHAPTER-1
INTRODUCTION

CHAPTER-1

INTRODUCTION

The strawberry (*Fragaria* x *ananassa* Duch.) is an important herbaceous perennial fruit crop belonging to the family rosaceae. It is a small fruit of great nutritional and medicinal value. Some commercial varieties of strawberries (*Fragaria* x *ananassa* Duch.) are grown everywhere in the world. Strawberries are a popular temperate berry fruit that may also be grown in sub-tropical climates (Sharma and Badiyala, 1980). In humid and dry climates, it can grow to a height of 3000 metres above sea level. It is also good for the kitchen garden because it is a fast-growing crop. The crop is in high demand for fresh fruits as well as in the processing industries, especially for flavoring. Strawberries originated in North America, but they are now widely grown in Europe, Israel, Japan, Turkey, Australia, and New Zealand. Though the crop is cultivated in a temperate climate, it can also be grown in tropical and subtropical climates. Its cultivation has also been extended from temperate regions to subtropical regions. Since its cultivation has recently expanded from temperate to subtropical regions, where this crop behaves as annual plants. Strawberry cultivation is mainly in Maharashtra, Punjab, Haryana, Himachal Pradesh, and Uttarakhand in India. The crop has gained economic importance in Jammu and Kashmir, owing to high returns per unit area. Strawberries are an excellent model for studying nutrient transformation among perennial crops. This has been attributed to berries being produced within a few months of planting due to small plant size and the establishment of more plots within uniform soil. Although strawberry cultivation is becoming popular in Jammu and Kashmir, the farmers are continuing to grow them as a subsidiary crop. Due to a lack of proper attention, farmers usually harvested smaller fruits and had poor yields.Strawberry (*Fragaria* x *ananassa* Duch.) is a perennial herbaceous dicot plant. Strawberry is an achene, or aggregate fruit. Fresh strawberries are high in vitamins and minerals, and they have a delicious flavor and a tantalizing aroma. Strawberry fruit is mostly made up of water (90 percent). Ellagic acid is a plant phenol that occurs naturally. It has been discovered that eating its fruits on a regular basis can help to prevent cancer and asthma. For successful cultivation, an ideal day temperature of 22^0 C to 23^0 C and a night temperature of 7^0 C to 13^0C are required. The basic chromosome number is 7. Strawberry fruits are in high demand for fresh market processing, industries, preserves, and confectionaries. The phenomenal increases in production over the last few years attest to its popularity. Strawberry production in the world was 8.9 million tons in 2019. (Million tons). Europe and North America account for 50% and 30% of total global production, respectively. France is the leading strawberry producer among European countries. Maharashtra is the leading strawberry-producing state in India. It is also grown commercially in Haryana, Punjab, Uttar Pradesh, Jammu and Kashmir, Uttarakhand, and the lower Himalayan hills.In India, the strawberry was first introduced in the early 1960s by the NBPGR Regional Research Station, Shimla (HP), but initial efforts to popularize its cultivation in Himachal Pradesh and Uttar Pradesh had a setback due to the poor adaptability of the varieties, low yields per unit area and lack of technical knowledge (Sharma, 2002).Some cultivars are being tried to generally grown in tropical and sub-tropical northern India are sweet Charlie, Chandler, Belrubi, Pusa Early Dwarf, Fern, Selva, Pajaro, Winter Down, Camarosa, Red coat, Addie, Swiss, Goreela, Jucunda, Sweet Heart, Mecharenj, Red Gro Florida-90, Brighton, Dilpans and Florida Go etc. However, some cultivars Sweet Charlie, Chandler and Selva have shown promising result under Lucknow condition. As far as global scenario is concerned, Europe produces about $1/3^{rd}$of total strawberries of the world. Among the various countries, Spain, Poland, Germany and France are the main strawberry producers in the world. The USA, Mexico, Egypt, Japan, Italy and the Russian Federation also produce a considerable amount of strawberries.However, due to pressing demand of farmers and consumers, adoption of modern and standardized agro-techniques, introduction of day-neutral varieties and use of protected cultivation, both the area and production in India have increased substantially during the past few years (Sharma, 2002). Strawberries may grow in a range of environments, including temperate, grassland, Mediterranean, Tioga, and subtropical. However, the majority of present production is restricted to temperate and Mediterranean regions between latitudes 28^0 and 60^0 degrees.Temperature and photoperiod patterns must be observed throughout the season, not only during the summer, when growing strawberries in hot areas. Strawberry is composed of multiple meristems that are impacted by photoperiod and temperature interactions (Darrow, 1996; Larson, 1994). Strawberry plants grown at day/night temperature regimes of $26/22^0$and $30/26^0$showed no floral induction under short days.In hot areas, high air temperature is likely to have a key role in limiting respiration rate (Larson, 1994). One of the most crucial factors of crop production is nutrition. Strawberry requires a number of minerals nutrients for proper growth and development.

The modern octaploid strawberry. The strawberry plant morphologically has a thick, vertically compressed stem known as the crown. In spring it forms rosettes of leaves and inflorescences. The leaves are pinnate and trifoliate with leaflets that vary from wedge-shaped to ovate. During the growing season, the helper sprouts produce prostrate growth called runners from the crown. Numerous daughter plants emerge from the nodes. When the base of these new leaves comes into contact with the moist soil, adventitious roots develop, the inflorescence is arranged in the form of cymes, the activated type flower is perfect, although there are diocesan species.fivesepals and an equal number of petals, bloom in the warm season and require a short photoperiod followed by a cooling of the crown in winter to stimulate vegetative growth in spring. Flowering occurs in six weeks in spring. The average time from the opening of the flower to the ripening of the berries is around 28 to 31 days. Matures in 20-25 days on long days, but lasts 55-60 days in high temperatures from midsummer to autumn. Fruits grow quickly and take 2060 days to ripen, depending on the habit of the fruit and the environmental conditions of the variety. Collection time is March in the subtropical plains, but it is collected in mid-June in cold climates. Fruits are collected when the twirl part of the fruit skin has participated in red horns on the long summer day. The edible fleshy berry consists of an enlarged, ripe container around the seed. It will take 2025 days to reach maturity. The taste of the fruit is attributed to the presence of volatile esters, which vary between varieties. The aromatic compound includes ethyl hexanoate and methyl butanoate. Strawberry red color due to anthocyanin pigment.Strawberry can be grown in different type soil ranging from heavy clay to gravel types, but it prefers light porous soils that are rich in humus. Planting can be done at any time between July to April either on furrows or on raised beds in a particular system of planting. Mostly sub surface irrigation is applied by drip and sprinkler system depending on localities. Adequate amount of manures and fertilizers is required for proper nourishment of the soil as well as to obtain uniformly high yield and quality fruits.

Mulching is one of the most beneficial intercultural practices in strawberry cultivation, improving soil and water retention, changing soil temperature to reduce weed population and growth, and increase nutrient availability. Therefore, it has a great influence on growth, yield, quality and harvest time. Frost protection and reduction of the number of sick and unhealthy berries.Different types of mulches are used, as black polythene, transparent polythene, paddy straw and rice husk etc.

Gibberellic acid promotes cell elongation, cell division, counteracts the phenomenon of apical dominance, initiates the growth of side buds and promotes leaf growth, GA3 induces flowering in long-day plants and in plants that require an inductive cold period, it also promotes the formation of the male flower by it plays an important role in the development of the androecium. GA3 has a positive effect on fruit set, increases fruit size, overall yield and quality. Naphthalene acetic acid (NAA) is one of the vital members of auxin. Application of a-naphthalene acetamide in early stage induce cell division in cambium cells, and leads to xylem tissue formation in lower internodes which gives mechanical support to plants, there by prevention of lodging. It is beneficial for enhancing fruit set and prevention of per harvest dropping of fruits. NAA induce profuse and early flowering and is also effective in controlling plant height and branching at low concentration. It also prevent the fruit shed.

Owing the medicinal properties (anti-carcinogenic, anti-diabetic and antioxidant), Strawberry is becoming increasingly popular with consumers of all ages.Strawberries are rich in natural antioxidants such as carotenoids, vitamins, phenols, flavonoids, dietary glutathione, and metabolites (Larson, 1988) .and have a high anti-oxidant capacity against various groups of free radicals such as superoxide, hydrogen peroxide, hydrogen radicals, and singlet oxygen (wangh*et al.*, 1960) and Heinonen *et al.*, 1998. (Wang and Jiao 2000). Strawberry antioxidant activity is influenced not only by genotype but also by growing temperature (Wang and Zheng, 2001) and cultural practises (Wang *et al*.,2002).

Sharma and Sharma (2003) conduct an experiment to determine the effect of different types of mulching on strawberry plant growth, yield, and quality, as well as albinism. Among the different type of mulch materials, plant had the best growth with black polythene (Repoted that hormones could successfully be used forencouraging fruit set in plant under unfavorable condition and Rappaport (1956)reported increased setting of both normal as well as parthenocarpic fruit by repeated formal spray containing 50 mg of GA 3. Vankoot (1947) The highest percent acidity and lowest sugar add ratio were also observed with 400ppm NAA treatment. He, however, observed no significant difference in fruit sugar among the different doses of NAA (Techawongestein.1989).

Although the crop is gaining popularity in this region of the plateau in general, particularly in Lucknow due to the favourable climatic conditions, however, very little work has been reported on the improvement of this particular crop in the presence of a regulator of plant growth regulator accompanied by mulching.. Thus, keeping in view of the above theme the present investigation entitled “Effect of plant growth regulators and mulches on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandlerwas plannedout with following objectives.

Objectives;

(1) To find out the effect of different plant growth regulators on growth, yield and quality of strawberry.
(2) To study the effect of different inorganic mulching materials on growth, yield and quality of strawberry.
(3) To assess the effect of different organic mulching materials on growth, yield and quality of strawberry.
(4) To investigate the effect of suitable combination on mulching and plant growth regulators on growth, yield and quality of strawberry.
(5) To calculate the economics of strawberry cultivation with different mulching materials and plant growth regulators application.

CHAPTER-2
REVIEW OF LITERATURE

CHAPTER-2

REVIEW OF LITRATURE

The present investigation was carried out to study **"Effect of plant growth regulators and mulches on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler".** The literatures on different affects is received under following heads

(2.1) Effect of mulching on growth, yield and quality

Mulching is a centuries-old practice of preparing the soil surface around plant grass to enhance plant development (Jacks et al., 1955). Mulching helps retain soil moisture, improve soil structure, regulate soil heat, and reduce wild plant growth (Rao and Patak, 1988; Reddy and Han, 2000). Continued utilize of organic mulching improves top soil organic matter and aeration (Borthakur and Bhattacharya, 1992), while mulching improves fruit quality and plant development, flowering and fruiting. (Pandey et al., 2005; Singh, Asrey 2005; Verma et al., 2005; Singh et al., 2006; Ali and Gaur, 2007).

Lourduraj*et al.*, (1996)To see how different mulching materials affect cv. Co, 3 field trials (plastic cover and organic cover to rain cover manage and irrigation ratios (IW: CPE ratios of 0.40, 0.60 and 0.80)) negatively affected yield and finances, indicating so as to tomatoes by black LLDPE has been found to mulch. The mulching film (25 micrometers) yielded a maximum yield of 12,735 kg/ha, which is 28.4% more than that of unmulched irrigated tomatoes at an IW:CPE ratio of 0.80. irrigation.

Wang *et al.*, (1998) The chemical composition of the fruit and plant parts of Northeaster and Primetime strawberries, Maryland, USA, was assessed using different types of coverings (black polyethylene, red polyethylene, or flower bed straw). Strawberry plants covered with straw had the highest leaf area and chlorophyll content, while strawberry plants covered with red polyethylene mulch had the shortest leaf area and the lowest chlorophyll content. Fruit citric acid was found highest in areas mulched with Northeaster straw and mulched with black polyethylene. plot.

Wang and Galletta, (1998) In Beltsville, Maryland, strawberries from plants grown on hilly bases (hill systems, double hills of raised beds covered with black polyethylene canopy) were investigated. The hill system produced fruit with higher soluble solids and ascorbic acid, lower titrated acidity, increased leaf area and chlorophyll. Also, compared to MR, total sugar, fructose, glucose and myoinositol were higher and sucrose lower. The culture system produced fruit with a higher content of malic, citric andellagic acids than H.S. system. The Matte Rows (MR) process produces fruit with a higher content of soluble solids, sugar and acid than when using the HS system in the hot season.

Aulakh and Sur (1999) Studies on pomegranate investigated the result of multiple cover on soil temperature, soil damp, weed population, growth and yield. Black polyethylene, white polyethylene, farm manure and basuti were evaluated and compare through no mulch. Polyethylene mulch also produced the longest shoots and more fruit per plant. Based on these data, black and white polyethylene mulch was initiate to be most successful in retaining soil moisture, sinking weeds, and improving pomegranate development and production.

Kaufmane and Libek (2000) Strawberry quantity and quality were investigated using black plastic sheeting, bed carpets, wood chips, and straw coverings (Senga and Sengan, Dragons and Bounty varieties). The average yield of fruit per plant when treated with black plastic and litter was significantly higher (p0.001) than untreated controls only in the next year of crop growing (first harvest). Black synthetic mulch provided the top results for the Sengi and Sengana. On average, 814% of fruits be rejected. compare to the unmixed control, the black plastic cover had a much higher percentage of berries damaged by beetles and a much lower percentage of berries destroyed by plant bugs.

Ingle *et al.*, (2001) A study was conducted to determine how growth regulators and mulching affect the yield and eminence of Nagpur. In February, August and September, Ambia crops were sprayed three times with 2.4D foliage at 10 parts per million (ppm), 30 parts per million (ppm), and 25 parts per million (ppm). Mulching with dehydrated grass (5 cm thick) in February 2001; and control (no growth regulator spraying and mulching). The use of all growth regulators in combination with dry grass cover up had a important effect on the number and weight of fruits compared to controls. Hay mulching NAA + show the greatest results in number and weight of berries (935 pieces and 148.206 kg, respectively). The use of growth regulators and mulching significantly increased all indicators of fruit quality (average weight, volume, juice, TSS). , ascorbic acid and acidity), NAA + dry grass cover are most important, followed by 2.4D + dry grass cover.

Ghosh and Bauri (2003) The study was conducted on a 16-year-old mango variety. Bidhan Chandra Krishi-Visvavidyalaya, West Bengal, India has grown the Himsagar tree with regular growth and vigor. There were black polyethylene sheet mulching (250 thickness), rice straw mulching, dried mango leaf mulching, and annealing and control treatment (without mulching) around 3 grasses. The most effective polyethylene is black polyethylene with a fruit retention rate of 68.0%. In 1995 and 1997, trees treated with black polyethylene cover produced the highest yields per tree (71.8 kg, 125.4 kg, and 22.1 kg, respectively). Provides 81.2% more control. Mulching increased the weight of individual fruits, which was the maximum when mulching with black polyethylene (322.0 g), and then loosened the sleep of the trees (321.0 g), the lowest in the control (288.0 g). The use of a variety of mulch greatly affects the quality of the fruit. The highest level of total soluble solids (18.3) and entirety sugar (12.45%) were found in black polyethylene sheaths, followed by rice straw.

Kesik and Maskalaniec (2003) conducted an experiment to determine how mulching affects the growth and development of strawberry cultivars. Senga and Sengan plants in climatic and soil conditions of Vilnius region, Lithuania. To mulch the strawberry farm, compost (peat and organic produce), rye straw, pine sawdust, coniferous bark and black plastic sheets were used. Strawberries in the control and those covered with black plastic film had the most leaves, but mulching the soil with rye straw and bark resulted in a important decrease number of leaf compare to the control. Control and black foil-treated plants had the highest number of inflorescences, and mulch plants made from rye straw and bark had the lowest number of inflorescences. Black foil had the most positive effect on fruit set speed among the mulches studied.

Sharma and Sharma (2003) Studies have been conducted to determine how different mulching methods affect the growth, yield and quality of strawberry and albinism plants. One of many types of covers, black polyethylene covers are best for plants.

Shirgure*et al.*, (2003) In Nagpur, Maharashtra, India, researchers investigated the effects of polyethylene (black and white) and organic (soybean straw, rice straw, natural grass) mulching on soil wetness retention, wild plant populations, development, yield with Nagpur mandarin quality. Plant tallness (0.28 m), root girth (4.1 cm) and scion breadth (2.12 cm) were most improved with black polyethylene mulching, followed by restricted grass mulching (0.27 m, 3, 78 cm and 0.7 cm, correspondingly). Followed Fruit yields were highest when using black polyethylene cover (73.7 kg/tree) followed by grass cover up (69.7 kg/tree). Fruit weight (140.5 g), total soluble solids (10.2Brix), acidity (0.55%) and juice contented were maximized using a black polyethylene cover (49.86%).

Moor *et al.*, (2004) Experiments were conducted to see how mulching and fertilizers affect strawberry quality. Fertilizer treatment had a helpful effect on vitamin-C content with plastic cover, and fertilizer reduced fruit damage with straw cover.

Patra*et al.*, (2004) Experts from Mohanpur, West Bengal have tested how different mulching methods, including black polyethylene, sawdust, cover crop (Dongwoo cultivar IR8) and non-mulching control, affect the quality and yield of guava varieties. Sadar. Plants mulched with black polyethylene had the highest yields (44.32 kg/plant as well as 12.32 t/ha). It should be noted that all types of mulching treatments gave higher yields than the uncut control (7.55 t/ha).

Singh *et al.*, (2004) Mulching affects the growth of soil moisture, yields, and the economy of plum fruit trees in the middle hills of the Himalayas under rainfall conditions. Within a randomized block design, the experiment was repeated 6 times with three different mulch treatments. Non-cover cover (control), plastic cover (black polyethylene sheet) and hay cover. It was found that mulching on sandy loam significantly increased the growth of plum and fruit yield compare to no mulching. The fruit give up of mulched hay was 93.3 c/ha, 41.0 c/ha higher than that of unmulched hay. However, the average yield of fruit under hay cover compared to trees with plastic cover was 6.8 c/ha, which is statistically consistent with the nominal value. The in situ soil moisture retention of fruit trees mulched with hay was 1.74-8.20% higher than that of unmulched trees. Seasonal revenues for hay and plastic covers were $1.56 million. The in situ soil moisture retention for mulched hay of fruit trees was 1.74-8.20% higher than that of unmulched trees. Seasonal incomes of hay and plastic cover were 1.56 times and 1.34 times higher than those of unmulched fruit trees.

Sharma *et al.*, (2004) In the subtropical climate of New Delhi, India, researchers found that Mulching was done with black polyethylene, white polyethylene, and rice straw in 10 strawberry varieties (Sweet Charlie Chandler, Douglas, Fern, Etna, Fairfax, Tioga, Torri, Selva and Pajaro). According to the data, albinism was found in about 33% of fetuses. All plant growth indicators (crown height, crown span, number of leaves along with leaf area) were modified with various mulching materials and black polyethylene was more effective than other treatments.

Pande*et al.*, (2005) Researchers from Ranichauri, Uttaranchal, India, considered the effects of varied types of cover on top of the productivity and superiority of apple trees. 2002 Red. Treatments included dry grass cover (15 cm thick), black plastic cover (size 100), pine needle cover (15 cm), dry leaf cover (15 cm) and clean crop care. The largest annual growth rates were achieved through the use of dry grass and the use of black polyethylene mulch. The control group produced the most fruit and the least fruit, while hay mulching had the best overall fruit retention and yield. The organic shroud had lower total soluble solids and acidity than the black polyethylene shroud and control. The largest fruit size (6.52 x 5.93 cm), weight (128.26 g), volume (136.75 ml), and juice content (48.46%) were observed when mulching dry grass and mulching dry leaves.

Phadung*et al.*, (2005) Experiments involving irrigation and mulching have been used to study the growth, yield, and quality of perlet berries. When mulching with straw and plastic, the weight of fruit and the number of bunches of vines increased more than without mulching, while the weights of bunches and TSS did not change. Yield and TA were highest for plastic mulch, but TSS/TA was lowest.

Singh *et al.*, (2005) The result of planting and mulching time on growth, fruiting, yield and flowering quality of strawberries (Chandler variety) was studied in Abhor, Punjab, India. In conditions of growth, fruit yield, and quality, black polyethylene was superior to other mulching materials.

Singh *et al.*, (2005) winter 1998-2000. Field trials were conducted in Abohar, Punjab, India to study the effects of transplantation period (10th, 30th and 20th of January) and mulching (black transparent polyethylene, sugarcane waste along with rice straw) on tomato varieties. rupali growth and productivity. Black polyethylene reserved more soil moisture and heat than other mulching resources and controls. Mulching with black polyethylene also increased fruit yield. Black polyethylene mulching yielded the highest net profit (Rs 52,700/ha), surpassing all other treatment combinations.

Shirguree*t al.*, (2005) Researchers tested black and white polyethylene also organic mulch on sour lime between 1999 and 2002 (Citrus AurantifoliaSwingle). In this test, mulching affected plant growth, yield and fruit quality, soil moisture retention, and weed growth. A three-year study found that 100m black plastic cover increased plant height and flock circumference the most, followed by local lawn cover at 3tha. The highest fruit yields (13.28 quintals per tree) were achieved using black polyethylene sheathing (100 m) followed by grass coverings (11.89 quintals per tree). Lime fruit weightTotal soluble solids, acidity, and sap content have all been raised. in 100 m of black plastic cover and herb cover. This study showed that mulching irrigated sour lime 3tha with black polyethylene cover (100 m) or grass cover can increase growth, yield and fruit quality while retaining soil moisture and removing weeds.

Kumar *et al.*, (2005) In the Northwest Himalayas, a field study of Chandler's strawberries was conducted (Fragaria x ananassa) to conclude the effect of the amount and process of irrigation and mulching on strawberry yield. The yield increased to 78.63 hectares thanks to black polyethylene cover (BP) and drip irrigation.

Wang-QiRui (2005) Sweet Cherry (Prunusavium) cv. Red lanterns surprised by mulching. Mulching increased not only the number of shoots and leaves, but also the nutritional value of the leaves, the number of shoots on fruiting branches (12), fruit setting (25.0428.01%) and fruit weight (18%). .) and soluble solids content (18%). (18%). (18% increase) (1.17% increase).

Verma *et al.*, (2005) Experiments from 1999 to 2002 in Shimla, Himachal Pradesh, India, confirmed the effects of mulching (black polyethylene mulching and grass mulching) and P and K applications (spreading or banding) on apple yield and value. Total soluble solids and total sugar were highest when weeds were mulched and mixed with P and K fertilizers, and final shoot growth, plant circumference, plant height, plant spread, fruit weight, Length, width, field, pressure and acidity were the highest.

Ali and Gaur (2007) In 2002-2003 experimented to see how different mulch affects strawberries (*Fargaria* x *ananassa*Duch.) cv. Sweet Charlie growth, yield and quality. Mulching materials included black polyethylene, sugarcane waste, paxi straw, sawdust, dried herbs, and unmulched controls. According to the data obtained, mulching contributed to the vegetative development and blossoming of plants. Plants mulched with black polyethylene had significantly higher plant height, distribution, and number of leaves and flowers. The use of black polyethylene cover increased the number of fruits per plant, standard weight and size (length and width), and fruit yield.

Sharma *et al.*, (2009) The effects of foliar processing of gibberellic acid on plant development, blossoming, fruiting and different diseases of Chandler strawberry varieties were studied. GA_3 (75 ppm) was administered to strawberry plants in mid-November (fruit discrimination stage), mid-February (pre-flowering period), or together. Fruits in the manage group be simply sprayed through tap water. plant characteristics such as crown tallness, crown span, petiole distance end to end, amount of leaves, and leaf area; Blooming and fruit set, fruit dimension; Albino Berry, Modified Berry and Button Berry Production, Gross Yield and profitable Fruit Yield; and superiority parameters such as juice substance, TSS, ascorbic acid content, acidity, etc. Results showed that spraying Chandler strawberries with GA_3 (75 ppm) in mid-November to February, or both improved the quality of all plants compared to the control. Also, although fruit set increased and yields of modified berries decreased, this did not affect albinism. Although the weight of individual berries decreased slightly, the number of berries, total yield and market yield were considerably increased compared to the control group without negatively affecting the quality of the berries. Overall, two GA_3 applications in mid-November to mid-February were significantly more efficient in achieving the desired results than a single GA_3 application in mid-November to February.

Singh *et al.*, (2009) The results showed that spraying strawberry Chandler GA_3 (75 ppm) in 15-November, 15-February, or both improved all plant quality above control levels. Also, although fruit sets increased and yields of modified berries decreased, albinism was not affected. Although the weight of individual berries decreased slightly, the number of berries, total yield and profitable yield were considerably improved compared to the control group without negatively affecting the quality indicators of the berries. Overall, two GA_3 applications in 15-November and 15-February were drastically more efficient in achieve the desired results than a single GA_3 application in mid-November and mid-February. The combination of biofertilizers and biocontrol agents has a significant contact on the dietary status of plants. Double inoculation of Azotobacter and Azospirilla combined with 60 kg N ha1 and 100 ppm GA_3 produced the highest plant N and Mg, whereas double inoculation of 90 kg N ha1 and 100 ppm GA3 produced the highest Zn in plants. ... However, the highest K content was found only at 100 ppm BA.

Kumar *et al.,* (2012) The purpose of this study was to use plant biomodulators to boost the growth, yield and value of strawberries in subtropical conditions for beneficial strawberry cultivation (PBR). During the experiment, three PBRs were investigated: GA (30, 60, and 90 parts per million), NAA (20, 30, and 40 parts per million), and cycocel or CCC (250, 500 and 750 ppm). Plant height (23.12 cm), three plants width (32.96 cm), petiole distance end to end (11.28 cm), leaves per plant (16.32), shoots per plant (4.77), leaf area index (0.82), fruit vitamins at 90 ppm GA C (63.03 mg/g) and titratable acid contented were the maximum (0.75%). On the other hand, when 500 ppm psychocell was used, the maximum produce yield (330.7 g/plant and 20.15 t/ha), exact gravity (1.17), TSS (10.01°B), total sugar (9, 14%), and sensory index were observed. Numerical evaluation (8.66 out of 10) and cost-benefit ratio (1:2.70) Strawberry plants treated through highest concentration of 750 ppm Cycocel after planting had the best time to first flowering (53.44 days) and time to fruiting (58 days). It was short. (27days).

(2.2) Effect of Growth Regulators on Growth, Yield and Quality

Because strawberries are considered non-menopausal fruits, no more ethylene synthesis is expected during ripening. As a result, the use of growth regulators cannot be avoided, as they affect the ripening and maturation of fruits. Fruit quality was determined by fruit length, width, weight, volume, Total sugar, reducing sugar, non-reducing sugar, ascorbic acid, TSS/acid ratio, anthocyanin, and total phenol. Gibberellins induce stem and leaf elongation in many higher plants, the most famous and first established effect. Flowering, pericarp, seed germination, activation of cambium processes in woody plants, and termination of dormancy or dormancy periods all depend on GA, whereas NAA increases shoot growth, cell elongation and reduces pressure on the cell wall. When ripe, several growth regulators and nutrients are applied to prolong the ripening period of many fruits. Some of these chemicals also contribute to the development of color.

Vankoot (1947) Studies have shown that the hormone can be used to successfully increase a plant's fruit production under adverse conditions. According to Rappaport, repeated formulation sprays containing 50 mg of GA improved immobilization of both normal fetuses and fetuses in unit time (1956). Gibberellins have been shown to inhibit the growth of genetically stunted plants such as dwarf corn, peas, and soybeans (Brain and Hemming 1955). The effect of gibberellins on the growth of various fruit plants has been studied by many scientists. According to Martha et al., treatment of tasty GA apple seedlings with 1% lanolin paste initially (1956) led to rapid growth. There were no visible growth differences between treated and control plants after 35 days of treatment. To properly exhibit growth-promoting activity, gibberellins require active or potentially active meristem regions (Brain et al. 1962). Paleg (1965) concluded that the action of gibberellins in the tops of sensitive plants increases protein synthesis, cell division and auxin production as a result of this process. According to many researchers, GA_3 treatment increased the height of pecan seedlings (Wiggans and Martin, 1961; Shreve and Campbell, 1967).

Thomas *et al.*, (1963) GA_3 has been tested on mango seedlings and has been shown to increase leaf count by up to 1000 ppm. According to Randhwa et al., risingthe GA3 concentration from 100 ppm to 300 ppm increased the number of leaves. (1965). According to Randhwa and colleagues, increasing the GA3 concentration from 50 to 500 ppm enlarged the number of leaves in grape seedlings (1968).

Srivastava and Singh (1969) GA_3 has been tested on mango seedlings and has been shown to increase leaf count by up to 1000 ppm. According to Randhwa et al., increasing the GA3 concentration from 100 ppm to 300 ppm increased the number of leaves. (1965). According to Randhwa and colleagues, increasing the GA_3concentration from 50 to 500 ppm increased the number of leaves in grape seedlings (1968).

Honda *et al.*, (1972) Flowering was promoted by the appearance of flower buds, and fruit maturity was increased by GA introduced into strawberry plants during flowering. Castro et al. (1976) found that 10 ppm of IAA and GA increased strawberry yield, whereas 5000 ppm of SADH, 2000 ppm of CCC and 50 ppm of GA decreased yield. Stoyanov and Welcov (1977) applied NM at 25 and 50 ppm to strawberry plants as a pretreatment using Ksalt solution. Compared to untreated plants, they noted an boost in fruit weight and yield.

Lucchesi and Minami (1980) Using compinas and Monte Algera strawberry varieties, the researchers found that after planting for three weeks, spraying with 30 ppm of GA_3, 75 ppm of CPA and 30 ppm of 1 m three times weekly gave higher yields than the control. They also found that GA_3 treatment produced the highest yield (26.5 t/ha).

Singh and Phogat (1983) GA_3 at 75 ppm was start to be the most useful in increasing strawberry yield from 43.3 to 55.5 c/ha among other concentrations tested. According to Lopez et al., 198586 (1989) at 2080 ppm of Pajaro and Douglas grown in low tunnels, GA_3 had no result on yield or fruit size. There is no appreciable difference in qualitative or quantitative outcomes when the GA_3 ratio was changed.

Singh and Phogat (1983) Adding leaves and crowns per plant increased the number of leaves and crowns per plant (CCC). GA_3 at 2550 ppm resulted in better shoot production and CCC at 1000-1500 ppm formed the highest number of crowns per plant.

Weidman and Stang (1983) Adding leaves and crowns per plant increased the number of leaves and crowns per plant (CCC). GA_3 at 2550 ppm resulted in better shoot production and CCC at 1000-1500 ppm formed the highest number of crowns per plant.

Singh *et al*., (1989) Studies have shown that increased cogeneration of GA_3 (100-300 ppm) significantly increases the number of leaves per plant in Citrus sinensisOsbek.

Techawongstein (1989) Sprinkled strawberry varieties. Tioga plants with varying concentrations of NAA (0, 50, 100, 200 and 400 ppm) found that NAA (400 ppm) produced the biggest fruit in terms of width, weight and volume. The maximum acidity percentage and the lowest sugar addition rate were also achieved at 400 ppm NAA. However, there was no significant difference in fruit sugar content at different NAA doses.

Thakur *et al.,* (1991) GA_3 @ 75 ppm used to spray plastic-coated strawberry leaves during the first year of testing produced significantly more fruit than the control Pusa early dwarfs. By themselves, there were no appreciable differences between GA and cloche regimens. Two applications of 75 ppm GA + Colche gave the best end results.

Pankov (1992) Bhautkar (1994) observed that GA3 had no effect on strawberry yield in Yasna and Sengana cultivars, but CCC @ 2.4% bigger fruit yield by 1.6 and 1.9 t/ha for Yasna and Sengana cultivars, correspondingly. At 35 and 51 days after planting in Australia with 25, 50 and 75 ppm of GA3 and NAA ascorbic acid, mean yields ranged from 34.3 g/plant to 103.0 g/plant after 50 ppm GA_3 and ascorbic acid (25 ppm) respectively. spray; The untreated control receives 55.5 g/plant.

Ozguven and Kaska (1993) In strawberries, GA3 was administered at three different doses (12.5, 25, and 50 ppm) at three different time between November and April. Compared to other treatments and dates, 50 ppm of GA_3 applied in November accelerated flowering.

Ozguven and Kaska (1993) GA_3 activity was observed when spraying strawberry varieties Alisopocahontas and Tioga in late November, January and April of 1981. Compared to controls, all treatments improved fruit quality (TSS).

Bhautkar (1994)) In field trials, the researchers tested the cv. Australia with varying doses of GA3, ascorbic acid, or NAA at 35 and 51 days post-transplant had a significant result on TSS.

Kumar *et al.*, (1996) For strawberry varieties. Tioga completed field testing. The addition of 50 ppm GA to the control spray with gibberellin improved the leaf area size (120.47 cm2). The number of leaves (6.4) and shoots (6.1) per plant improved overall yield. Varieties of strawberries, but not the total yield of strawberry varieties.

Das and Das (1999) The effects of the plant growth regulators GA_3, NAA, 2,4D Ethrel and CCC were evaluated. Variety of concentrations of flowering, fruit setting and rich fruit holdings. Plant growth regulators responded differently to flowering, fruit setting, and fruit preservation. Best results in terms of the number of hermaphrodites (128.34 and 125.40 in both seasons). Percentage of fruit sets (34.08 and 33.12) and numbers of holdings (14.10 and 13.8) per drink at harvest were recorded with a GA_3 concentration of 50 ppm. Treatment had no significant effect on the day before flowering, and 2.4D at 20ppm showed good results in terms of stickiness and maintenance.

Kale *et al.*, (1999)Spray 7-year-old berberry varieties. GA_3 and NAA alone (10 and 20 ppm) and combinations were killed up to 60 days after full bloom, and the same spraying was repeated for 30 days after the first spray. Fruit retention and yield were found to increase at 20 ppm GA_3. Borowaski*et al*. The effect of tomatex form of triacontanol on induced basic chlorophyll, tomato leaf was investigated (cv. Dalfing), study (2000), fruit yield and fruit dry matter content. All doses of tricontanol significantly improved the optimal oxygen capture efficiency when Tomatex was injected into the roots at 0.3, 3, or 30 μg per plot at a time. Again during the germination stage (67 leaves) and the second inflorescence is flowering.

Bhautkar (2001) On days 35 and 51 after sowing, application of GA_3 at 25, 50 and 75 ppm improved average yield. 50 ppm compared to untreated control. GA_3 yielded the highest yield (103.0 g/plant).

Montero *et al.*, (2001) The spraying effect of young strawberry varieties. Chandler plants containing gibberellic acid (30 or 60 ppm) were studied for fruit development, and the weight and size, phenolic content, and activity of phenylalanine ammonia Ammonia degradation (TAL) was decreased and the color of the fruit was increased.

Ozguven*et al.*, (2002) Experiments were conducted to investigate whether exogenous GA3 could be used to disrupt bud dormancy. By prolonging the growing season, this therapy increases the yield of strawberries. The effects of GA_3 at 0, 5, 10 and 20 ppm were tested exogenously during the second and fourth weeks of January. Experiments have shown that 10ppm of GA_3 is effective in initiating early flowering and affects the physicochemical properties of fruits.

Asrey*et al.*, (2003) the researchers found that during Punjab's mild summer (March-April), the growth and inhabitants of runners was significantly elevated than that of the control group. As the summer passed, it withered and withered and eventually intensified the death of the plants. June had the highest GA_3 concentration and the plants died the most. Consequently, GA_3 NAA, TIBA and 2.4D are not recommended for growing strawberry sprouts in the semi-arid regions northwest of Punjab.

Khokhar *et al.*, (2004) Experiments were conducted in Himachal Pradesh, India to see how NAA (30 and 60 ppm) and GA_3 (50 and 75 ppm) affect. Strawberry production and cultivation cv.chandler. A GA of 75 ppm produces the highest plants and requires consideration of maximum leaf area, number of leaves, yield, weight and volume of fruit. Fruit anthocyanins were highest at 50 ppm of GA.

Jain and Singh (2004) It has been found successful to use four growth regulators (NAA, TIBA, GA3 & 2,4D) and calcium salts (calcium nitrate and calcium chlorite) to extend the shelf life of Chandler strawberries. Pre-harvest spraying of leaves with GA3, NAA, 2,4D and calcium nitrate prolongs harvest viability, which promotes the development of high-quality ripe fruits with high reducing sugar content, minimal cumulative physiological weight loss, and increased vitamin C. Treatment was sprayed with 25 ppm GA3, 10 ppm 2.4D, and 1% calcium nitrate for 14 days, which not only extensive shelf life (up to 9 days) but also compact post-harvest losses (1.55%). water loss as well as impaired metabolic activity during maturation without compromising quality. Vitamin C levels during storage (49.30 mg/100 g pulp) were aided by 25 ppm NAA pre-harvest treatment.

Khokhar *et al.*, (2004) Effect of NAA (30 and 60 ppm) and GA3 (50 and 75 ppm) on yield and superiority of cv in field trials in Himchal Pradesh, India. A study by Chandler found that although the strawberry was of the highest quality, the highest anthocyanin content was recorded at 50 ppm in GA_3.

Banday*et al.*, (2005) Two levels of BA (benzyladenine), GA_3 (gibberellic acid), NAA (neptalic acid) and TRIA (triacontanol) were tested at the sprout stage and after 15 days in two strawberry varieties, Confitura and Brighton, they I checked what effect it has. Physical and chemical properties and flow rates. Among the growth regulators, GA_3 (25 ppm) produced the largest length, diameter and volume of the fruit. Plants sprayed with GA_3 (40 ppm) required a minimum number of days to mature. Plants treated through 25 ppm of GA_3 had the maximum fruit weight and yield per plant.

Hafiz and Hanan (2005) Effect of GA_3 on strawberry varieties. Murray has been carefully studied. They tested GA_3 at 0, 10, 25, 50 and 100 ppm and found that at 50 ppm GA_3 produced the longest production period (41 days), the largest fruit weight (6.7 g) and the highest total yield (20 plants). Found it. (2242.7 g).

Singh and Singh (2005) In the course of their research, scientists studied the effects of growth regulators on strawberries. Treatments incorporated water irrigation (control), 50 and 100 ppm gibberellic acid, and 50 and 100 ppm benzyladenine. Plants injected with 100 ppm GA3 had the earliest flowering (116.50 days) and produced the most blossoms per plant and themost flowers per plant. Although 100 ppm of NAA produced the most flowers, 100 ppm of GA3 provided the best yield performance and yield properties.

Hafiz and Hanan (2005) Investigation of the effect of GA_3on strawberry varieties. Murray performed. GA_3 was used at concentrations of 0, 10, 25, 50 and 100 ppm, with plants treat at 100 ppm showing the maximum plant height (31 cm), leaves per 20 plants (395.7) and suckers/20 plants (98.7) pay. GA_3.

.**Dale *et al.*, (2006)** Studies have shown that spraying GA_3 leaves increases the productivity of daytime neutral strawberry shoots. As the GA_3 concentration increased by 100 ppm, the impeller productivity increased linearly.

Camacaro*et al.*, (2009) exogenous gibberellic acid treatment significantly affects vegetative growth and blossoming of strawberry plants of the Chandler in vitro cultivar. According toward the data obtained, plants of the Chandler variety were treated by 20 ppm. gibberellic acid had the highest number of leaves, crowns, inflorescences and flowers during the evaluation period.

EI-shabasi*et al.*, *(*2009) Etrel (ethephon) and GA_3 have different effects on strawberries. Was investigated and the introduction of GA_3 was found to increase plant height. Total glucose content in strawberry leaves was increased by GA_3 and ether. 10 ppm of GA3 or 250 ppm of ether better the number of flowers and the monthly and total yield.

Kumar and Tripathi (2009) For strawberry varieties. In Chandler plant growth, the researchers investigated the effects of NAA (10, 15, 20 ppm), GA_3 (50, 75, 100 ppm), and boric acid (0.1, 0.2, 0.3%). Plants were sprayed twice with aqueous solutions of these plant biocontrol agents and trace elements, once 25 days after planting and once again in the germination stage (65 days after transplantation). Plants treated with 100 ppm of GA_3 were the tallest plants (20.50 cm), the most leaves (18.75), the most crowns (3.50), the most shoots (3.50), the most flowers (3.50), (3.50), (16.13). Span (29.40 cm) and leaf area index (0.816). For lush strawberry growth, spray of 75 ppm gibberellic acid is recommended.

Kumar and Tripathi (2009) Strawberrycv. We investigated the factors that determine Chandler's profitability and profitability. Plants were sprayed twice with an aqueous solution of these plant biocontrol agents and trace elements (65 DAT) during the germination phase, once at 25 DAT. The data showed that plants treat by 100 ppm of GA_3 produced the most fruits (15.10), berry length (3.14 cm), berry width (1.95 cm) and yield (110.68 g) for every plant. 100 ppm of GA_3 also significantly increased the harvest period of plants (67.95 days).

Roussos *et al.,* (2009) when the plant is a strawberry cv. Camaro is treated with various plant growth stimulants. Plant growth promoters have increased the number and size of fruits sold. They increased total anthocyanin concentrations but had no effect on total anthocyanin levels, organic acid and carbohydrate content, or fruit color.

Kumar and Tripathi (2009) Effect of NAA (10, 15 and 20 ppm), GA_3 (50, 75 and on strawberry cultivars, boric acid (0.1, 0.2, and 0.3 percent) and phosphoric acid (100 ppm) were tested. Chandler quality was investigated. The data clearly show that plants treated through 20 ppm NAA formed fruit with the highest soluble solids (7.68 ^{o}Brix), total sugar (5.97%) and acidity (0.92%), while plants treated with 100 ppm GA_3 gave fruit. showed It has the highest ascorbic acid content (56.66 mg).

Tripathi and Shukla (2010) Plant bio-regulators have effects on strawberry varieties (NAA, GA_3, CCC and BA). The range, volume, weight and yield of Chandler fruits were studied. Aqueous solution of NAA (5, 10 and 15 ppm), GA_3 (25, 50 and 100 ppm), CCC (500, 1000 and 1500 ppm) and BA (25, 50 and 100 ppm) were sprayed on plants 65 days after transplantation before germination has been. GA_3 at 100 ppm created the largest berries in terms of length, volume and mass, while CCC at 1000 ppm produced the largest berries in terms of width. The plots treated with 100 ppm GA_3 and 1000 ppm CCC produced much higher yields per hectare.

Kumar *et al.,*(2011) Gibberellic acid (25, 30 and 75 ppm), triacontanol (1.25, 2.5 and 5 ppm) and Cyclocel (300, 600 and 900 ppm) v. The yield of Sweet Charlie has been studied. Plants treated with 900 ppm cyclocell yielded the most fruit per plant, while plants treated with 50 ppm GA_3 yielded the least. The maximum number of fruits (23.31 pieces), yield for each plant (376.69 g/plant), yield per hectare (27.90 tonnes) and length-to-diameter ratio (1.50) were found in plants treated with triacontanol at a concentration of 5 ppm.

Kumar *et al.*, (2011)On strawberry cultivars, Chandler the effects of NAA (10, 15, and 20 ppm), GA_3 (50, 75, and 100 ppm), and boric acid (0.1, 0.2, and 0.3 percent) quality was investigated. The data clearly show that plants treated among 20 ppm NAA produced fruit through the maximum soluble solids (7.68 ^{o}Brix), total sugar (5.97%) and acidity (0.92%), whereas plants treated with 100 ppm GA_3 gave fruit. showed It has the highest ascorbic acid content (56.66 mg).

Csukasi*et al.*, (2011) they found that the plant hormone gibberellic acid increased the yield and yield-determining factors of strawberries. GA_3 is sprayed on the berries at 100 ppm to produce the longest, longest and heaviest berries. The plots treated with 100 ppm GA_3 yielded much higher yields per hectare.

Jamaluddin*et al.*, (2012) Study the effect of gibberellic acid levels on strawberry yield. Various concentrations of GA_3 were used in the experiments: 50, 75 and 100 ppm. relevance of 75 ppm GA_3 produced the maximum number of fruits for every plant (25.9), fruit weight (13.2 g) and yield (336.6 g), while the lowest yield (336.6 g) was under control. In terms of yield, the best results were obtained when 75 ppm GA_3 was applied to strawberry leaves.

Jamaluddin*et al.*, (2012)the effect of gibberellic acid on strawberry growth was investigated. At 75 ppm treatment, height (31.4 cm), number of leaves (11.1), leaf area (64.5 cm2), number of buds (30.0), and the maximum number of flowers (28.7) were observed. When strawberries were sprayed on leaf surfaces with 75 ppm GA_3, the growth performance has been improved the most.

Isamabdulbas*et al.*, (2012) The flowering and fruiting of strawberries was observed under the influence of exogenous hormones. Strawberry varieties Camaroza and Camaroza were grown in greenhouses and treated with auxins (GA_3) or cytokinins at 0 and 50 ppm gibberellic acid (IBA). The results show that there was a important difference between the average flowering time and the average flowering time. The parameter fruit ratio was used to estimate the average weight of the two varieties. When 50 ppm GA_3 was applied to plants, the number of flowers per plant greater than before by approximately 138% compared to control plants.

Kumar *et al.*, (2012) Experiments used GA_3 (30, 60 and 90 ppm), NAA (20, 30 and 40 ppm) and cycocel (20, 30 and 40 ppm) (250, 500 and 750 ppm). 90 ppm GA_3outperformed other plants in height (23.12 cm), plant length (32.96 cm), number of leaves (16.32), and shoots per plant (4.77).

Viasus-Quintero *et al.*, (2013) Plant growth regulators have been found to increase strawberry yield in low-yielding areas. The utilize of growth regulators that can affect the behavior of fruits after harvest has been investigated. Strawberry plants were sprayed with GA_3 at concentrations of 300, 600 and 900 ppm (cv Albion). Result showed that, on average, all growth regulators increased fruit size during harvest. Regulators were able to improve average fruit size and yield in terms of dosage, but without affecting organoleptic quality.

Asadi*et al.*, (2013) Gibberellins have been found to play a role in many biochemical and morphogenetic reactions in plants. After the last flower was picked, the plants were sprayed with a treatment agent and the process was repeated a week later. The effects of GA_3 treatment on productivity, flowering and plant characteristics were studied. Use of GA_3 did not significantly affect market yield, fertilization and unfertilization, crowns of leaves and branches, average fruit weight, or number of inflorescences and shoots, but significantly increased inflorescences and shoots. . Spraying GA_3 at 50 ppm in strawberry plants better the number of buds, so more strawberries helped greatly.

Camcaro*et al.*, (2013) Effect of gibberellins on cultivars. Investigated the harvest of Camaroza Strawberries. Plants planted on Wednesday showed maximum growth and yield when the leaves were sprayed with 4 different dose of gibberellic acid (0, 10, 20 and 40 ppm). A concentration of 40 ppm gibberellic acid was favorable for plant development.

Prasad *et al.*, (2013) By strawberry variety, Douglas, the researchers studied the effects of various mulch and plant growth regulators.GA_3 (25, 50, 100 ppm) with black polyethylene cover, GA_3 with clear polyethylene (25, 50, 100 ppm), GA_3 with rice straw cover (25, 50, 100 ppm), NAA (10, 20, 40 ppm) rice Straw manure, NAA (10, 20, 40 ppm) Straw manure, NAA (10, 20, 40 ppm) Straw manure, NAA (10, 20, 40 ppm. Growth regulators combined with mulching have a significant effect on physicochemical effects Strawberry Characteristics and Post-harvest

Characteristics.GA3 100ppm + black polyethylene cover provides the highest levels of TSS (12.71oB), acidity (0.71%), total sugar (7.41%), reducing sugar (6.25%) and ascorbic acid. Acid (63.20mg/100g of fruit) takes first place on the list. 100 ppm GA_3 + black polyethylene cover provided the longest fruit life under both ambient conditions (2.48 days) and cooled conditions (3.78 days).

Kumar *et al.*, (2013) the cause of gibberellic acid on strawberry varieties was investigated. The highest fruit juice content (86.70 / 86.46%), TSS (7.56 / 7.43ºB), sugar contented (4.33 / 4.26%) and fruit pH (3.87 / 3.86) of the subtropical Belrubi fruit were reported in the gibberellic acid group. at a concentration of 150 ppm. The maximum vitamin C substance (63.75/63.66 mg/100 g) was found for the 100 ppm GA3 treatment mixture. Also, the fruits with the highest acidity (0.77 and 0.79%) were controlled (water irrigation). They also found that spraying plants treated with GA3 (150 ppm) improved fruit quality.

Lolaei*et al*., (2013) Studies have shown that the use of 150 ppm GA_3 has the most effect on the number of leaves and fruits. Gibberellic acid treated with 50, 100 and 150 ppm increased the mass of both types of fruit compared to the control group. TSS was decreased while phenol and tannin were higher; indicating that spraying with GA_3 slowed fruit ripening. Compared to controls, GA_3 drastically increased the number of solons at 100 and 150 ppm concentrations.

Jasrotia*et al.*, (2014) Effect of gibberellic acid on blossoming characteristics and productivity of strawberry cultivars. Investigated Belrubi. Different parameters were tracked using three GA_3 concentrations of 50 ppm, 100 ppm and 150 ppm, also plants treated with 150 ppm GA_3 showed the shortest time to early flowering (54.22/53.55) and blossom formation (60.77). /60.08), plants treated with 50 ppm of GA_3 had the maximum number of flowers per plant (23.64 / 22.56) and fruit yields per plant (288.74 / 269.89) were higher in strawberry plants treated with GA_3 (50 ppm). Growth, flowering and yield par plant.

Khunte*et al.*, (2014)Physicochemical properties of strawberry varieties. Chandler is influenced by plant growth regulators and organic fertilizers. For foliar application, NAA (100, 150, 200 ppm), GA3 (100, 150, 200 ppm), triacontanol (100, 150, 200 ppm), and CCC (400, 800, 120 ppm) were used. . Organic maturation (2.50, 5.50 and 8.50 t / ha) applied to the soil through soil preparation. Treatment with 100 ppm

GA_3yielded the highest total soluble solids (10.19 ^{o}B), whereas treatment with 200 ppm NAA yielded the highest content of fruit juice (90.12%). Fruit juice had the highest acidity (0.87%) when the GA_3 level was 150 ppm.

Saima*et al.*, (2014) Effect of plant bio-control agents on the growth characteristics of strawberry cultivars. A Chandler study originate that 75 ppm of GA_3 increased maximum plant height (20.50 cm), plant (20.50 cm), number of leaves for each plant (23.00), petiole length (0, 20 cm), and leaf area after 75 days of transplantation. (136.30 cm2) and strawberry yield (356.56 g/plant) (66.66 DAT). The number of flowers (30.22) and fruit (24.80) per plant was also maximum using 75 ppm of GA_3.

Jasrotia*et al.*, (2014) Effect of gibberellic acid on strawberry varieties. We investigated the characteristics of Bellruby productivity. The highest yields each plant (288.74 g) and yields per hectare (17.67 c/ha) were recorded at a GA_3 concentration of 50 ppm. They also found that plants treated with GA3 (50 ppm) produced higher yields and better quality characteristics.

Thakur *et al.*, (2015) Plant growth regulators such as gibberellic acid were tested at concentrations of 25, 50 and 75 ppm per cv of strawberry yield. Chandler. Plants with the highest number of crowns, fruits and yields for each plant were treated with 75 ppm GA_3. The maximum weight, length and physical properties of fruit were affected by the same processing method.

Hazarika*et al.*, (2015) Compound effects on strawberry varieties have been studied. GA_3, BA, and NAA Festival Growth, Yield and Quality Researchers have found that gibberellins and NAA have significant effects on the growth, production, and value of strawberries. The combination of RDF + 50 ppm GA_3 + 50 ppm BA provided the maximum growth in requisites of height, width and number of crowns per plant. The similar treatment increased the number of shoots per plant, the weight of the berries and the number of berries per plant.

Thakur *et al.*, (2015) A test was conducted to determine how GA_3 (25, 50, and 75 ppm) affected the growth and yield of Chandler strawberry varieties. GA_3 75 ppm provided the best results in conditions of plant growth, yield, fruit worth, leaf area and shoots per plant compare to other treatments. Crown, fruit length, fruit weight and yield per plant be highest in GA_3 treatment.

Rajbahar*et al.*, (2015)The effects of growth regulators and earthworm manure on the qualitative characteristics of some strawberry varieties have been studied. With 100 ppm gibberellic acid, Douglas had the highest total soluble solids (10.68 ^{o}B), follow by Confictura, Selva and Gorella. Chandler had the lowest TSS (9.41oB).

Thakur *et al.*, (2015)The effects of GA_3 (25, 50 and 75 ppm) on fruit quality in Chandler strawberries were investigated. The 75 ppm GA_3 treatment had the maximum total soluble solids and TSS: acid ratio, but the fruit acidity was the highest for the same treatment.

Ikram and Qureshi (2016) Plant height (25.33 cm), petiole length (22.60 cm), number of pine needles (2.9), leaf area (139.86 cm2), number of shoots (20.55), number of leaves (7.44), shoot width (30 cm), shoot leaf area (80.33 cm2) and parent Sprout weight (22.90 g) increased significantly in response to GA_3 @ 400 ppm application, but the cooling temperature decreased (40 °C).

Sekhar*et al.*, (2016) To find out how plant growth regulators affect strawberry varieties. Chandler conducted an experimental study. Plants treated with GA_3 75 ppm grew the fastest in terms of plant height, petiole length, number of leaves for every plant, leaf area and plant growth. The use of CPPU 6 with 50 ppm ga3 treatment had a significant effect on maximum flowering period, flowers for each plant, fruit set, and number of fruits.

Palet*et al.*, (2016) Experiments were conducted in Odisha to study the effect of plant growth regulators on strawberry varieties. Chandler. The study was repeated 3 times and used a randomized blocking solution with 10 treatments: control (water), GA_3 (25, 50 and 100 ppm) and GA_3 treatment at 100 ppm provided the top results in terms of vegetative growth and sprouting.

Vishal *et al.*, (2016)) NAA (15 and 20 ppm), GA_3 (100 and 125 ppm), CCC (1000 and 1250 ppm) and BA were field tested to determine how they affect the nutritional performance of strawberries (100 and 125 ppm). GA_3 125 ppm, plant height (22.39 cm), number of triplets per plant (28.33), trifoliate length (11.64 cm), trifoliate width (15.88 cm), plant distribution in EW (29.70 cm) and NS (24.63 cm), plants Maximum number of shoots per (5.87). However, the same value was the lowest when CCC 1250ppm was used. The largest leaf area (128.53 cm2), leaf area index (3.70), total growth rate (0.43 g/plant/day) and yield growth time (4.77 g/m2/day) be achieved at 125 ppm GA_3, while the highest net assimilation A rate (0.250 mg/cm2/day) was achieved with 1000 ppm CCC.

Mastuane*et al.*, (2016) the effect of various concentration of gibberellic acid (0, 25, 50, 75 ppm) on strawberry quality was experimentally investigated. Plants treated through 75 ppm GA_3 had lower leaf nitrogen (1.78%) and chlorophyll indicator (25.01). Fruits treated with 75 ppm GA_3 had significantly lower titrated acidity and increased vitamin C (71.88 mg/g) and total soluble solids (6.90 ^oB).

Yadav*et al.*, (2017) A look at determined that the GA_3 seventy five ppm remedy resulted withinside the earliest flowering (923.50 days), the longest harvesting time (96.00 days), and the most pickings (34.17), The outcomes of the look at tested to foliar spraying with GA_3 seventy five ppm after forty five days of transplanting changed into advanced to all different remedies in phrases of enhancing strawberry output on severa metrics.

Yadav*et al.*, (2017) When GA_3 was treated at 75 ppm, fruit length (4.91 cm), diameter-to-weight ratio (1.92), and length-to-diameter ratio (1.92) were found. However, the 0.4% boric acid treatment produced the largest fruit diameter (4.20 cm) but 0.4% zinc sulfatetreatment resulted in the highest fruit weight, wet weight (28.09 g) and dehydrated weight (2.05 g). Studies have shown that GA_3 levels reached 75 ppm when the leaves were sprayed 45 days after transplantation. It outperformed all other treatments in provisos of yield and performance, increasing strawberry yield in Jalavar conditions.

Tiwari*et al*., (2017) Plant growth regulators affect strawberry varieties. Chandler. Has been studied. Plant growth regulators were tested using NAA, GA, tricontanol (TRIA) and CCC. After completing the experiment, they found that 30, 60, 90 and 120 days after transplantation, foliar application of GA_3 @ 200 ppm was the largely effective plant growth regulator in expressions of maximal physiological parameter, whereas a combination of GA_3 @ 150 ppm The effect was the mainly effective plant growth regulator in terms of increased biochemical parameter such as total soluble solids (9.6 ^oB), acidity (0.65%) and ascorbic acid (53.43 mg/100) (3.06). As a result of this study, it was found that the application of GA3 leaves had the greatest effect on the physicochemical properties of Chandler strawberries.

Yadav*et al.*, (2018) the quality criteria evaluated in this experiment were TSS; reducing, non-reducing, and total sugars are all examples of total soluble solids. After spraying the leaves with ZnSo4 (0.4) + NAA (15 ppm), total soluble solids (8.06 oB), reducing sugars (5.45%), non-reducing sugars (2.58%), and total sugars (8.03%) were at their highest levels.

(2.3) Effect of NAA and GA3 on Benefit: Cost ratio

Kumar *et al.*, (2012) the quality criteria investigated in this experiment were total soluble solids, reducing, non-reducing, and total sugars. Total soluble solids (8.06 ^{o}B), reducing sugars (5.45%), non-reducing sugars (2.58%) and total sugars (8.03%) be most after spraying the leaves with ZnSo4 (0.4) + NAA (15 ppm). .

Prasad *et al.*, (2012) Studies have shown that various plant growth regulators and mulching contain a important effect on strawberry yield along with yield indicators. Compared to control strawberries, the use of 100 ppm GA_3 with a black polyethylene sheath increased cost-benefit (1:1.62).

CHAPTER-3
MATERIALS AND METHODS

CHAPTER-3

MATERIALS AND METHODS

The present investigation entitled **"Effect of plant growth regulators and mulches on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler" was carried out at Horticulture Research Farm of the Department of Applied Plant Science (Horticulture)** Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow 226025 during the winter season of 2018-19 and 2019-20 respectively. The details of materials and methods applied during the present case of investigation are presented in this chapter with details of test on experiments followed by statistical procedures and as for plan of works.

LOCATION AND SITE OF EXPERIMENT

The study was conducted at the Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow, Department of Horticulture, Research Farm-1. The experimental plot is located approximately 10 km from Lucknow on the Rae Bareli Road towards the south city of Lucknow. The farm is located at a height of 129 metres above mean sea level. Lucknow is a geographically substantial city and is found in the subtropical zone tract of central U.P. at 26^{o} 46’ North latitude and 80^{o} 55’ East longitude.

TOPOGRAPHY, CLIMATE AND WEATHER CONDITION:

The region's climate is subtropical, with a summer maximum temperature range of between 29.3°C and 46°C and a winter minimum temperature range of between 3.5°C and 12°C. The relative humidity (RH) varies from 50 to 70% depending on the season, with hot summers and freezing winters. The average rainfall is 700 mm, with the majority falling between July and September over a period of around 100 days, with the peak months being July and August. During the winter, there are also sporadic showers. The temperature ranges from 5°C to 42°C in general. The coldest month of the year is January, while the hottest months are May and June, respectively. During the experiment, the experimental farm's soil was saline, with a pH of less than

8.2, an electrical conductivity of more than 4.0, and a sodium exchangeable percentage of less than 15.0. ICAR-Indian Institute of Sugarcane Research, Lucknow, recorded metrological observations, which are presented in the table.

Table No. 3.1Observations on the weather on a weekly recorded during the Experimental period of the crop (2018-19 and 2019-20)

Meteorological parameters during 2018-19.

Standard meteorological Week	Period 2018-2019	Temperature (^{0}C)		Relative humidity (%)	Annual Rainfall (mm)
		Max.	Min.		
43	**Oct, 25-31**	32.4	14.8	62.5	0.0
44	**Nov, 01-07**	32.0	14.3	67.0	0.0
45	**Nov, 08-14**	28.5	11.0	64.0	0.0
46	**Nov, 15-21**	29.1	12.7	63.0	0.0
47	**Nov, 22-28**	28.1	10.3	64.5	0.0
48	**Nov, 29-Dec, 05**	26.9	9.8	70.5	0.0
49	**Dec, 06-12**	25.1	6.7	69.5	0.0
50	**Dec, 13-19**	23.9	7.0	69.5	0.0
51	**Dec, 20-26**	23.5	3.4	64.5	0.0
52	**Dec, 27-Jan, 02**	21.8	2.5	62.0	0.0
1	**Jan, 03-09**	22.7	4.9	71.0	0.0
2	**Jan, 10-16**	22.6	5.8	65.0	0.0
3	**Jan, 17-23**	22.9	4.5	68.0	0.0
4	**Jan, 24-30**	21.8	10.3	77.5	0.0
5	**Jan, 31- Feb, 06**	22.3	7.0	69.5	0.0
6	**Feb, 07-13**	22.5	9.5	77.5	0.0
7	**Feb, 14-20**	23.6	10.4	73.5	0.0
8	**Feb, 21-27**	26.4	11.3	67.5	0.0
9	**Feb, 28- Mar, 06**	23.6	9.5	71.0	0.0
10	**Mar, 07-13**	27.5	10.9	63.0	0.0
11	**Mar, 14-20**	30.5	13.1	54.0	0.0
12	**Mar, 21-27**	32.1	15.0	49.0	0.0
13	**Mar, 28- April, 03**	34.7	17.0	51.1	0.0
14	**April, 04-10**	35.6	18.3	54.5	0.0

Meteorological parameters during 2019-20.

Standard meteorological Week	Period 2018-2019	Temperature (^{0}C)		Relative humidity (%)	Annual Rainfall (mm)
		Max.	Min.		
43	**Oct, 25-31**	30.0	11.6	73.2	0.0
44	**Nov, 01-07**	30.0	15.2	75.0	0.0
45	**Nov, 08-14**	29.5	14.9	67.5	0.0
46	**Nov, 15-21**	29.4	13.0	64.0	0.0
47	**Nov, 22-28**	27.7	11.9	69.0	0.0
48	**Nov, 29-Dec, 05**	26.5	12.5	76.0	0.0
49	**Dec, 06-12**	24.9	8.2	70.0	0.0
50	**Dec, 13-19**	22.2	10.4	79.5	0.0
51	**Dec, 20-26**	17.9	7.9	80.0	0.0
52	**Dec, 27-Jan, 02**	15.2	5.7	79.0	0.0
1	**Jan, 03-09**	20.4	8.3	75.3	0.0
2	**Jan, 10-16**	17.7	7.1	84.5	4.6
3	**Jan, 17-23**	17.7	10.2	93.1	12.2
4	**Jan, 24-30**	20.8	6.6	71.3	67.8
5	**Jan, 31- Feb, 06**	22.3	7.2	71.2	0.0
6	**Feb, 07-13**	22.9	5.3	65.2	0.0
7	**Feb, 14-20**	25.6	9.5	62.1	0.0
8	**Feb, 21-27**	26.5	12.1	75.5	9.2
9	**Feb, 28- Mar, 05**	26.7	12.7	73.6	0.2
10	**Mar, 06-12**	26.3	13.2	72.1	24.8
11	**Mar, 13-19**	27.0	14.0	73.6	18.0
12	**Mar, 20-26**	31.2	16.5	62.3	0.0
13	**Mar, 27- April, 02**	31.8	18.1	55.1	4.8
14	**April, 03-09**	35.2	17.6	44.3	0.0

Soil status of experimental area:

The soil in the experimental field is a sandy loam that is somewhat alkaline, with a pH of 8.2. In the table below, the physical and chemical qualities of soil are listed.

A	**Physical Property of Soil**		
S.No.	**Soil Particle**	**Percentage**	
1	Sand	34.50	Hydrometer meter method (Black,1965)
2	Silt	50.20	
3	Clay	15.30	
4	Texture class	Sandy loam	Triangular method
B	**Chemical Property of Soil**		
	Component	**Amount**	**Method of determination**
1	Available N_2 (Kg/ha)	110.50	Kjeldahl’s method (A.O.A.C.,1980)
2	Available P_2O_5 (Kg/ha)	40.50	Olsen’s method (Jackson,1973)
3	Available K_2O (Kg/ha)	190.40	Flame photometer (Jackson,1973)
4	CO_2 (organic) %	0.12	Rapid titration method (Jackson,1973)
5	pH	8.2	pH metre with a glass electrode (Jackson,1973)
6	E.C (1:1)	0.26	Conductivity meter (Jackson,1973)
7	E.S.P	14.80	Conductivity meter (Jackson,1973)

With the use of a tractor, the experimental field was ploughed to a depth of 5 cm. The field was left open to the sun for 10 days to kill weeds and insect eggs, then ploughed again and planked to get beautiful tilth. According to the layout plan, the required area was marked and prepared. A total of 20 plots were created, each measuring 1.20 x 1.20 m^2. A 0.5 m wide drainage channel was made between the two replications. Each plot contains four rows (rows were raised by 30cm from the main field) and planting runners at a distance of 30 x 30 cm (4 plants in each row) accommodated 16 plants in each plot. The strawberry runners were planted on October 23rd, 2018 in the evenings of 2018-19 and 2019-20, respectively. The details of the experimental layout are presented in Fig.

Layout of research field

Chanel	Replication 1	Chanel	Replication 2	Chanel	Replication 3	Chanel
	T_1		T_4		T_{15}	
	T_2		T_5		T_{16}	
	T_3		T_6		T_{17}	
	T_4		T_7		T_1	
	T_5		T_8		T_2	
	T_6		T_9		T_3	
	T_7		T_{10}		T_4	
	T_8		T_{11}		T_5	
	T_9		T_{12}		T_6	
	T_{10}		T_{13}		T_7	
	T_{11}		T_{14}		T_8	
	T_{12}		T_{15}		T_9	
	T_{13}		T_{16}		T_{10}	
	T_{14}		T_{17}		T_{11}	
	T_{15}		T_1		T_{12}	
	T_{16}		T_2		T_{13}	
	T_{17}		T_3		T_{14}	

EXPERIMENTAL MATERIAL

In both years, runners of the Chandler strawberry variety were brought in from the Central Institute of Temperate Horticulture in Srinagar (Jammu & Kashmir). The runners were hardened in the shade for two days before being transplanted into well-prepared beds in open field condition plots that were distributed randomly in three replications with seventeen treatments. During this time, cultural practises were followed. Experiment to maintain the runner's quality and yield also.

Technical Programme of Experiment

Mulching Material

Black Polyethylene - 200 micron

Transparent Polyethylene- 200 micron

Paddy Straw- 5 cm

Plant Growth Regulators

GA_3 - 50 ppm

GA_3 - 75 ppm

NAA - 20 ppm

NAA - 40 ppm

Fertilizer Dose

N: P_2O_5: K_2O – 75:80:50 Kg/ha

Farmyard Manure – 200 q/ha

Preparation of Plant Growth Regulators Solution

(A) To make the Gibberellic (GA3) stock solution at 75 ppm (parts per million), 75 mg of Gibberellic acid was dissolved in a small amount of alcohol, and the final volume was increased to one litre with the addition of distilled water.This stock solution was diluted to make the strength of Gibberellic acid 50 ppm using the formula $N_1V_1 = N_2V_2$. In the same way, different solutions of GA3 were made as per treatments.

(B 40 mg of NAA (Naphthalene acetic acid) in a small amount of alcohol. It was dissolved and the last volume was created by adding distilled water to make the stock solution of NAA (Naphthalene acetic acid) 40 ppm concentration. To prepare the solution of 20 ppm NAA, this stock solution of 40 ppm NAA was diluted by using the formula $N_1V_1 = N_2V_2$. After 30 and 45 days of planting, the plants were thoroughly sprayed with a high volume hand sprayer until solution began to drip from the leaves.

(C) For control: distilled water was taken for control treatments, The plants were drenched by spraying with distilled water.

N2 = Normality of standard acid, N2 = Normality of standard NaOH
V1 = Volume of standard acid, V2 = Volume of standard NaOH

Planting:

The planting was done in a single row system. Healthy runners were transplanted on October 23rd, 2018-19 and 219–20 during the evening hours. In each plot, runners were planted in four rows with 30 cm between the rows and 30 cm between plants.

Irrigation:

The first irrigation was applied shortly following the planting and the subsequent irrigations were given at an interval of 7–10 days during winter and 4-5 days during summer.

Intercultural operation:

The beds were kept clean by regular weeding and hoeing with the use of a hand hoe and a khurpi. Weeding and hoeing were done by hand. Generally, four to five weeding and hoeing tasks are done during the crop period.

DETAIL OF EXPERIMENTAL LAYOUT

An area of 22.40 x 7.60 m size was divided in to 51 plots having the size 1.20 x 1.20 m and arranged in the three replications of 17 plots. R.B.D. was used to plan the experiment.under 17 treatments.

Crop	Strawberry
Cultivar	Chandler
Experimental design	Randomized Block Design (RBD)
No. of treatment	17
No. of replication	3
Total No. of plot	51
Distance between rows	30 cm
Distance between plants	30 cm
Area of one Plot	1.2 x1.2 m
Width of Irrigation Channel	1.0m
Width of Border	1.0 m
Length of Experimental Field	22.4 m
Width of Experimental Field	7.6 m
Total area of Experimental Field	170.24m^2

.

Plate: General view of field

Plate: Weighting of plant growth regulators

Plate: A general view at the time of spraying plant growth regulators

Plate: A general view of experimental field after mulching

Location:

Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow Horticulture Research Farm (U.P.)

Detail of treatments combination

S. No.	Symbols	Treatments Combination
1	$\mathbf{T_1}$	Control (No mulching)
2	$\mathbf{T_2}$	GA_3 50ppm + Black polyethylene
3	$\mathbf{T_3}$	$GA_3$75ppm + Black polyethylene
4	$\mathbf{T_4}$	GA_3 50ppm + Transparent polyethylene
5	$\mathbf{T_5}$	$GA_3$75ppm + Transparent polyethylene
6	$\mathbf{T_6}$	GA_3 50ppm + Paddy straw
7	$\mathbf{T_7}$	$GA_3$75ppm + Paddy straw
8	$\mathbf{T_8}$	GA_3 50ppm + Rice husk
9	$\mathbf{T_9}$	$GA_3$75ppm + Rice husk
10	$\mathbf{T_{10}}$	NAA 20ppm + Black polyethylene
11	$\mathbf{T_{11}}$	NAA 40ppm + Black polyethylene
12	$\mathbf{T_{12}}$	NAA 20ppm + Transparent polyethylene
13	$\mathbf{T_{13}}$	NAA 40ppm + Transparent polyethylene
14	$\mathbf{T_{14}}$	NAA 20ppm + Paddy straw
15	$\mathbf{T_{15}}$	NAA 40ppm + Paddy straw
16	$\mathbf{T_{16}}$	NAA 20ppm + Rice husk
17	$\mathbf{T_{17}}$	NAA 40ppm + Rice husk

Treatment Viz. Fruit

T1

T2

T3

T4

T5

T6

T7

T8

T9

T10

T11

T12

T13

T14

T15

T16

T17

OBSERVATIONS RECORDED

(A) Growth Parameters:

(1) Plant height (cm)

The average height of the plants was estimated using a measuring scale from the ground level of the terminal end of the leaf at 30 day intervals (60, 90) from planting to harvest, and the data was represented in centimeters.

(2)Number of leaves:

The number of leaves was counted every 30 days from planting to harvest, and the data was expressed as a number of leaves per plant.

(3) Length of leaf (cm):

The length of leaf was also observed with the help of measuring scale and expressed in centimeter.

(4) Length of petiole (cm):

Leaf petiole length was measured from mature tagged plant with the help measuring scale in centimeter.

(5) Length of leaf with petiole (cm):

The leaf's length with petiole was measured from ground level to end of leaf by measuring scale and expressed in centimeter.

(6) Plant spread (cm):

Average plant spread was measured in both direction i.e E-W and N-S from tagged plants with the assistance of measuring scale and mean of each direction was calculated.

(7) Plant fresh and dry weight (g):

After the harvesting period, three plants were uprooted for the estimation of plant weight and thereafter washed properly. Subsequently, these were dried and placed in an oven at a temperature of 70 ^{o}C. An average fresh and dry plant, a computerised electronic weighing balance, was used to record the weight.

(B) Yield Parameters:

(1) Days taken to 1st flower:

Following the appearance of panicles, a frequent visit to the field was made, and the length of time from transplanting to the first flower opening was recorded, and the average number of days from the first flowering appearance was measured.

(2) Number of flowers per plant:

The number of flowers was noted from randomly selected tagged strawberry plants. The number of flowers was counted at the time of blooming and the value was denoted as the number of flowers per plant.

(3) Days taken Initial of fruit set:

When the petals of dried flowers collapsed and the achenes on the fleshy receptacle began to grow, the number of days it took to reach the first stage of fruit set was noted.

(4) Fruits per plant (number):

The total number of fruits in each harvest was used to calculate the number of fruits a plant has, and the results were expressed as the number of fruits per plant.

(5) Days taken to first harvesting:

After full colour development, strawberry fruits were ready for harvest. The total days were counted from the date of transplanting to the fruit harvest. Strawberry fruits differ from other fruits in that their colour changes from green to red as they mature. Harvesting was done when three-quarters of the skin had become a bright red hue.

(6) No. of picking:

The number of picks from three randomly selected plants was recorded, as was the total number of fruit picked during the fruiting period.

(7) Fruit length (cm):

A digital verniercalliper was used to measure the length of mature fruit from each treatment. In centimeters, the average length was measured.

(8) Fruit width (cm):

With the use of a digital calliper, mature measurements were taken of the fruits from each treatment for diameter. In centimeters, the average diameter was computed.

(9) Fruit volume (cc):

To calculate the fruit volume, a measuring cylinder was filled completely with water, then the fruits were dipped in the cylinder and the amount of water displaced was calculated, which approximated the fruit volume.

(10) Fruit weight per berry (g):

Three fruits per plant per treatment were selected from each replication and weighed separately on an electronic weighing machine, with the average fruit weight calculated and expressed in grammes.

(11) Fruit weight per plant (g):

Each plant's harvest was recorded, and the average weight of the fruits per plant was calculated and represented in grammes.

(C) Quality Parameters:

Sugars (%)

The lane and Eynon (1984) copper titration method was used to determine reducing sugars and total sugars, as described below.

Reagents

1. Solution (A) by Fehling, The volume was increased by 1000 ML, and what man's paper no. 4 was filtered after that. The volume was accumulated from copper sulphate, 69.28 g, dissolved in water. A volume of 69.28 g of copper sulphate dissolved in water was used to create the volume. Copper sulphate (69.28 g) was used.

2. By dissolving Rchella salt and 100 g NaOH in 1000 ML water, Fehling's solution (B) yielded 346 g.

3. In 100 ML of water, 1 g of methylene blue was dissolved as an indicator.

4. Lead acetate was dissolved in 250 g of neutral in water, and the volume was increased to 500 ML to form a 45 percent cerebral lead acetate solution.

5. 22 percent potassium oxalate solution In a total volume of 500 ML, 110 g potassium oxalate was dissolved in water.

6. Standard invert sugar solution: 100 ML water and 5 ML concentrated HCL were added to 9.5 g of AR Sucrose in a 1 litter volumetric flask and left to rest for three days at 20-25o C before volume was built up to 1 litter with water. Pipette 25 ML of the standard inversion into a 100 ML volumetric flask, filter, and add 50 ML water. A few drops of phenolphthalein indicator were added and neutralized with 20 percent NaOH until the solution turned pink. To acidify the solution, 1 N HCL was added drop by drop until the pink color disappeared. Then, to produce a mark, it was combined with water (1ML=2.5mg invert sugar).

Standardization of Fehling’s solution

In a 250 mL conical flask, 5 ML of each Fehling's solution were added to 25 ML of water. A 50-ml burette was filled with a sugar invert solution that had been prepared ahead of time. In a conical flask, Fehling's solution is kept. A regular invert sugar solution of 10 ML was added. The mixture was heated in a conical flask and boiled for 2-3 minutes on low heat before the sugar solution was inverted and immediately added to the flask with the help of the burette, turning the solution colour of the conical flask vivid blue. The titration was completed in 2-3 minutes. By adding 2 to 3 drops of methylene blue indicator to the flask, the titration was completed in 2-3 minutes, and by adding more sugar solution to the flask, the titration was completed in 2 to 3 minutes. A brick red precipitate formed at this location. at the end of the process.

$$\text{Factor for Fehling's solution (g of invert sugar)} = \frac{\text{Titre (Burette Reading) x 2.5}}{1000}$$

(1) Reducing sugar (%)

10 mL of filtered juice was blended with 2 mL of lead acetate in a conical flask. It was given a brisk shake and left aside for 10 minutes before adding 2 ML of potassium oxalate. By adding distilled water, the capacity was increased to 100 ML. After the solution was filtered through manila paper No. 4, the filtrate was collected in a conical flask. 5 ML of Fehling's solutions A and B were mixed with 25 ML of distilled water in a conical flask. On an electric heater, this was kept boiling, and then 2-3 drops of methyl blue indicator were added. The Fehlings' solution can also be titrated with filtered fruit juice. The final point, as well as the appearance of a brick red color, was chosen. To calculate sugar reduction, use the formula below.

$$\text{\% reducing sugar} = \frac{\text{mg of invert sugar x Dilution x 100}}{\text{Titre x Water volume of the sample x 100}}$$

(2) Total sugar (%)

To hydrolyze molecules, 2 ML concentrated HCL was applied to 10 ML juice. It had been left unattended for a period of 24 hours. After that, it was diluted with a 40 percent NaOH solution. To guarantee complete neutralization, blue and red litmus paper was utilized. This solution was then titrated against Fehling's A and B as a decreasing sugar titration, and the overall sugar percentage was calculated.

Total sugar as invert sugar = Calculated in percentages Using the titer value acquired during total sugar determination after inversion to reduce sugar

% non-reducing sugar = (% Total invert sugar - % reducing sugar original present) x 0.95

% Total Sugar = (% Reducing sugar + % non-reducing sugar)

*(10 ML of Fehling solution = 0.05 g of sugar)

(3) Non-reducing sugar (%)

By removing the sugar from the total sugar and multiplying by the minimum, the total sugar is lowered. The influence of non-reducible sugar was found to be significant (0.95). There was a specified amount of non-reducing sugar stated in g/100 g of juice in the calculations.

(4) Total Soluble Solids (^{o}Brix)

A hand refractometer was used to measure total soluble solids (TSS). Each treatment's fully ripe fruits were obtained, and a few splashes of fruit juice were taken and discarded on the refractometer's prism base by a clean glass rod. It was then viewed through aneue-place with the projection in front of a light source, and a point was recorded where the shaded area's border line intersected the scale's area.

(5) Specific gravity of fruits:

The fruits' specific gravity was calculated by dividing their weight by their volume.

(6) Acidity:

The titrable acidity of the juice is assessed by comparing it to a standard alkali solution (0.1N NaOH). Distilled water was placed in a volumetric flask to create the volume.The juice was diluted in a 250 ml beaker with a 100 ml part of the pipette.

The fluid was spiked with 1-2 drops of phenolphthalein indicator. A 0.1N NaOH solution was used to titrate the juice from the conical flask. Drop by drop, the alkali was added into the conical flask using a funnel, continual swirling till the end stop was achieved and the pink colour disappeared. The following formula was used to compute the acidity percentage:

$$\% \text{ of acidity} = \frac{\text{Titre volume x 0.1 x 64 x 10}}{\text{Aliquot x 10}}$$

Benefit: cost ratio

The cost of production for each treatment was calculated using the current cost of input used in crop cultivation and the market price of the product. The net realisation was obtained by subtracting the cost of production per hectare from the gross realization. The cost of production per hectare was divided by the net realisation per hectare to determine the economic impact of the treatment.

Net income/ha = Gross return/ha – Total cost/ha

Statistical analysis:

The data collected for various vegetative, flowering, fruiting, yield, and quality characteristics during the years 2018–19 and 20–20 of the experiment were statistically analysed as per the method described. The significance of the difference was tested through variance ratio and the significance of the difference between any two means was also assessed. At a 5% level of significance, the critical difference (C.D.), which was calculated using the formula: The standard error (S.E.M) for the difference in treatment mean was computed as follows?

$$\text{S.E.M} \pm = \frac{\sqrt{MSEr}}{r}$$

Where,

MSE= Mean sum of square due to error

R = replication

CRITICAL DIFFERENCE:

C.D. (0.05) = S.E. (d) x t (5% at error d. f.)

Where,

C.D. (0.05) = Critical difference at 5 percent level of significance

CHAPTER-4
EXPERIMENTAL FINDINGS

CHAPTER-4

EXPERIMENTAL FINDING

The present investigation entitled **"Effect of plant growth regulators and mulches on growth, yield and quality of strawberry (*Fragaria x ananassa* Duch.) cv. Chandler"** was carried out at Horticulture Research Farm-1, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow (U.P.) during 2018-19 and 2019-20 respectively. In this chapter, the observations recorded during the period of experiment are systematically arranged and are being discussed in detailed after their statistical analysis.

The findings of the present investigation were:

(A) Growth parameters

(B) Yield Parameters

(P) Physico – Chemicals (Quality) Parameters

4.1 Characteristics of Plant Growth:

4.1.1 Plant height (cm):

From 30 days to 90 days after planting, data on plant height was recorded at 30-day intervals. The data illustrated in Table 4.1 and Fig. 4.1.1 clearly indicated a significant difference between the various combinations with respect to height of plant in strawberry cv. Chandler during 2018–19 and 2019–20. During the period 2018–19, the height of the plant varies from 6.83cm to 24.00cm at 90 days after planting, whereas the highest plant height was observed at 30 days after planting under the treatment T_3 (GA_3 75ppm + Black polythene), followed by the treatment T_2 (GA_3 50ppm + Black polythene) and the maximum plant height (24.00cm) was measured 90 days after planting. T3 treatment (75ppm GA_3 + black polythene).Among the plant heights of the rest of the treatments, the shortest plants (15.11cm) were noticed in T_1 (control).

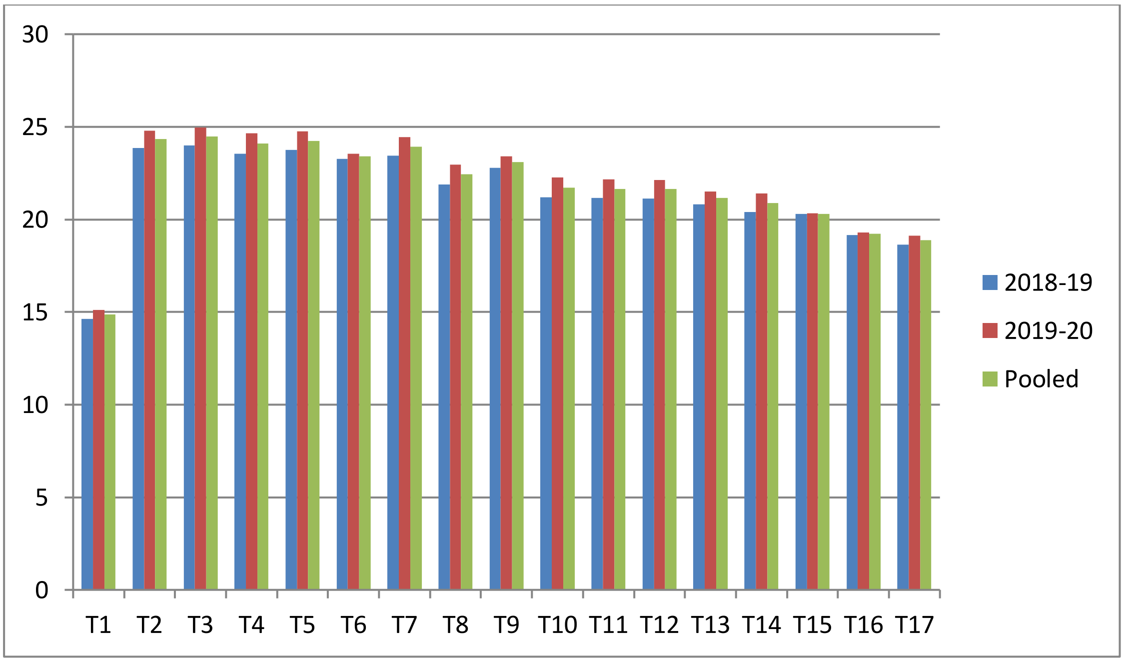
The height of plants ranged from 7.50 cm to 24.96 cm during the period 2019–20. The maximum plant height at 30 days after planting (7.50cm) was observed in treatment T_3 (GA_3 75ppm + Black polythene) followed by treatment T_2 (GA_3 50ppm + Black polythene). The maximum plant height (24.96cm) was observed in the plots which were treated with T_3 (GA_3 75ppm + Black polythene) followed by T_2 (GA_3 50ppm + Black polythene). From the observations made during both years, it was noted that treatment T_3 (GA_3 75ppm + Black polythene) produced the tallest plant.

The maximum pooled value of plant height was observed in treatment T_3 (GA_3 75ppm + Black polyethylene) at 30 days after planting, followed by treatment T_2 (GA_3 50ppm + Black polythene) and the lowest value in treatment T_1 (Control). However, 90 days after planting, the maximum plant height (24.48cm) was observed in treatment T_3 (GA_3 75ppm + Black polythene), followed by T_2 (GA_3 50ppm + Black polythene), with 24.33cm, and the lowest value was obtained in treatment T_1 (Control).

Table-4.1: Effect of plant growth regulators and mulches on plant height (cm) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	14.63	15.11	14.87
T_2(GA_3 50ppm + Black polyethylene)	23.86	24.80	24.33
T_3(GA_3 75ppm + Black polyethylene)	24.00	24.96	24.48
T_4(GA_3 50ppm + Transparent polyethylene)	23.56	24.66	24.11
T_5(GA_3 75ppm + Transparent polyethylene)	23.75	24.74	24.24
T_6(GA_3 50ppm + Paddy straw)	23.26	23.56	23.41
T_7(GA_3 75ppm + Paddy straw)	23.43	24.46	23.94
T_8(GA_3 50ppm + Rice husk)	21.90	22.96	22.43
T_9(GA_3 75ppm + Rice husk)	22.80	23.40	23.10
T_{10}(NAA 20ppm +Black polyethylene)	21.20	22.26	21.73
T_{11}(NAA 40ppm +Black polyethylene)	21.16	22.16	21.66
T_{12}(NAA 20ppm + Transparent polyethylene)	21.13	22.13	21.63
T_{13}(NAA 40ppm + Transparent polyethylene)	20.80	21.50	21.15
T_{14}(NAA 20ppm + Paddy straw)	20.40	21.40	20.90
T_{15}(NAA 40ppm + Paddy straw)	20.30	20.33	20.31
T_{16}(NAA 20ppm + Rice husk)	19.15	19.30	19.22
T_{17}(NAA 40ppm + Rice husk)	18.63	19.11	18.87
CD at (P=0.05)	1.284	1.330	1.307
SEm±	0.444	0.460	0.452

Fig.No.-4.1.1: Effect of plant growth regulators and mulches on plant height (cm) at 90 DAT.



4.1.2 Number of leaves per plant:

The number of leaves observed from 30 days to 90 days after planting. The number of leaves per plant varied from 6.46 to 26.15 during 2018–19 and from 6.93 to 29.95 during 2019–20, as detailed in 4.2 and Fig.4.2.1. In 2018-19, the treatment combination T_3 (GA_3 75ppm + Black polyethylene) produces the most leaves per plant, followed by T_2 (GA_3 50ppm + Black polyethylene).However, treatment T_1 produced the lowest number of leaves per plant (15.09) compared to control.

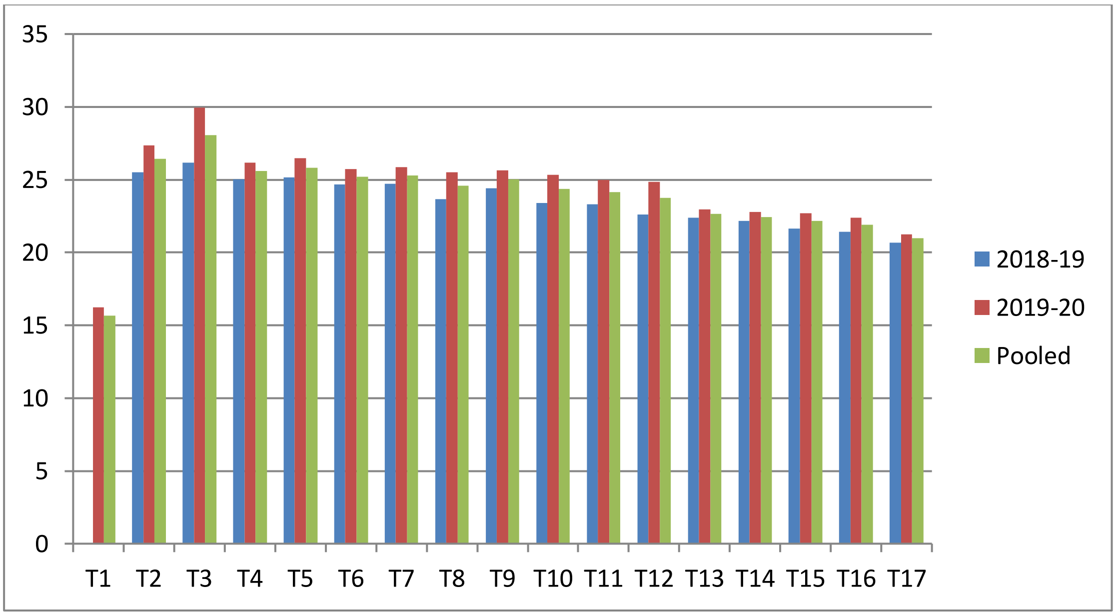
During the period of 2019–20, maximum numbers of leaves per (29.95) were recorded in the plants treated with T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene) and the minimum number of leaves ascertained in the treatment T_1 (Control).

The mean value of both years clearly revealed that the maximum number of leaves (28.05) was observed in treatment T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (26.42), while the lowest number of leaves (15.67) was found in T_1 Control.

Table-4.2: Effect of plant growth regulators and mulches on number of leaves per plant at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	15..09	16.25	15.67
T_2(GA_3 50ppm + Black polyethylene)	25.49	27.36	26.42
T_3(GA_3 75ppm + Black polyethylene)	26.15	29.95	28.05
T_4(GA_3 50ppm + Transparent polyethylene)	25.02	26.17	25.59
T_5(GA_3 75ppm + Transparent polyethylene)	25.16	26.48	25.82
T_6(GA_3 50ppm + Paddy straw)	24.66	25.74	25.20
T_7(GA_3 75ppm + Paddy straw)	24.71	25.84	25.27
T_8(GA_3 50ppm + Rice husk)	23.66	25.50	24.58
T_9(GA_3 75ppm + Rice husk)	24.41	25.65	25.03
T_{10}(NAA 20ppm +Black polyethylene)	23.38	25.33	24.35
T_{11}(NAA 40ppm +Black polyethylene)	23.33	24.98	24.15
T_{12}(NAA 20ppm + Transparent polyethylene)	22.61	24.85	23.73
T_{13}(NAA 40ppm + Transparent polyethylene)	22.37	22.96	22.66
T_{14}(NAA 20ppm + Paddy straw)	22.15	22.76	22.45
T_{15}(NAA 40ppm + Paddy straw)	21.66	22.70	22.18
T_{16}(NAA 20ppm + Rice husk)	21.42	22.38	21.9
T_{17}(NAA 40ppm + Rice husk)	20.66	21.26	20.96
CD at (P=0.05)	1.648	1.799	1.723
SEm±	0.569	0.622	0.595

Fig.No-4.2.1: Effect of plant growth regulators and mulches on number of leaves per plant at 90 DAT.



4.1.3 Length of leaves (cm)

The detailed analysis of leaf length is done at 30 day intervals from 30 to 90 days of planting and finds out the relevant data, which is shown below. The data on leaf length clearly demonstrated in Table 4.3 with Fig. no. 4.3.1 that there was a significant difference between the various treatments during the years 2018-19.Table 4.3 leaf length ranged from 4.43cm to 9.20cm, with T_3 (GA_3 75ppm + Black polyethylene) having the longest, followed by T_2 (GA_3 50ppm + Black polyethylene).In the years 2019–20, the leaf length varies between 4.73cm and 9.70cm. The lowest leaf length (6.33cm) was assessed at 90 days after planting in treatment T_1 Control.

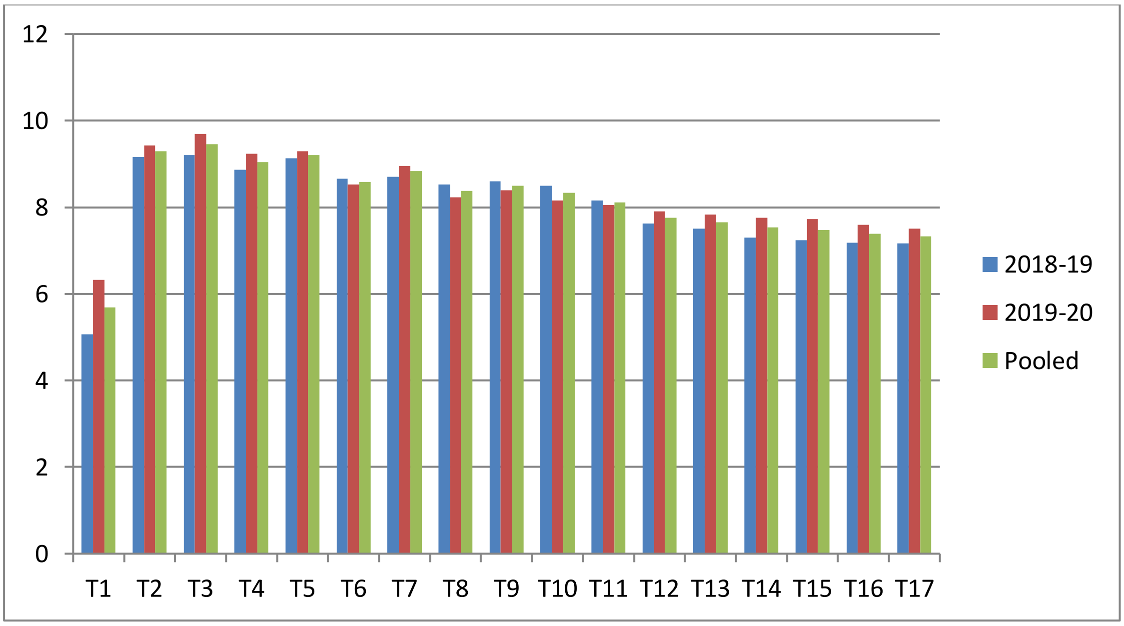
The plants having a maximum leaf length of 9.70cm were grown in the plots which were treated with T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (GA_3 50ppm + Black polyethylene) 9.43cm at 90 days after planting in the year 2019-20. The minimum leaf length of 6.33cm was noted under the control.

The mean value of both years' maximum leaf length was discovered, which clearly exhibited treatment T_3 followed by T_2 (GA_3 50ppm + Black polyethylene), and the minimum leaf length was observed under the control.

Table-4.3: Effect of plant growth regulators and mulches on length of leaves (cm) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	5.06	6.33	5.69
T_2(GA_3 50ppm + Black polyethylene)	9.16	9.43	9.29
T_3(GA_3 75ppm + Black polyethylene)	9.20	9.70	9.45
T_4(GA_3 50ppm + Transparent polyethylene)	8.86	9.23	9.04
T_5(GA_3 75ppm + Transparent polyethylene)	9.13	9.30	9.21
T_6(GA_3 50ppm + Paddy straw)	8.66	8.53	8.59
T_7(GA_3 75ppm + Paddy straw)	8.70	8.96	8.83
T_8(GA_3 50ppm + Rice husk)	8.53	8.23	8.38
T_9(GA_3 75ppm + Rice husk)	8.60	8.40	8.50
T_{10}(NAA 20ppm +Black polyethylene)	8.50	8.16	8.33
T_{11}(NAA 40ppm +Black polyethylene)	8.16	8.06	8.11
T_{12}(NAA 20ppm + Transparent polyethylene)	7.63	7.90	7.76
T_{13}(NAA 40ppm + Transparent polyethylene)	7.50	7.83	7.66
T_{14}(NAA 20ppm + Paddy straw)	7.30	7.76	7.53
T_{15}(NAA 40ppm + Paddy straw)	7.24	7.73	7.48
T_{16}(NAA 20ppm + Rice husk)	7.18	7.60	7.39
T_{17}(NAA 40ppm + Rice husk)	7.16	7.50	7.33
CD at (P=0.05)	0.875	0.406	0.640
SEm±	0.302	0.140	0.221

Fig.No.-4.3.1: Effect of plant growth regulators and mulches on length of leaves (cm) at 90 DAT.



4.1.4: Length of petiole (cm)

The length of the petiole was measured at 30 day intervals from 30 to 90 days after planting to calculate the effective data that influenced plant growth. The data in Table 4.4, together with Fig.No.-4.4.1, showed significant differences in petiole length between both the GA_3, NAA, and various mulches in combination with treatments during 2018–19 and 2019–20.

During the period of 2018–19, the length of the petiole varied from 3.83cm to 11.83cm at 30 days to 90 days of planting. The maximum value (5.80cm) was found under the treatment T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (5.76cm), while the minimum length of petiole (3.83cm) was noticed in the plots treated under control at 30 days of planting. The highest value noted under the treatment T_3 (GA_3 75ppm + Black polyethylene) was 11.83 cm, followed by T_2 (11.50 cm), while the minimum length of petiole (7.10 cm) was noticed in the plots treated under control.

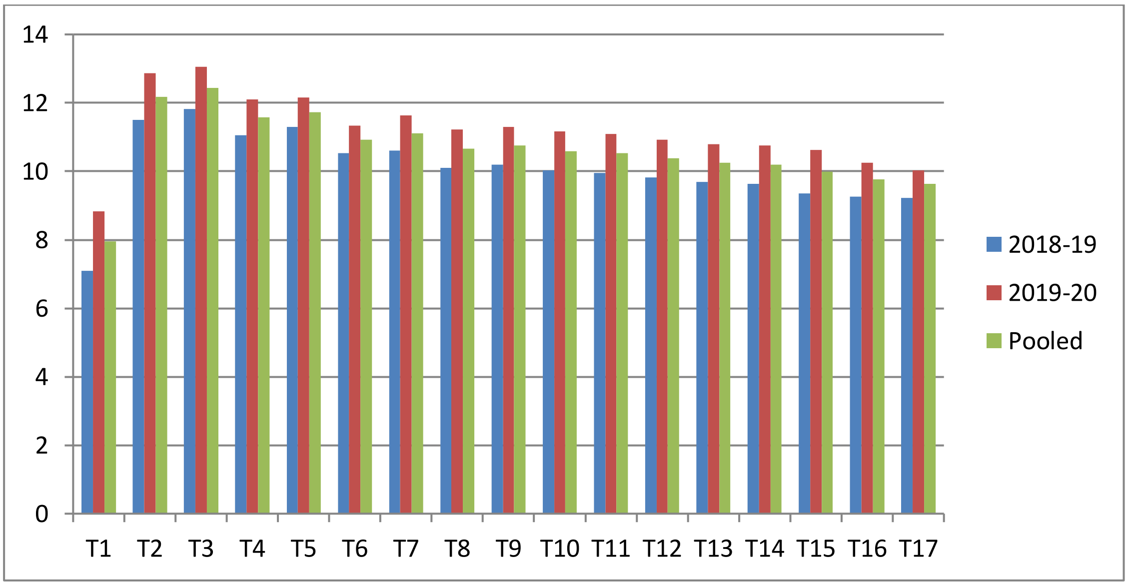
The length of the petiole ranged from 3.46 cm to 13.06 cm during 2019–20. The plants having a maximum length of petiole of 13.06 cm were grown in the plots which were treated with T_3 (GA_3 75ppm + Black polyethylene) followed by (12.86 cm) T_2 (GA_3 50ppm + Black polyethylene) at 90 days of planting. The minimum leaf length was observed at 8.83cm under control.

The average value of both years clearly revealed the significant differences among the various treatments, with the maximum length of petiole in T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (GA_3 50ppm + Black polyethylene). The pooled data pertaining to the length of the petiole shows the minimum length of the petiole was observed in control (no PGR_S and no mulching).

Table-4.4: Effect of plant growth regulators and mulches on length of petiole (cm) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	7.10	8.83	7.96
T_2(GA_3 50ppm + Black polyethylene)	11.50	12.86	12.18
T_3(GA_3 75ppm + Black polyethylene)	11.83	13.06	12.44
T_4(GA_3 50ppm + Transparent polyethylene)	11.06	12.10	11.58
T_5(GA_3 75ppm + Transparent polyethylene)	11.30	12.16	11.73
T_6(GA_3 50ppm + Paddy straw)	10.53	11.33	10.93
T_7(GA_3 75ppm + Paddy straw)	10.60	11.63	11.11
T_8(GA_3 50ppm + Rice husk)	10.10	11.22	10.66
T_9(GA_3 75ppm + Rice husk)	10.20	11.30	10.75
T_{10}(NAA 20ppm +Black polyethylene)	10.03	11.16	10.59
T_{11}(NAA 40ppm +Black polyethylene)	9.96	11.10	10.53
T_{12}(NAA 20ppm + Transparent polyethylene)	9.83	10.93	10.38
T_{13}(NAA 40ppm + Transparent polyethylene)	9.70	10.80	10.25
T_{14}(NAA 20ppm + Paddy straw)	9.63	10.76	10.19
T_{15}(NAA 40ppm + Paddy straw)	9.36	10.63	9.99
T_{16}(NAA 20ppm + Rice husk)	9.26	10.26	9.76
T_{17}(NAA 40ppm + Rice husk)	9.23	10.03	9.63
CD at (P=0.05)	1.049	1.006	1.027
SEm±	0.363	0.348	0.355

Fig.No.-4.4.1: Effect of plant growth regulators and mulches on length of petiole (cm) at 90 DAT.



4.1.5: Length of leaves with petiole (cm)

From 30 days to 90 days after planting, the length of the leaves with petiole was measured at 30-day intervals. The length of the leaves with petiole varied from 6.06cm to 21.03cm during 2018–19 and 5.82cm to 22.76cm during 2019–20, as elaborated in 4.5 and Fig.4.5.1. In 2018-19, the treatment combination T3 (GA3 75ppm + Black polyethylene) produces the longest leaves with petiole, followed by T2 (GA3 50ppm + Black polyethylene).However, the minimum length of leaves with petioles of 12.16cm was recorded at 90 days under the treatment T_1 (Control).

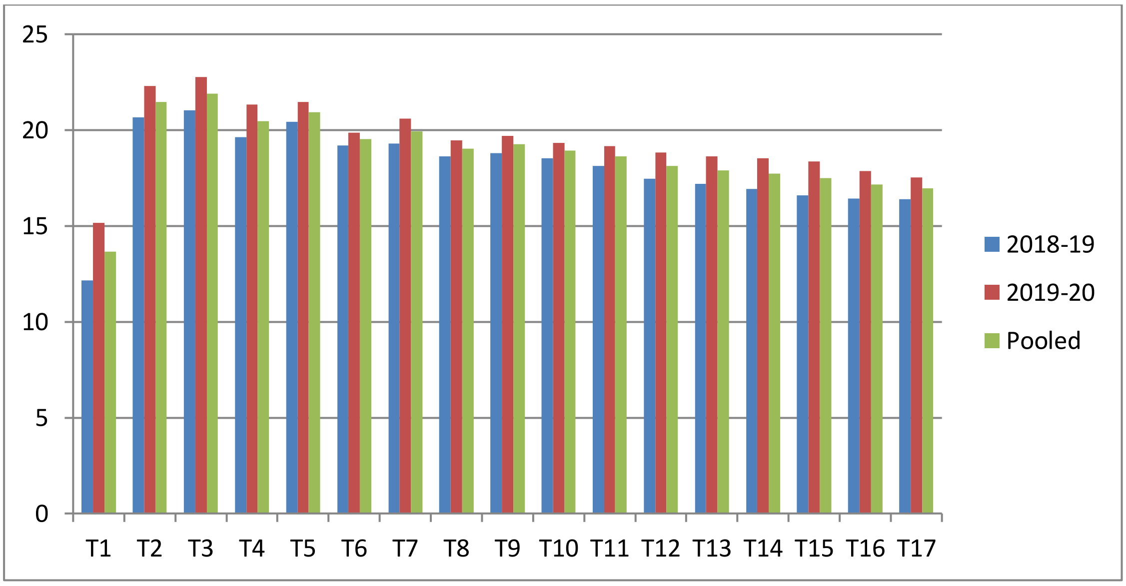
During the period of 2019–20, the maximum length of leaves with petiole (22.76cm) was recorded in the plants treated with T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene) and the minimum length of leaves with petiole was ascertained in the treatment T_1 (Control).

The mean value of both years clearly revealed that the maximum length of leaves with petiole (21.89cm) was observed in treatment T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (21.47cm), while the minimum length of leaves with petiole (13.66cm) was found in T_1 Control.

Table-4.5: Effect of plant growth regulators and mulches on length of leaves with petiole (cm) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	12.16	15.16	13.66
T_2(GA_3 50ppm + Black polyethylene)	20.66	22.29	21.47
T_3(GA_3 75ppm + Black polyethylene)	21.03	22.76	21.89
T_4(GA_3 50ppm + Transparent polyethylene)	19.62	21.33	20.47
T_5(GA_3 75ppm + Transparent polyethylene)	20.43	21.46	20.94
T_6(GA_3 50ppm + Paddy straw)	19.19	19.86	19.52
T_7(GA_3 75ppm + Paddy straw)	19.30	20.59	19.94
T_8(GA_3 50ppm + Rice husk)	18.63	19.45	19.04
T_9(GA_3 75ppm + Rice husk)	18.80	19.70	19.25
T_{10}(NAA 20ppm +Black polyethylene)	18.53	19.32	18.92
T_{11}(NAA 40ppm +Black polyethylene)	18.12	19.16	18.64
T_{12}(NAA 20ppm + Transparent polyethylene)	17.46	18.83	18.14
T_{13}(NAA 40ppm + Transparent polyethylene)	17.20	18.63	17.91
T_{14}(NAA 20ppm + Paddy straw)	16.93	18.52	17.72
T_{15}(NAA 40ppm + Paddy straw)	16.60	18.36	17.48
T_{16}(NAA 20ppm + Rice husk)	16.44	17.86	17.15
T_{17}(NAA 40ppm + Rice husk)	16.39	17.53	16.96
CD at (P=0.05)	1.527	0.985	1.256
SEm±	0.528	0.340	0.434

Fig.No.-4.5.1 Effect of plant growth regulators and mulches on length of leaves with petiole (cm) at 90 DAT.



4.1.6: Plant spread (cm)

From 30 days to 90 days after planting, data on plant spread was obtained at 30-day intervals. Table No. 4.6, 4.7 with Fig. No. 4.6.1, 4.7 representing the effect of PGRs, with a combination of various mulches, influenced the spread of plants significantly in strawberry cv. Chandler during two consecutive years of experimentation (2018-19 and 2019-20). During 2018-19, it varied from 6.08cm to 30.02cm. The maximum plant spread (10.43cm) under treatment T_3 (GA_3 75ppm + Black polyethylene) at 30 days after planting was followed by T_2 (GA_3 50ppm + Black polyethylene) in the N-S direction. The maximum value was found at 90 days after planting (30.02cm) in the treatment T_3 (GA_3 75ppm + Black polyethylene) and statistically at T_5 (GA_3 75ppm + Transparent polyethylene).

In the year 2019–20, the minimum observation found in the N-S direction was 30 days in (6.15cm) in the treatment T_1 (Control) and the maximum value (10.59cm) was observed in treatment T_3 (GA_3 75ppm + Black polyethylene). At 90 days after planting, the higher value was ascertained in the treatment T_3 (GA_3 75ppm + Black polyethylene) and the minimum value was noted in the treatment T_1 Control.

In pooled data, the highest value (30.12cm) was assessed in the treatment T_3 (GA_3 75ppm + Black polyethylene) and the lowest data was observed in the treatment T_1 Control.

At 30 days after planting in 2018-19, the minimum spread (5.12cm) was observed in treatment T_1 (Control) with no PGRs and no mulching, and the maximum value (9.93cm) was observed in treatment T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene).The maximum spread (29.70cm) was assessed in the treatment T_3 (GA_3 75ppm + Black polyethylene). The minimum plant spreading (21.06cm) was noticed in the control at 90 days after planting.

The spread of the plants ranged from 5.22 cm to 30.23 cm during 2019–20. The plants having a maximum spread of (30.23cm) were grown in the plots which were treated with T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (GA_3 50ppm + Black polyethylene) at 29.79cm.

The mean value of both years' maximum plant spread was clearly illustrated in treatment T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (GA_3 50ppm + Black polyethylene), whereas the minimum plant spread was achieved in T_1 (Control).

Table-4.6: Effect of plant growth regulators and mulches on plant spread N-S (cm) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	21.43	21.90	21.65
T_2(GA_3 50ppm + Black polyethylene)	29.73	29.79	29.76
T_3(GA_3 75ppm + Black polyethylene)	30.02	30.23	30.12
T_4(GA_3 50ppm + Transparent polyethylene)	28.11	28.40	28.25
T_5(GA_3 75ppm + Transparent polyethylene)	29.14	29.16	29.15
T_6(GA_3 50ppm + Paddy straw)	27.20	27.40	27.30
T_7(GA_3 75ppm + Paddy straw)	27.83	28.10	27.96
T_8(GA_3 50ppm + Rice husk)	26.56	26.73	26.64
T_9(GA_3 75ppm + Rice husk)	27.10	27.16	27.13
T_{10}(NAA 20ppm +Black polyethylene)	25.30	25.86	25.58
T_{11}(NAA 40ppm +Black polyethylene)	25.16	25.63	25.39
T_{12}(NAA 20ppm + Transparent polyethylene)	25.10	25.26	25.18
T_{13}(NAA 40ppm + Transparent polyethylene)	25.07	25.23	25.15
T_{14}(NAA 20ppm + Paddy straw)	24.87	25.16	25.01
T_{15}(NAA 40ppm + Paddy straw)	24.53	25.03	24.78
T_{16}(NAA 20ppm + Rice husk)	24.35	24.41	24.38
T_{17}(NAA 40ppm + Rice husk)	23.90	24.18	24.04
CD at (P=0.05)	2.609	1.351	1.980
SEm±	0.902	0.590	0.764

Fig.No.-4.6.1: Effect of plant growth regulators and mulches on plant spread N-S (cm) at 90 DAT.

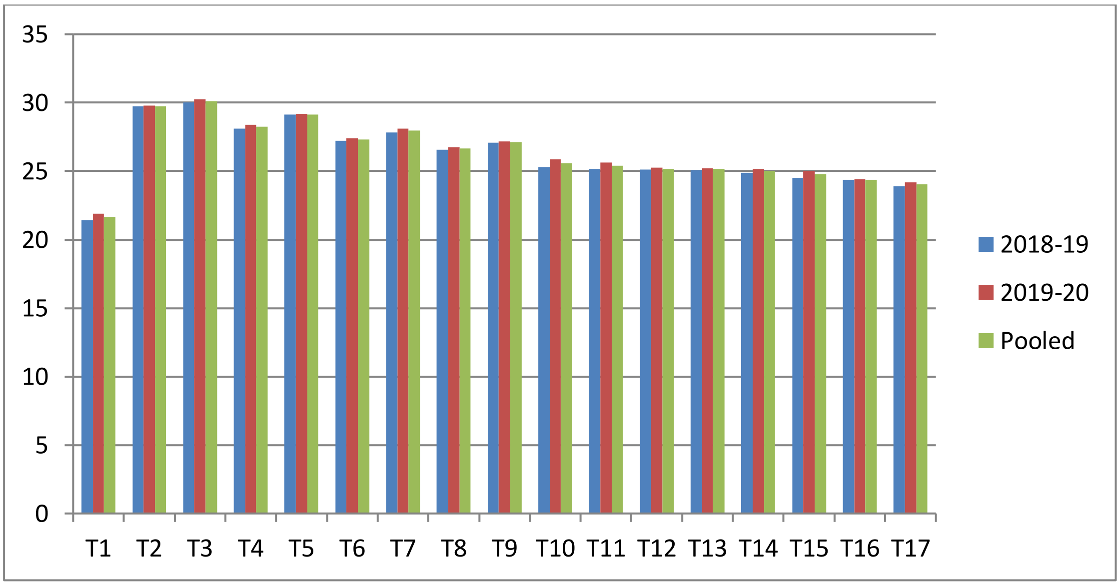
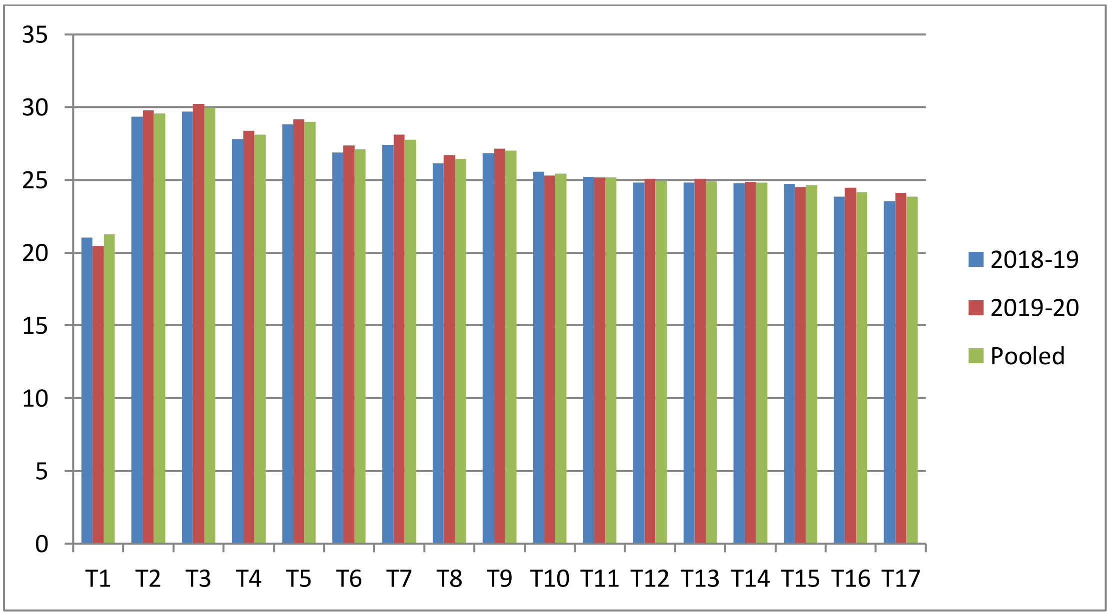


Table-4.7: Effect of plant growth regulators and mulches on plant spread E-W (cm) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	21.06	20.46	21.26
T_2(GA_3 50ppm + Black polyethylene)	29.33	29.79	29.56
T_3(GA_3 75ppm + Black polyethylene)	29.70	30.23	29.96
T_4(GA_3 50ppm + Transparent polyethylene)	27.80	28.40	28.10
T_5(GA_3 75ppm + Transparent polyethylene)	28.80	29.16	28.98
T_6(GA_3 50ppm + Paddy straw)	26.90	27.35	27.12
T_7(GA_3 75ppm + Paddy straw)	27.40	28.10	27.75
T_8(GA_3 50ppm + Rice husk)	26.16	26.73	26.44
T_9(GA_3 75ppm + Rice husk)	26.86	27.14	27.00
T_{10}(NAA 20ppm +Black polyethylene)	25.56	25.30	25.43
T_{11}(NAA 40ppm +Black polyethylene)	25.23	25.16	25.19
T_{12}(NAA 20ppm + Transparent polyethylene)	24.83	25.10	24.96
T_{13}(NAA 40ppm + Transparent polyethylene)	24.80	25.07	24.93
T_{14}(NAA 20ppm + Paddy straw)	24.76	24.87	24.81
T_{15}(NAA 40ppm + Paddy straw)	24.73	24.53	24.63
T_{16}(NAA 20ppm + Rice husk)	23.86	24.46	24.16
T_{17}(NAA 40ppm + Rice husk)	23.56	24.14	23.85
CD at (P=0.05)	1.618	1.351	1.484
SEm±	0.559	0.467	0.513

Fig.No.-4.7.1: Effect of plant growth regulators and mulches on plant spread E-W (cm) at 90 DAT.



4.1.7: Plant fresh weight (g)

The data in table 4.8 shows that this is the case. Fig. no. 4.8.1 shows that various treatments showed significant differences during 2018-19 and 2019-20 at 90 days of planting.

During the first year of 2018–19, the maximum plant fresh weight (177.33g) was recorded in the plants treated with treatment T_3 (GA_3 75ppm + Black polyethylene), followed by (170.00g) treatment T_2 (GA_3 50ppm + Black polyethylene). The minimum plant fresh weight (95.33g) was observed in treatment T_1 (Control).

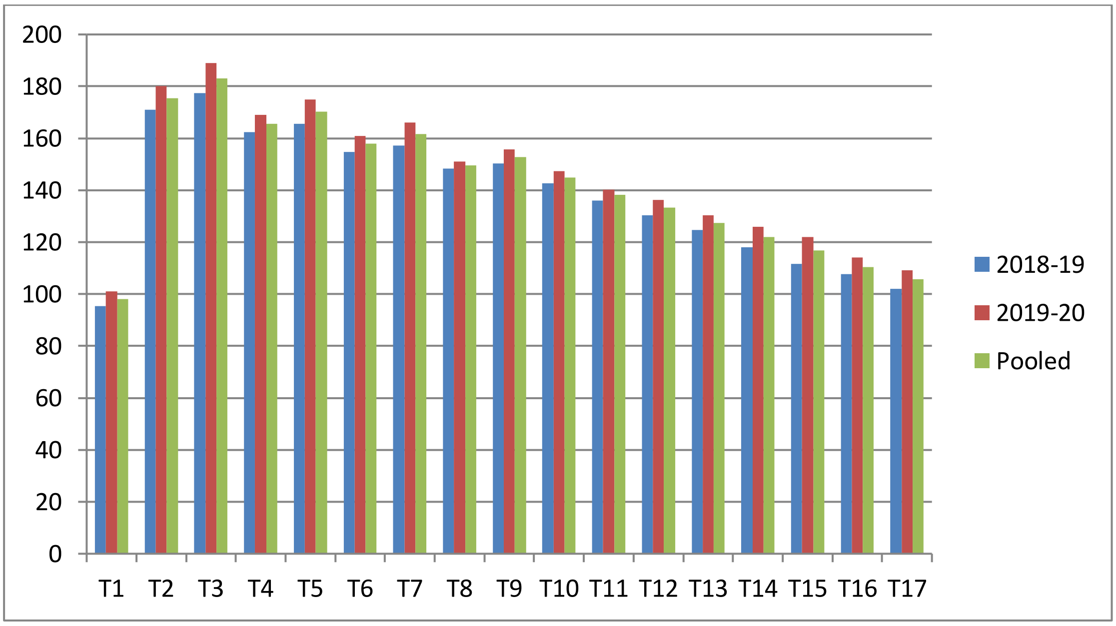
Plant fresh weight varied from 101.00g to 189.00g in the year 2019-20. Treatment T_3 (GA_3 75ppm + Black polyethylene) resulted in the highest plant fresh weight, followed by treatment T_2 (GA_3 50ppm + Black polyethylene).

The pooled data clearly shows that the maximum plant fresh weight (183.16g) was found in T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (GA_3 50ppm + Black polyethylene), whereas the lowest plant fresh weight of 98.16g was recorded under the treatment control.

Table-4.8: Effect of plant growth regulators and mulches on plant fresh weight (g) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	95.33	101.00	98.16
T_2(GA_3 50ppm + Black polyethylene)	171.00	180.00	175.50
T_3(GA_3 75ppm + Black polyethylene)	177.33	189.00	183.16
T_4(GA_3 50ppm + Transparent polyethylene)	162.33	169.00	165.66
T_5(GA_3 75ppm + Transparent polyethylene)	165.66	175.00	170.33
T_6(GA_3 50ppm + Paddy straw)	154.66	161.00	157.83
T_7(GA_3 75ppm + Paddy straw)	157.33	166.00	161.66
T_8(GA_3 50ppm + Rice husk)	148.33	151.00	149.66
T_9(GA_3 75ppm + Rice husk)	150.33	155.66	152.66
T_{10}(NAA 20ppm +Black polyethylene)	142.66	147.33	144.99
T_{11}(NAA 40ppm +Black polyethylene)	136.00	140.33	138.16
T_{12}(NAA 20ppm + Transparent polyethylene)	130.33	136.33	133.33
T_{13}(NAA 40ppm + Transparent polyethylene)	124.66	130.33	127.49
T_{14}(NAA 20ppm + Paddy straw)	118.00	126.00	122.00
T_{15}(NAA 40ppm + Paddy straw)	111.66	122.00	116.83
T_{16}(NAA 20ppm + Rice husk)	107.66	114.00	110.30
T_{17}(NAA 40ppm + Rice husk)	102.00	109.22	105.61
CD at (P=0.05)	14.608	37.868	26.238
SEm±	5.048	13.086	9.067

Fig.No.-4.8.1: Effect of plant growth regulators and mulches on plant fresh weight (g) at 90 DAT.



4.1.8: Plant dry weight (g)

The data reported in Table 4.9 with Fig. No. 4.9.1 shows that various treatments showed significant differences during 2018-19 and 2019-20 at 90 days of planting.

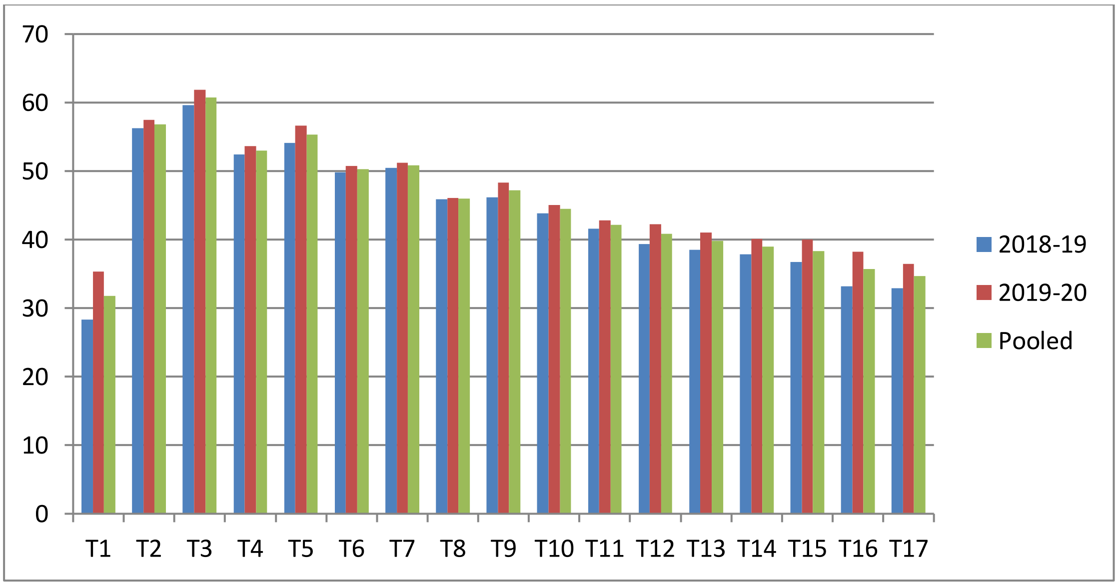
The data influenced plant dry weight during 2018-19, being higher (59.63g) in T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (56.29g) treatment was treated with (GA_3 50ppm + Black polyethylene) and the lowest plant dry weight (28.33g) was recorded under treatment T1 control. T_3 (GA_3 75ppm + Black polyethylene) had the highest plant dry weight (61.89g) in 2019-20, while T_1 (control) had the lowest plant dry weight (35.32g).

The pooled analysis data showed that plant dry weight was found to be the highest to the tune of 60.76g in treatment T_3 (GA_3 75ppm + Black polyethylene) followed by 58.86g in T_2 (GA_3 50ppm + Black polyethylene), whereas the minimum plant dry weight was found at 31.82g in treatment T_1 Control.

Table-4.9: Effect of plant growth regulators and mulches on plant dry weight (g) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	28.33	35.32	31.82
T_2(GA_3 50ppm + Black polyethylene)	56.29	57.44	56.86
T_3(GA_3 75ppm + Black polyethylene)	59.63	61.89	60.76
T_4(GA_3 50ppm + Transparent polyethylene)	52.40	53.62	53.01
T_5(GA_3 75ppm + Transparent polyethylene)	54.11	56.6	55.35
T_6(GA_3 50ppm + Paddy straw)	49.81	50.77	50.29
T_7(GA_3 75ppm + Paddy straw)	50.47	51.20	50.83
T_8(GA_3 50ppm + Rice husk)	45.88	46.08	45.98
T_9(GA_3 75ppm + Rice husk)	46.15	48.28	47.21
T_{10}(NAA 20ppm +Black polyethylene)	43.88	45.04	44.46
T_{11}(NAA 40ppm +Black polyethylene)	41.60	42.77	42.18
T_{12}(NAA 20ppm + Transparent polyethylene)	39.38	42.24	40.81
T_{13}(NAA 40ppm + Transparent polyethylene)	38.51	41.05	39.78
T_{14}(NAA 20ppm + Paddy straw)	37.82	40.14	38.98
T_{15}(NAA 40ppm + Paddy straw)	36.71	39.97	38.34
T_{16}(NAA 20ppm + Rice husk)	33.16	38.25	35.70
T_{17}(NAA 40ppm + Rice husk)	32.93	36.50	34.71
CD at (P=0.05)	7.398	3.351	5.374
SE(d)	2.557	1.158	1.857

Fig.No.-4.9.1: Effect of plant growth regulators and mulches on plant fresh weight (g) at 90 DAT.



4.2: Yield parameters

4.2.1: Days taken to first flower

Data on the first blooming of plants planted under various treatments was recorded and is reported in Table 4.10 and shown in Fig. No. 4.10.1.

During the experimental year (2018–19), the lowest time to first flowering (30.66 days) was recorded under T_{10} (NAA 20ppm + Black polyethylene), followed by (31.00 days) T_{11} (NAA 40ppm + Black polyethylene). Treatment T_1 had the highest number of days till blooming (37.66 days) (Control).

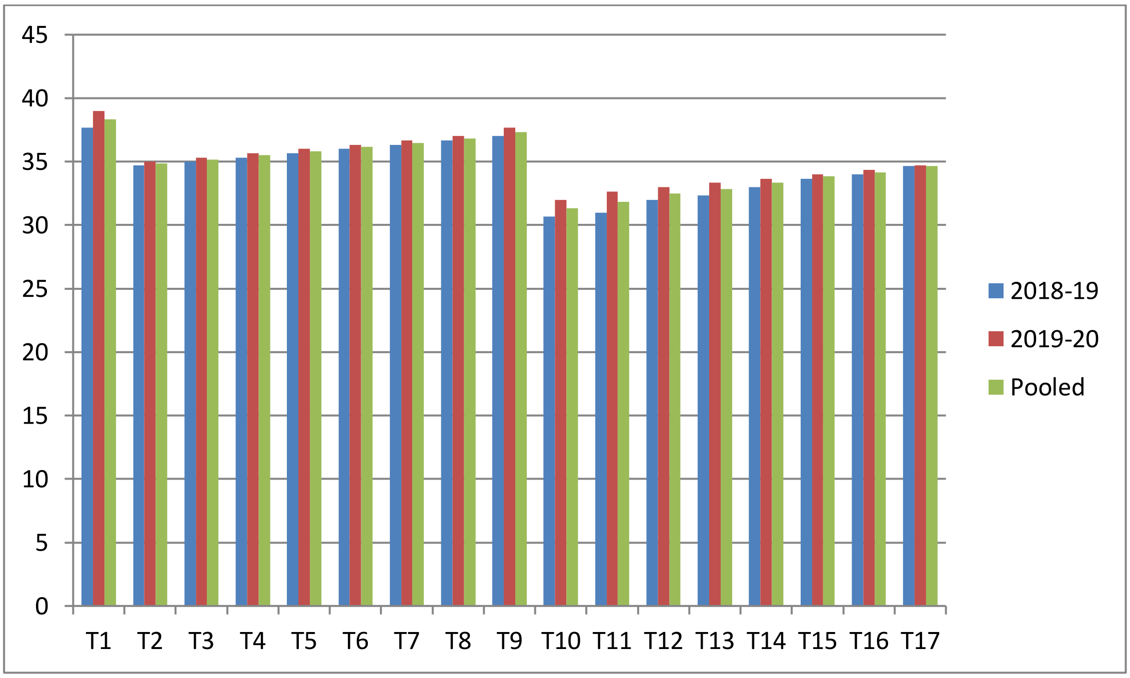
In the following year (2019-20), T_{10} (NAA 20ppm + Black polyethylene) had the fewest days to first flowering (32.0 days), T_{11} (NAA 40ppm + Black polyethylene) had the shortest days to first flowering (32.66 days), and T_1 (NAA 40ppm + Black polyethylene) had the longest days to first flowering (39.00 days) (control).

The pooled analysis of data also revealed that T_{10} (NAA 20ppm + Black polyethylene) had the least time to first flowering (31.33 days), followed by T_{11} (NAA 40ppm + Black polyethylene), whereas T_1 (Control) had the maximum time (38.33 days).

Table-4.10: Effect of plant growth regulators and mulches on days taken to first flower at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	37.66	39.00	38.33
T_2(GA_3 50ppm + Black polyethylene)	34.69	35.00	34.84
T_3(GA_3 75ppm + Black polyethylene)	35.00	35.33	35.16
T_4(GA_3 50ppm + Transparent polyethylene)	35.33	35.66	35.49
T_5(GA_3 75ppm + Transparent polyethylene)	35.66	36.00	35.83
T_6(GA_3 50ppm + Paddy straw)	36.00	36.33	36.16
T_7(GA_3 75ppm + Paddy straw)	36.33	36.66	36.49
T_8(GA_3 50ppm + Rice husk)	36.66	37.00	36.83
T_9(GA_3 75ppm + Rice husk)	37.00	37.66	37.33
T_{10}(NAA 20ppm +Black polyethylene)	30.66	32.00	31.33
T_{11}(NAA 40ppm +Black polyethylene)	31.00	32.66	31.83
T_{12}(NAA 20ppm + Transparent polyethylene)	32.00	33.00	32.5
T_{13}(NAA 40ppm + Transparent polyethylene)	32.33	33.33	32.83
T_{14}(NAA 20ppm + Paddy straw)	33.00	33.66	33.33
T_{15}(NAA 40ppm + Paddy straw)	33.66	34.00	33.83
T_{16}(NAA 20ppm + Rice husk)	34.00	34.33	34.16
T_{17}(NAA 40ppm + Rice husk)	34.66	34.69	34.67
CD at (P=0.05)	1.509	1.352	1.430
SEm±	0.522	0.467	0.494

Fig.No.-4.10.1: Effect of plant growth regulators and mulches on days taken to first flower at 90 DAT.



4.2.2: Number of flowers per plant

Table 4.11 and figure 4.11.1 show the statistics on the number of flowers per plant as a measure of the treatments performed.

During the first year of the train (2018–19), the treatment T_3 (GA_3 75ppm + Black polyethylene) yielded the most flowers per plant (29.00), followed by T_2 (GA_3 50ppm + Black polyethylene). On the other hand, T_1 plants produced the lowest number of flowers per plant (11.00) compared to control.

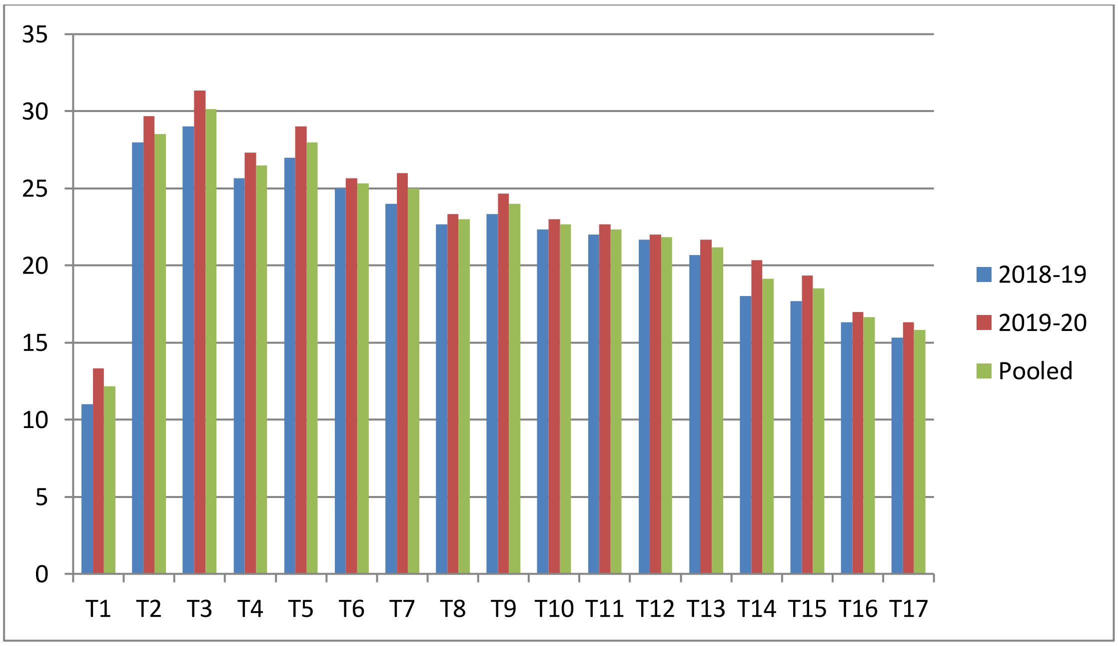
In the second year of the trail (2019–20), the plants from T_3 (GA_3 75ppm + Black polyethylene) recorded the highest number of flowers per plant (31.33), which was statistically similar to T_2 (GA_3 50ppm + Black polyethylene). The treatment T_1 had the lowest number of flowers (13.33) of any control.

The maximum number of flowers per plant (30.16) was found in treatment T_3 (GA_3 75ppm + Black polyethylene), followed by (8.53) in treatment T_2 (GA_3 50ppm + Black polyethylene), and the minimum number of flowers per plant was observed in treatment T_1 (Control).

Table-4.11: Effect of plant growth regulators and mulches on number of flowers per plant at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	11.00	13.33	12.16
T_2(GA_3 50ppm + Black polyethylene)	28.00	29.67	28.53
T_3(GA_3 75ppm + Black polyethylene)	29.00	31.33	30.16
T_4(GA_3 50ppm + Transparent polyethylene)	25.67	27.33	26.50
T_5(GA_3 75ppm + Transparent polyethylene)	27.00	29.00	28.00
T_6(GA_3 50ppm + Paddy straw)	25.00	25.67	25.33
T_7(GA_3 75ppm + Paddy straw)	24.00	26.00	25.00
T_8(GA_3 50ppm + Rice husk)	22.67	23.33	23.00
T_9(GA_3 75ppm + Rice husk)	23.33	24.67	24.00
T_{10}(NAA 20ppm +Black polyethylene)	22.33	23.00	22.66
T_{11}(NAA 40ppm +Black polyethylene)	22.00	22.67	22.33
T_{12}(NAA 20ppm + Transparent polyethylene)	21.67	22.00	21.83
T_{13}(NAA 40ppm + Transparent polyethylene)	20.67	21.67	21.17
T_{14}(NAA 20ppm + Paddy straw)	18.00	20.33	19.16
T_{15}(NAA 40ppm + Paddy straw)	17.67	19.33	18.50
T_{16}(NAA 20ppm + Rice husk)	16.33	17.00	16.66
T_{17}(NAA 40ppm + Rice husk)	15.33	16.33	15.83
CD at (P=0.05)	1.491	1.706	1.598
SEm±	0.515	0.590	0.552

Fig.No-4.11.1: Effect of plant growth regulators and mulches on number of flowers per plant at 90 DAT.



4.2.3: Days taken to 50% flowering

As stated in, the observation was made for the days taken to reach 50% flowering of the strawberry.Table-4.12 with Fig. No. 4.12.1 revealed that there was significant variation from 42.93 days to 48.74 days during 2018-19 and 43.06 days to 49.29 days during 2019-20.

The minimum days taken to 50% during the 2018-19 academic year flowering were recorded under T_{10} (NAA 20ppm + Black polyethylene) (42.93 days), followed by T_{11} (42.96 days) (NAA 40ppm + Black polyethylene). The maximum number of days taken to 50% flowering (48.74 days) in strawberries was obtained from T_1 (Control) with no PGRs and no mulching.

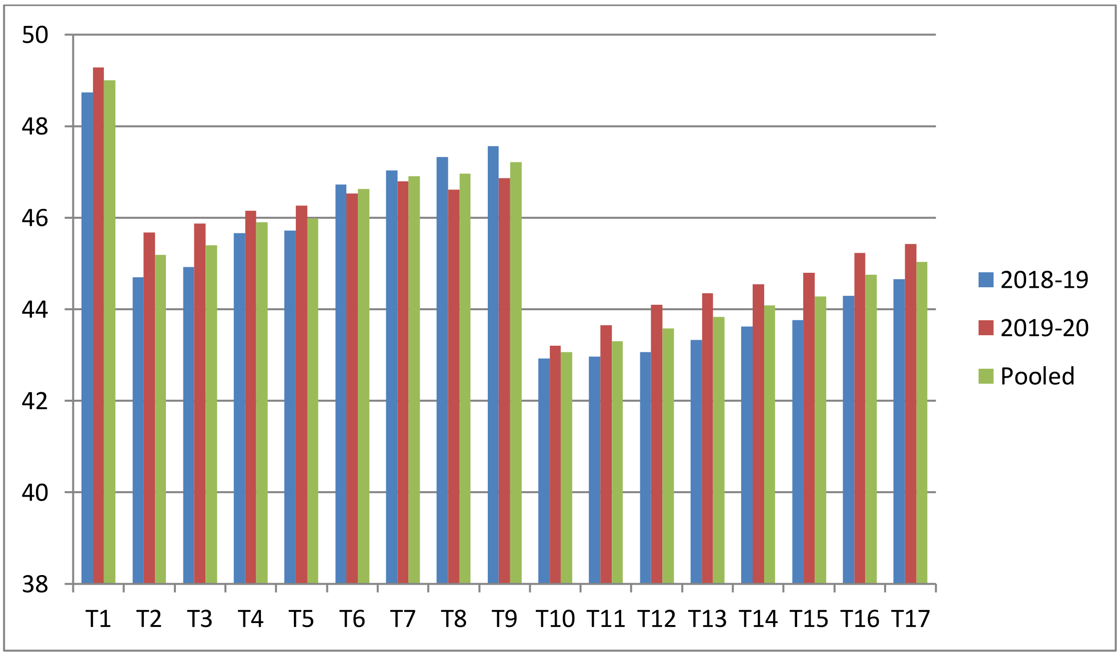
During the second year 2019–20, the minimum number of days it takes to achieve 50% flowering (43.220 days) was recorded under T_{10} (NAA 20ppm + Black polyethylene) and followed by T_{11} (43.65 days) treated with NAA 40ppm + Black polyethylene. The maximum number of days taken to 50% flowering (49.29 days) was recorded from T_1 (Control) with no PGRs and no mulching.

The average value of both years revealed that the days taken to 50% flowering minimum days under T_{10} (NAA 20ppm + Black polyethylene) was followed by T_{11} (NAA 40ppm + Black polyethylene) and the maximum days recorded in T_1 Control.

Table-4.12: Effect of plant growth regulators and mulches on days taken to 50% flowering at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	48.74	49.29	49.01
T_2(GA_3 50ppm + Black polyethylene)	44.70	45.68	45.19
T_3(GA_3 75ppm + Black polyethylene)	44.93	45.87	45.40
T_4(GA_3 50ppm + Transparent polyethylene)	45.66	46.15	45.90
T_5(GA_3 75ppm + Transparent polyethylene)	45.72	46.27	45.99
T_6(GA_3 50ppm + Paddy straw)	46.73	46.53	46.63
T_7(GA_3 75ppm + Paddy straw)	47.03	46.79	46.91
T_8(GA_3 50ppm + Rice husk)	47.33	46.62	46.97
T_9(GA_3 75ppm + Rice husk)	47.56	46.87	47.21
T_{10}(NAA 20ppm +Black polyethylene)	42.93	43.20	43.06
T_{11}(NAA 40ppm +Black polyethylene)	42.96	43.65	43.30
T_{12}(NAA 20ppm + Transparent polyethylene)	43.06	44.10	43.58
T_{13}(NAA 40ppm + Transparent polyethylene)	43.33	44.35	43.84
T_{14}(NAA 20ppm + Paddy straw)	43.63	44.55	44.09
T_{15}(NAA 40ppm + Paddy straw)	43.76	44.80	44.28
T_{16}(NAA 20ppm + Rice husk)	44.30	45.23	44.76
T_{17}(NAA 40ppm + Rice husk)	44.66	45.42	45.04
CD at (P=0.05)	1.601	1.582	1.591
SEm±	0.553	0.547	0.550

Fig.No.-4.12.1: Effect of plant growth regulators and mulches on days taken to 50% flowering at 90 DAT.



4.2.4: Days taken to initial of fruit set

During the experimentation years 2018–19 and 2019–20, the number of days it took for the first fruit set was recorded with flower petals shedding and achenes on freshly received fruit starting to swell in different treatments, and the data was shown in Table 4.13 with Fig. No. 4.13.1.

A closer look at the mean value revealed that the treatments had a significant impact on the time it took to complete the first full set. The fewest days taken to first fruit set (4.16 days) after flowering was reported under T_{10} (NAA 20ppm + Black polyethylene) in the first year of the study (2018–19), which is statistically comparable to T_{11} (NAA 40ppm + Black polyethylene). Under treatment T_1, the maximum number of days to first fruit set (6.30 days) was noted (Control).

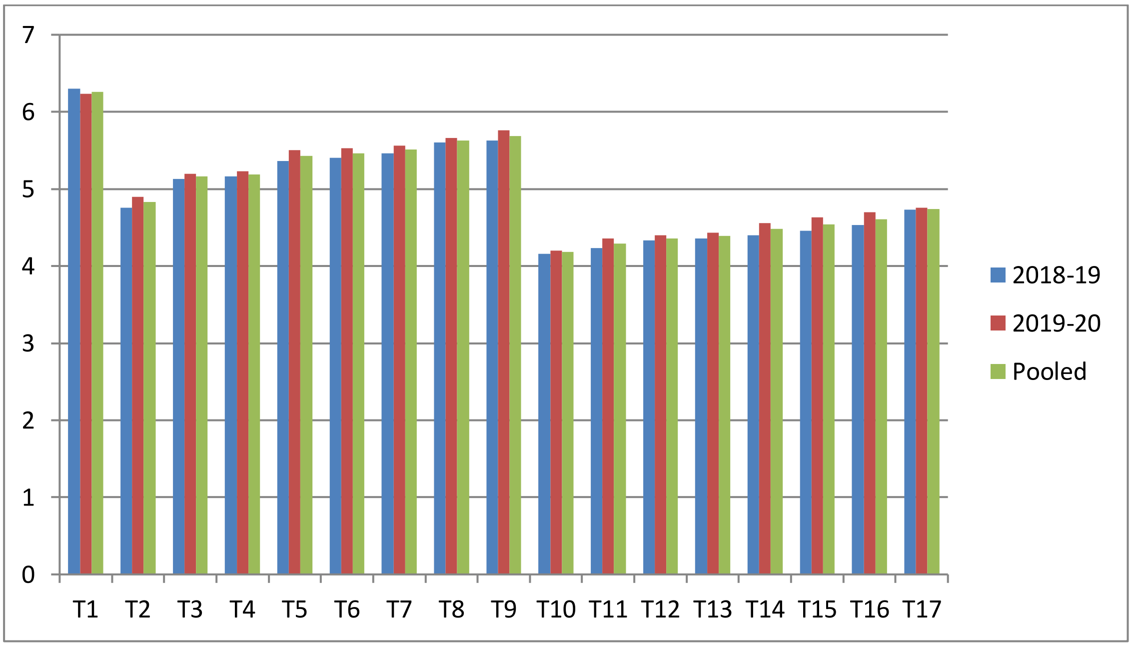
The minimum days to fruit set (4.20 days) was also recorded in the second year 2019–20 under T_{10} (NAA 20ppm + Black polyethylene), which was statistically comparable to T_{11} (NAA 40ppm + Black polyethylene). However, with treatment T_1, the longest time to fruit set (6.23 days) was recorded (Control).

In terms of the pooled data, the shortest time to fruit set (4.18 days) was recorded under T_{10} (NAA 20ppm + Black polyethylene), which was statistically comparable to T_{11} (NAA 40ppm + Black polyethylene) and T_{12} (NAA 20ppm + Transparent polyethylene), and the longest time to fruit set (6.26 days) was recorded under T_1 (NAA 20ppm + Black polyethylene) (Control).

Table-4.13: Effect of plant growth regulators and mulches on Days taken to initial of fruit set at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	6.30	6.23	6.26
T_2(GA_3 50ppm + Black polyethylene)	4.76	4.90	4.83
T_3(GA_3 75ppm + Black polyethylene)	5.13	5.20	5.16
T_4(GA_3 50ppm + Transparent polyethylene)	5.16	5.23	5.19
T_5(GA_3 75ppm + Transparent polyethylene)	5.36	5.50	5.43
T_6(GA_3 50ppm + Paddy straw)	5.40	5.53	5.46
T_7(GA_3 75ppm + Paddy straw)	5.46	5.56	5.51
T_8(GA_3 50ppm + Rice husk)	5.60	5.66	5.63
T_9(GA_3 75ppm + Rice husk)	5.63	5.76	5.69
T_{10}(NAA 20ppm +Black polyethylene)	4.16	4.20	4.18
T_{11}(NAA 40ppm +Black polyethylene)	4.23	4.36	4.29
T_{12}(NAA 20ppm + Transparent polyethylene)	4.33	4.40	4.36
T_{13}(NAA 40ppm + Transparent polyethylene)	4.36	4.43	4.39
T_{14}(NAA 20ppm + Paddy straw)	4.40	4.56	4.48
T_{15}(NAA 40ppm + Paddy straw)	4.46	4.63	4.54
T_{16}(NAA 20ppm + Rice husk)	4.53	4.70	4.61
T_{17}(NAA 40ppm + Rice husk)	4.73	4.76	4.74
CD at (P=0.05)	0.864	0.797	0.830
SEm±	0.298	0.275	0.286

Fig.No.-4.13.1: Effect of plant growth regulators and mulches on Days taken to initial of fruit set at 90 DAT.



4.2.5: Days taken to 50% fruit set

Table-4.14 with Fig. no. 4.14.1 displays data on the number of days required for 50 percent of the fruits to set as a result of various treatments.

T_{10} (NAA 20ppm + Black polyethylene) required the fewest days to achieve 50% fruit set, i.e., 50.75 days, which was statistically comparable to T_{11} (NAA 40ppm + Black polyethylene) and T_{12} (NAA 20ppm + Transparent polyethylene) during the first year (2018-19).Treatment T_1 (Control) took the longest to reach 50% fruit set, at 57.14 days.

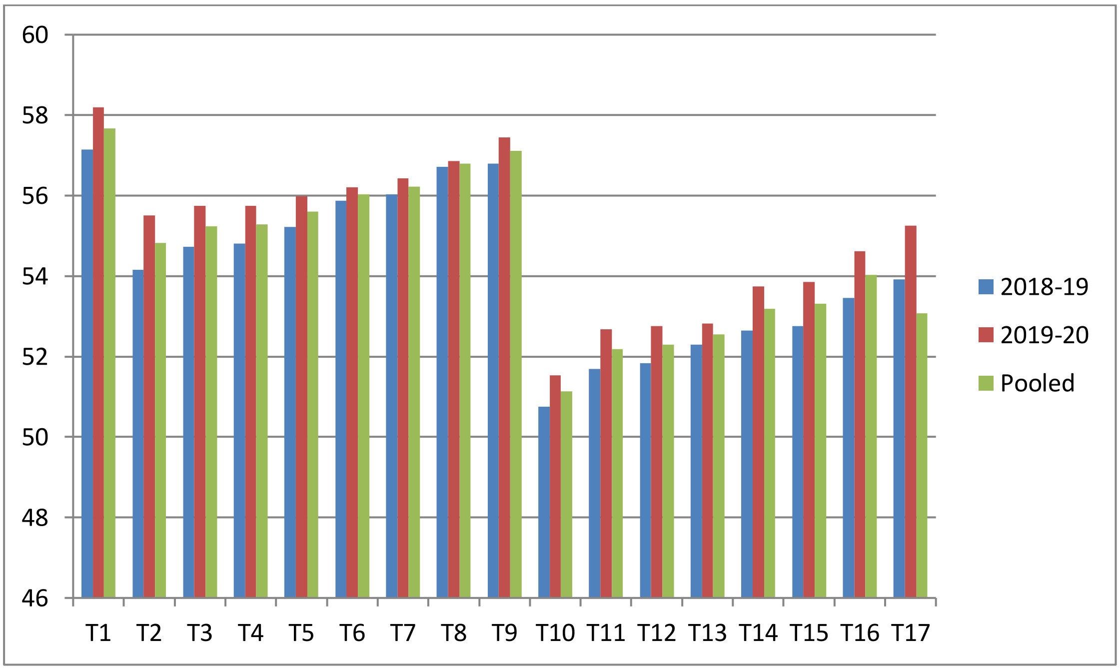
The minimum days to 50% fruit set recorded (51.53 days) in the year (2019-20) was also under T_{10} (NAA 20ppm + Black polyethylene), which was comparable to T_{11} (NAA 40ppm + Black polyethylene), but the maximum days to 50% fruit set recorded (58.20 days) was under T_1 (NAA 40ppm + Black polyethylene) (Control).

T_{10} (NAA 20ppm + Black polyethylene) had the shortest time to 50% fruit set (51.14 days) in the pooled data, which was comparable to T_{11} (NAA 40ppm + Black polyethylene).Under T_1, the longest time it took to reach 50% fruit set was 57.67 days (Control).

Table-4.14: Effect of plant growth regulators and mulches on Days taken to 50% fruit set at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	57.14	58.20	57.67
T_2(GA_3 50ppm + Black polyethylene)	54.15	55.50	54.82
T_3(GA_3 75ppm + Black polyethylene)	54.73	55.75	55.24
T_4(GA_3 50ppm + Transparent polyethylene)	54.81	55.75	55.28
T_5(GA_3 75ppm + Transparent polyethylene)	55.22	55.99	55.60
T_6(GA_3 50ppm + Paddy straw)	55.88	56.21	56.04
T_7(GA_3 75ppm + Paddy straw)	56.03	56.43	56.23
T_8(GA_3 50ppm + Rice husk)	56.72	56.86	56.79
T_9(GA_3 75ppm + Rice husk)	56.80	57.45	57.12
T_{10}(NAA 20ppm +Black polyethylene)	50.75	51.53	51.14
T_{11}(NAA 40ppm +Black polyethylene)	51.69	52.68	52.18
T_{12}(NAA 20ppm + Transparent polyethylene)	51.84	52.76	52.30
T_{13}(NAA 40ppm + Transparent polyethylene)	52.29	52.82	52.55
T_{14}(NAA 20ppm + Paddy straw)	52.65	53.74	53.19
T_{15}(NAA 40ppm + Paddy straw)	52.76	53.86	53.31
T_{16}(NAA 20ppm + Rice husk)	53.46	54.61	54.03
T_{17}(NAA 40ppm + Rice husk)	53.91	55.25	53.08
CD at (P=0.05)	1.520	1.349	1.434
SEm±	0.525	0.466	0.485

Fig.No.-4.14.1: Effect of plant growth regulators and mulches on Days taken to 50% fruit set at 90 DAT.



4.2.6: Number of fruits par plant

The data on the number of fruits per plant, as shown in Table 4.15 with Fig. no. 4.15.1, demonstrated significant differences between treatments in 2018–19, ranging from 8.33 to 24.00 fruits per plant. The plants treated with T_3 (GA_3 75ppm + Black polyethylene) produced the most fruits per plant (24.00), followed by T_2 (GA_3 50ppm + Black polyethylene) (22.66). Under the control, the least number of fruits per plant (8.33) was recorded.

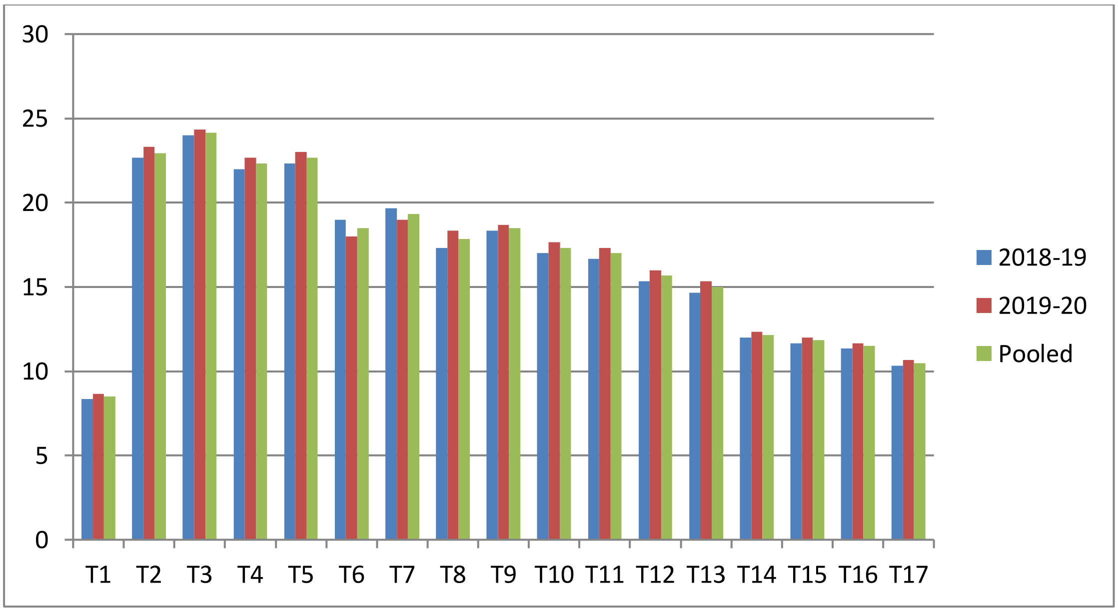
It varied from 8.66 to 24.33 throughout the 2019–20 academic years. Plants treated with T_3 (GA_3 75ppm + Black polyethylene) produced the most fruits per plant (24.33), followed by T_2 (GA_3 50ppm + Black polyethylene). Under T_1, the lowest quantity of fruits per plant (8.66) was found (Control).

The average value of both years clearly illustrated that treatment T_3 (GA_3 75ppm + Black polyethylene) (24.16) had the most fruits, followed by T_2 (GA_3 50ppm + Black polyethylene) (22.95), and T_1 (GA_3 50ppm + Black polyethylene) had the lowest (8.49). There will be no PGRs or mulching.

Table-4.15: Effect of plant growth regulators and mulches on number of fruits par plant at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	8.33	8.66	8.49
T_2(GA_3 50ppm + Black polyethylene)	22.66	23.33	22.95
T_3(GA_3 75ppm + Black polyethylene)	24.00	24.33	24.16
T_4(GA_3 50ppm + Transparent polyethylene)	22.00	22.66	22.33
T_5(GA_3 75ppm + Transparent polyethylene)	22.33	23.00	22.66
T_6(GA_3 50ppm + Paddy straw)	19.00	18.00	18.50
T_7(GA_3 75ppm + Paddy straw)	19.66	19.00	19.33
T_8(GA_3 50ppm + Rice husk)	17.33	18.33	17.83
T_9(GA_3 75ppm + Rice husk)	18.33	18.66	18.49
T_{10}(NAA 20ppm +Black polyethylene)	17.00	17.66	17.33
T_{11}(NAA 40ppm +Black polyethylene)	16.66	17.33	16.99
T_{12}(NAA 20ppm + Transparent polyethylene)	15.33	16.00	15.66
T_{13}(NAA 40ppm + Transparent polyethylene)	14.66	15.33	14.99
T_{14}(NAA 20ppm + Paddy straw)	12.00	12.33	12.16
T_{15}(NAA 40ppm + Paddy straw)	11.66	12.00	11.83
T_{16}(NAA 20ppm + Rice husk)	11.33	11.66	11.49
T_{17}(NAA 40ppm + Rice husk)	10.33	10.66	10.49
CD at (P=0.05)	1.424	1.492	1.458
SEm±	0.492	0.516	0.504

Fig.No.-4.15.1: Effect of plant growth regulators and mulches on number of fruits par plant at 90 DAT.



4.2.7: Days taken to first harvesting

Table 4.16 shows the data on the days it takes for fruits to be harvested for the first time in terms of treatment and is graphically represented in Fig. 4.16.1.

The minimum days to first harvest were under T_{10} (NAA 20ppm + Black polyethylene), i.e., 55.10 days, which was statistically comparable to T_{11} (NAA 40ppm + Black polyethylene), and the maximum days to harvest were under T_1 (Control), i.e., 65.26 days, according to the data from the first year (2018–19).

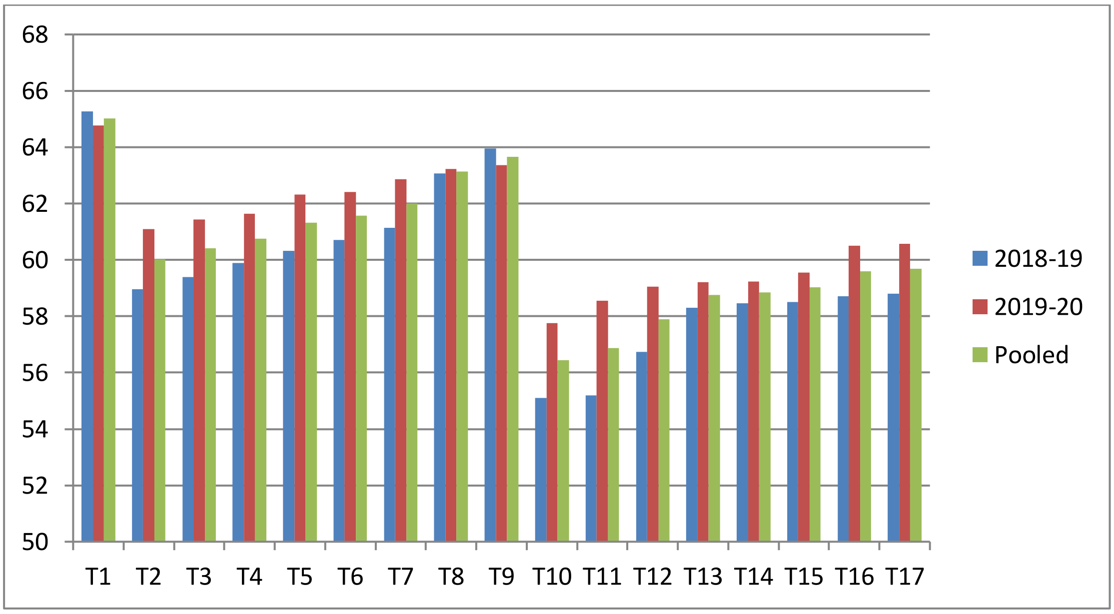
In the following 2019-20 investigation, the minimum days taken to harvest (57.76) days was also under T_{10} (NAA 20ppm + Black polyethylene), which was at par with T_{11} (NAA 40ppm + Black polyethylene). However, the maximum days taken to harvest (64.76) days was under T_1 (Control).

In terms of the pooled data, the harvesting time is measured in days (56.43 days), which was recorded under T_{10} (NAA 20ppm + Black polyethylene), which was comparable with T_{11} (NAA 40ppm + Black polyethylene). The minimum of 65.01 days taken to harvest was recorded as T_1 (Control).

Table-4.16: Effect of plant growth regulators and mulches on days taken to first harvest at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	65.26	64.76	65.01
T_2(GA_3 50ppm + Black polyethylene)	58.96	61.10	60.03
T_3(GA_3 75ppm + Black polyethylene)	59.40	61.43	60.41
T_4(GA_3 50ppm + Transparent polyethylene)	59.90	61.63	60.76
T_5(GA_3 75ppm + Transparent polyethylene)	60.33	62.33	61.33
T_6(GA_3 50ppm + Paddy straw)	60.70	62.42	61.56
T_7(GA_3 75ppm + Paddy straw)	61.13	62.86	61.99
T_8(GA_3 50ppm + Rice husk)	63.06	63.23	63.14
T_9(GA_3 75ppm + Rice husk)	63.96	63.36	63.66
T_{10}(NAA 20ppm +Black polyethylene)	55.10	57.76	56.43
T_{11}(NAA 40ppm +Black polyethylene)	55.20	58.56	56.88
T_{12}(NAA 20ppm + Transparent polyethylene)	56.73	59.06	57.89
T_{13}(NAA 40ppm + Transparent polyethylene)	58.30	59.20	58.75
T_{14}(NAA 20ppm + Paddy straw)	58.46	59.23	58.84
T_{15}(NAA 40ppm + Paddy straw)	58.50	59.56	59.03
T_{16}(NAA 20ppm + Rice husk)	58.70	60.50	59.60
T_{17}(NAA 40ppm + Rice husk)	58.79	60.58	59.68
CD at (P=0.05)	3.618	2.840	3.229
SEm±	1.250	1.982	1.616

Fig.No.-4.16.1: Effect of plant growth regulators and mulches on days taken to first harvest at 90 DAT.



4.2.8: Number of picking

Table 4.17 and Fig. no.4.17.1 indicate significant changes in the total number of fruits picked in strawberry cv. Chandler influenced by different treatments at 90 days after planting in 2018-19 and 2019-20.

During the experimentation in 2018–19, the maximum number of fruit pickings (18.00) was counted in the plants treated with treatment T_3 (GA_3 75ppm + Black polyethylene), followed by treatment T_2 (GA_3 50ppm + Black polyethylene). The minimum number of fruit picked (6.33) was counted in treatment T_1 (Control).

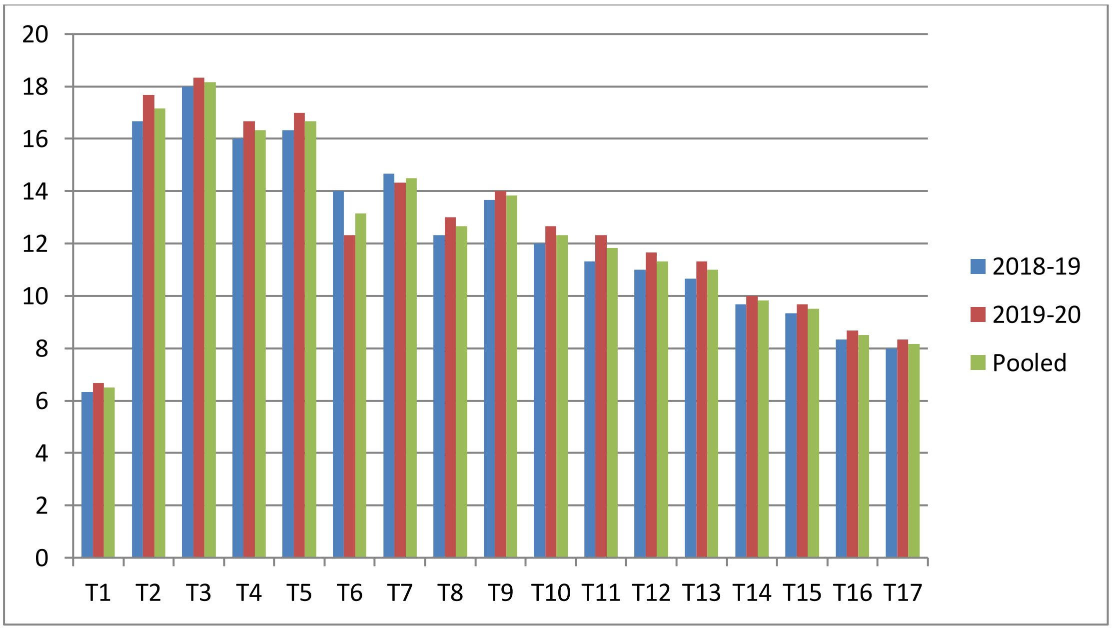
The number of fruit picked varied from 6.67 to 18.33 in the year 2019–20. The maximum number of fruit pickings was counted in the plots treated with treatment T_3 (GA_3 75ppm + Black polyethylene), followed by treatment T_2 (GA_3 50ppm + Black polyethylene).

The pooled data clearly shows that the maximum under fruit picking (18.16) were found in T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (GA_3 50ppm + Black polyethylene) whereas, the lowest number of fruit picking (6.50) was counted under the T_1 (Control).

Table-4.17: Effect of plant growth regulators and mulches on number of picking at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	6.33	6.67	6.50
T_2(GA_3 50ppm + Black polyethylene)	16.67	17.67	17.17
T_3(GA_3 75ppm + Black polyethylene)	18.00	18.33	18.16
T_4(GA_3 50ppm + Transparent polyethylene)	16.00	16.67	16.33
T_5(GA_3 75ppm + Transparent polyethylene)	16.33	17.00	16.66
T_6(GA_3 50ppm + Paddy straw)	14.00	12.33	13.16
T_7(GA_3 75ppm + Paddy straw)	14.67	14.33	14.50
T_8(GA_3 50ppm + Rice husk)	12.33	13.00	12.66
T_9(GA_3 75ppm + Rice husk)	13.67	14.00	13.83
T_{10}(NAA 20ppm +Black polyethylene)	12.00	12.67	12.33
T_{11}(NAA 40ppm +Black polyethylene)	11.33	12.33	11.83
T_{12}(NAA 20ppm + Transparent polyethylene)	11.00	11.67	11.33
T_{13}(NAA 40ppm + Transparent polyethylene)	10.67	11.33	11.00
T_{14}(NAA 20ppm + Paddy straw)	9.67	10.00	9.83
T_{15}(NAA 40ppm + Paddy straw)	9.33	9.67	9.50
T_{16}(NAA 20ppm + Rice husk)	8.33	8.67	8.50
T_{17}(NAA 40ppm + Rice husk)	8.00	8.33	8.16
CD at (P=0.05)	1.589	1.437	1.513
SEm±	0.549	0.497	0.523

Table-4.17.1: Effect of plant growth regulators and mulches on number of picking at 90 DAT.



4.2.9: Fruit length (cm)

Strawberry cv. Chandler data on the length of the fruit as presented in Table 4.18 with Fig. No. 4.18.1 revealed the significant differences among the various treatments during 2018–19 and 2019–20. During the period of 2018–19, it ranged from 2.53cm to 3.83cm, while it was 2.58 to 3.85cm during 2019–20.

The maximum fruit length was measured in the plant treated with treatment T_3 (GA_3 75ppm + Black polyethylene) during both consecutive cropping years 2018-19 and 2019-20. During 2018-19, maximum fruit length was observed in T_3 (GA_3 75ppm + Black polyethylene) (3.83cm), statistically on par with treatment T_2 (GA_3 50ppm + Black polyethylene), and T_5 (GA_3 75ppm + Transparent polyethylene).

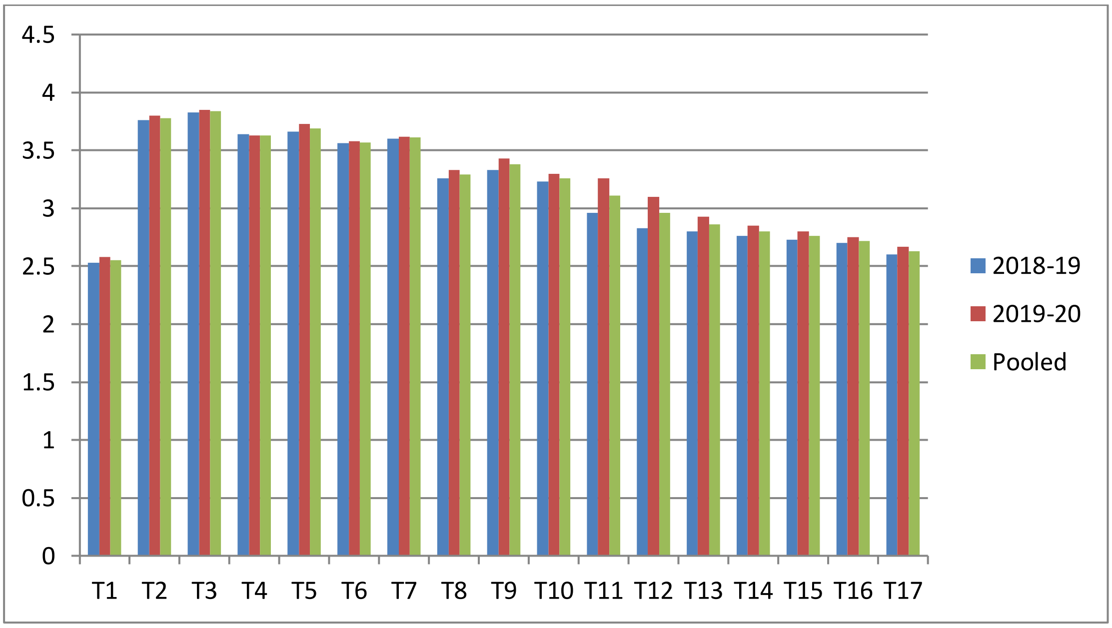
During the second year (2019–20), the longest fruit (3.85cm) was observed in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene), and T_5 (GA_3 75ppm + Transparent polyethylene).

Table 4.18 shows the pooled data, which clearly shows the significant differences between the treatments. T_3 (GA_3 75ppm + Black polyethylene) (3.84cm) had the longest fruits, which were much longer than the other treatments, whilst control had the shortest fruit (no PGRs and no mulching).

Table-4.18: Effect of plant growth regulators and mulches on length of fruits (cm) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	2.53	2.58	2.55
T_2(GA_3 50ppm + Black polyethylene)	3.76	3.80	3.78
T_3(GA_3 75ppm + Black polyethylene)	3.83	3.85	3.84
T_4(GA_3 50ppm + Transparent polyethylene)	3.64	3.63	3.63
T_5(GA_3 75ppm + Transparent polyethylene)	3.66	3.73	3.69
T_6(GA_3 50ppm + Paddy straw)	3.56	3.58	3.57
T_7(GA_3 75ppm + Paddy straw)	3.60	3.62	3.61
T_8(GA_3 50ppm + Rice husk)	3.26	3.33	3.29
T_9(GA_3 75ppm + Rice husk)	3.33	3.43	3.38
T_{10}(NAA 20ppm +Black polyethylene)	3.23	3.30	3.26
T_{11}(NAA 40ppm +Black polyethylene)	2.96	3.26	3.11
T_{12}(NAA 20ppm + Transparent polyethylene)	2.83	3.10	2.96
T_{13}(NAA 40ppm + Transparent polyethylene)	2.80	2.93	2.86
T_{14}(NAA 20ppm + Paddy straw)	2.76	2.85	2.80
T_{15}(NAA 40ppm + Paddy straw)	2.73	2.80	2.76
T_{16}(NAA 20ppm + Rice husk)	2.70	2.75	2.72
T_{17}(NAA 40ppm + Rice husk)	2.60	2.67	2.63
CD at (P=0.05)	0.743	0.626	0.684
SEm±	0.257	0.216	0.236

Fig.No.-4.18.1: Effect of plant growth regulators and mulches on length of fruits (cm) at 90 DAT.



4.2.10: Fruit width (cm)

During the period of 2018–19, fruit width was measured in the range of 2.6cm to 3.26cm (Table 4.19 with Fig. No. 4.19.1). The widest fruit (3.26cm) was found in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene), and T_5 (GA_3 75ppm + Transparent polyethylene).

On the other hand, the smallest fruit width, at 2.06cm, was found in control. During the second year, 2019–20, fruit width varied from 2.13cm to 3.36cm.

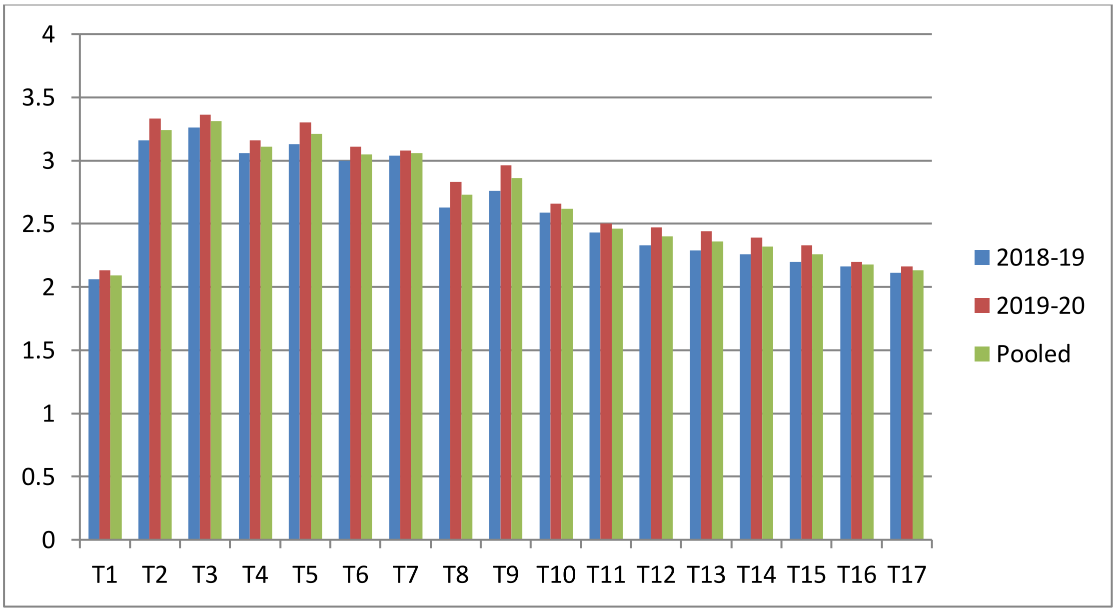
The maximum fruit width (3.36cm) was recorded in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene) (3.33cm) and T_5 (GA_3 75ppm + Transparent polyethylene) (3.30cm), whereas a minimum (2.13cm) fruit width was observed in control.

The pooled data clearly shows the fruit width (3.31cm) in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene) (3.24cm) and T_5 (GA_3 75ppm + Transparent polyethylene) (3.21cm) and the minimum under control (No PGRs and no mulching).

Table-4.19: Effect of plant growth regulators and mulches on width of fruits (cm) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	2.06	2.13	2.09
T_2(GA_3 50ppm + Black polyethylene)	3.16	3.33	3.24
T_3(GA_3 75ppm + Black polyethylene)	3.26	3.36	3.31
T_4(GA_3 50ppm + Transparent polyethylene)	3.06	3.16	3.11
T_5(GA_3 75ppm + Transparent polyethylene)	3.13	3.30	3.21
T_6(GA_3 50ppm + Paddy straw)	3.00	3.11	3.05
T_7(GA_3 75ppm + Paddy straw)	3.04	3.08	3.06
T_8(GA_3 50ppm + Rice husk)	2.63	2.83	2.73
T_9(GA_3 75ppm + Rice husk)	2.76	2.96	2.86
T_{10}(NAA 20ppm +Black polyethylene)	2.59	2.66	2.62
T_{11}(NAA 40ppm +Black polyethylene)	2.43	2.50	2.46
T_{12}(NAA 20ppm + Transparent polyethylene)	2.33	2.47	2.40
T_{13}(NAA 40ppm + Transparent polyethylene)	2.29	2.44	2.36
T_{14}(NAA 20ppm + Paddy straw)	2.26	2.39	2.32
T_{15}(NAA 40ppm + Paddy straw)	2.20	2.33	2.26
T_{16}(NAA 20ppm + Rice husk)	2.16	2.20	2.18
T_{17}(NAA 40ppm + Rice husk)	2.11	2.16	2.13
CD at (P=0.05)	0.764	0.635	0.699
SEm±	0.264	0.219	0.241

Fig.No.-4.19.1: Effect of plant growth regulators and mulches on width of fruits (cm) at 90 DAT.



4.2.11: Fruit volume (cc)

Table 4.20 with Fig. No.4.20.1 shows the relevant data on fruit volume (cc) affected by different treatments over the years 2018–19 and 2019–20.

The berries of significantly higher fruit volume (12.92cc) during 2018-19 were produced in plants treated with treatment T_3 (GA_3 75ppm + Black polyethylene), which was statistically significant, followed by T_2 (GA_3 50ppm + Black polyethylene) (12.54cc). Whereas T_1 had the lowest fruit volume (9.75cc) under control.

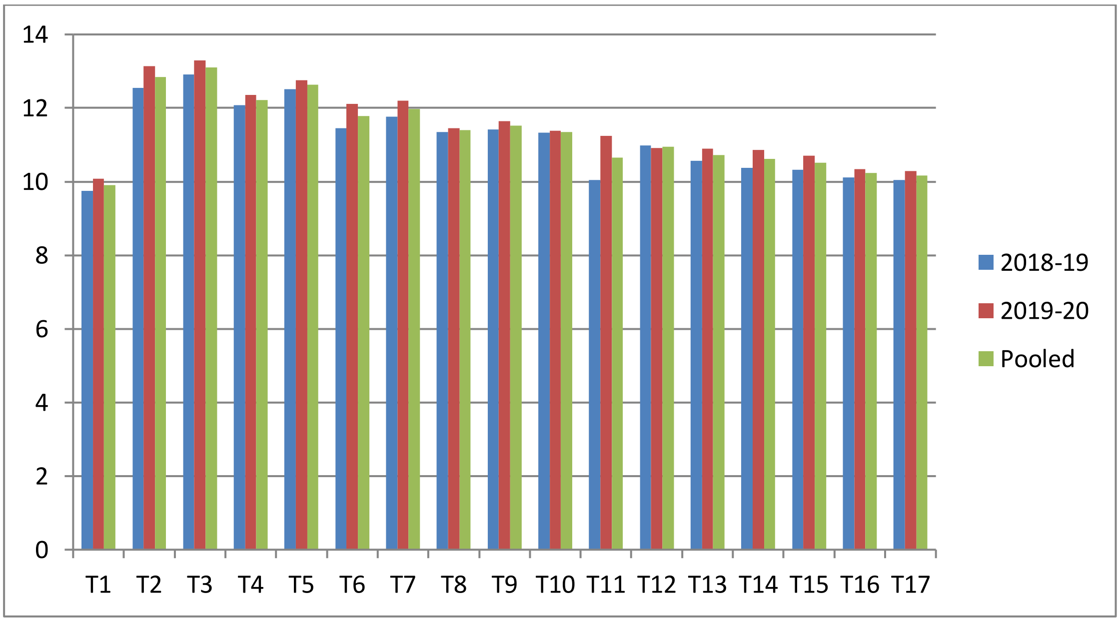
The largest fruit volume (13.29cc) was reported in plants treated with treatment T_3 (GA_3 75ppm + Black polyethylene) during the 2019–20 season, followed by (13.14cc) in plants treated with treatment T_2 (GA_3 50ppm + Black polyethylene). Under T_1 control, the lowest fruit volume (10.08cc) was recorded.

The average value of both years clearly revealed that the maximum fruit volume was found in treatment T_3 (GA_3 75ppm + Black polyethylene) (13.10cc) followed by T_2 (GA_3 50ppm + Black polyethylene) (12.84cc), whereas the minimum fruit volume was observed in T_1 (9.91cc) control.

Table-4.20: Effect of plant growth regulators and mulches on fruit volume (cc) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	9.75	10.08	9.91
T_2(GA_3 50ppm + Black polyethylene)	12.54	13.14	12.84
T_3(GA_3 75ppm + Black polyethylene)	12.92	13.29	13.10
T_4(GA_3 50ppm + Transparent polyethylene)	12.08	12.35	12.21
T_5(GA_3 75ppm + Transparent polyethylene)	12.52	12.76	12.64
T_6(GA_3 50ppm + Paddy straw)	11.46	12.12	11.79
T_7(GA_3 75ppm + Paddy straw)	11.77	12.20	11.98
T_8(GA_3 50ppm + Rice husk)	11.35	11.46	11.40
T_9(GA_3 75ppm + Rice husk)	11.42	11.65	11.53
T_{10}(NAA 20ppm +Black polyethylene)	11.33	11.38	11.35
T_{11}(NAA 40ppm +Black polyethylene)	10.05	11.25	10.65
T_{12}(NAA 20ppm + Transparent polyethylene)	10.99	10.91	10.95
T_{13}(NAA 40ppm + Transparent polyethylene)	10.56	10.90	10.73
T_{14}(NAA 20ppm + Paddy straw)	10.38	10.86	10.62
T_{15}(NAA 40ppm + Paddy straw)	10.33	10.71	10.52
T_{16}(NAA 20ppm + Rice husk)	10.12	10.34	10.23
T_{17}(NAA 40ppm + Rice husk)	10.05	10.28	10.16
CD at (P=0.05)	1.353	1.120	1.236
SEm±	0.468	0.387	0.427

Fig.No.-4.20.1: Effect of plant growth regulators and mulches on fruit volume (cc) at 90 DAT.



4.2.12: Fruit weight par berry (g)

Fruit weight changed greatly during the experimentation years of 2018–19 and 2019–20, as shown by data in Table 4.21 with Fig. 4.21.1. Fruit weights ranged from 9.90g to 13.56g in the first year. The berry weight of T_3 (GA_3 75ppm + black polyethylene) was the greatest (13.56g), followed by T_2 (GA_3 50ppm + black polyethylene) (13.36g). However, T_1 had the lowest fruit weight (9.90g) of control.

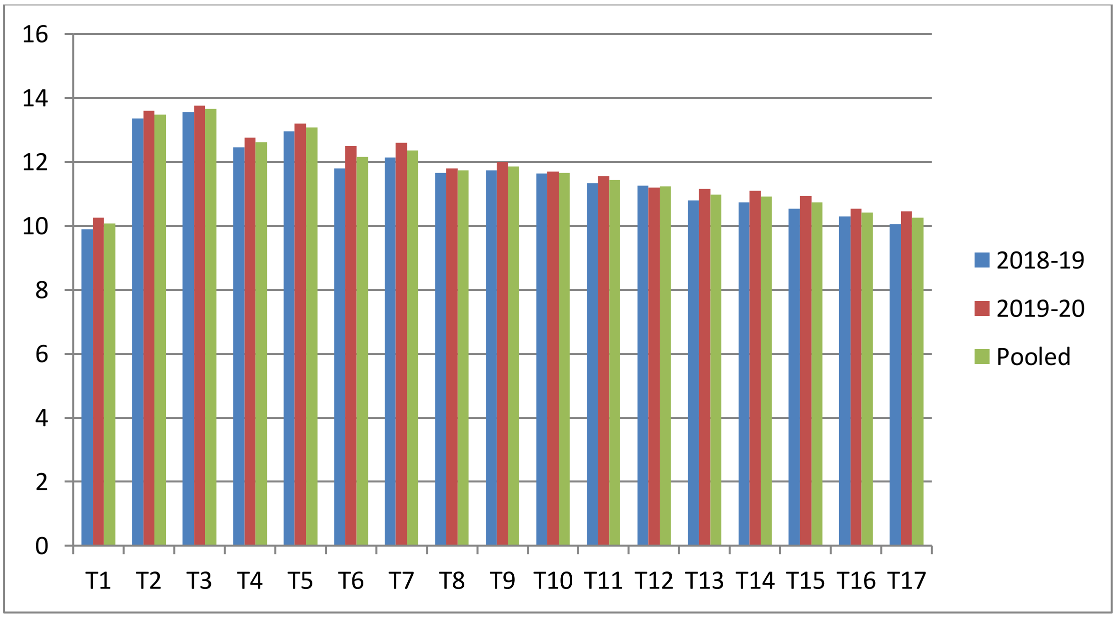
During the period of 2019–20, the fruit weights ascertained ranged from 10.26g to 13.76g. The maximum fruit weight (13.76g) was observed in plants treated with T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (GA_3 50ppm + Black polyethylene) (13.60g), while the minimum fruit weight was observed in T_1 Control (10.26g).

The mean value of both years revealed that the maximum fruit weight was observed in T_3 (GA_3 75ppm + Black polyethylene) followed by T_2 (GA_3 50ppm + Black polyethylene) respectively, but the minimum value was assessed in T_1 (Control).

Table-4.21: Effect of plant growth regulators and mulches on fruit weight par berry (g) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	9.90	10.26	10.08
T_2(GA_3 50ppm + Black polyethylene)	13.36	13.60	13.48
T_3(GA_3 75ppm + Black polyethylene)	13.56	13.76	13.66
T_4(GA_3 50ppm + Transparent polyethylene)	12.46	12.76	12.61
T_5(GA_3 75ppm + Transparent polyethylene)	12.96	13.20	13.08
T_6(GA_3 50ppm + Paddy straw)	11.80	12.50	12.15
T_7(GA_3 75ppm + Paddy straw)	12.13	12.60	12.36
T_8(GA_3 50ppm + Rice husk)	11.66	11.80	11.73
T_9(GA_3 75ppm + Rice husk)	11.73	12.00	11.86
T_{10}(NAA 20ppm +Black polyethylene)	11.63	11.70	11.66
T_{11}(NAA 40ppm +Black polyethylene)	11.33	11.56	11.44
T_{12}(NAA 20ppm + Transparent polyethylene)	11.26	11.20	11.23
T_{13}(NAA 40ppm + Transparent polyethylene)	10.80	11.16	10.98
T_{14}(NAA 20ppm + Paddy straw)	10.73	11.10	10.91
T_{15}(NAA 40ppm + Paddy straw)	10.53	10.93	10.73
T_{16}(NAA 20ppm + Rice husk)	10.30	10.53	10.41
T_{17}(NAA 40ppm + Rice husk)	10.06	10.46	10.26
CD at (P=0.05)	1.390	1.148	1.269
SEm±	0.480	0.397	0.438

Fig.No.-4.21.1: Effect of plant growth regulators and mulches on fruit weight par berry (g) at 90 DAT.



4.2.13: Fruit weight par plant (g)

Fruit yield was found in the data par plant varied significantly as per the data given in Table 4.22 with Fig. No 4.22.1 during 2018-19. It ranged from 93.55g to 306.20g per plant, with T_3 (GA_3 75ppm + Black polyethylene) having the highest (302.43g), followed by T_2 (GA_3 50ppm + Black polyethylene).T_1 had the lowest fruit yield per plant (93.55g) under control.

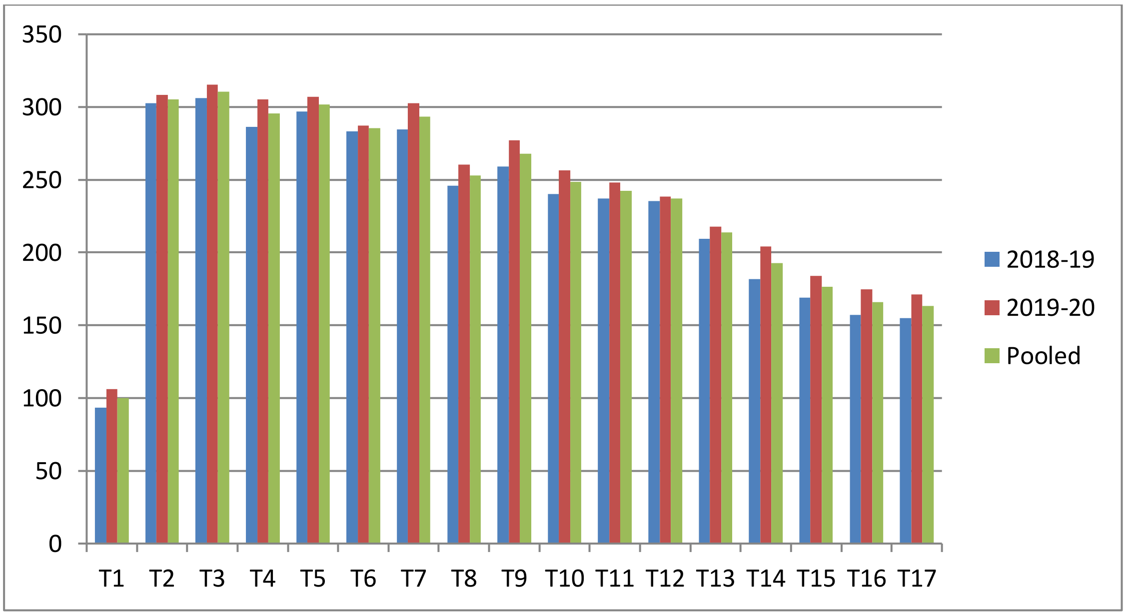
During the year, the 2019-20 fruit yield per plant varied from 106.29g to 315.30g. The maximum fruit yield per plant was recorded at (315.30g) in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene) (308.20g). The minimum fruit yield per plant was observed in control.

The mean value of both years revealed that the maximum fruit yield per plant was recorded in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene) and T_5 (GA_3 75ppm + Transparent polyethylene). Under control (no PGRs and no mulching), the minimum yield per plant was observed.

Table-4.22: Effect of plant growth regulators and mulches on fruit weight par plant (g) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	93.55	106.29	99.92
T_2(GA_3 50ppm + Black polyethylene)	302.43	308.20	305.31
T_3(GA_3 75ppm + Black polyethylene)	306.20	315.30	310.75
T_4(GA_3 50ppm + Transparent polyethylene)	286.26	305.30	295.78
T_5(GA_3 75ppm + Transparent polyethylene)	296.86	306.93	301.89
T_6(GA_3 50ppm + Paddy straw)	283.33	287.43	285.38
T_7(GA_3 75ppm + Paddy straw)	284.43	302.46	293.44
T_8(GA_3 50ppm + Rice husk)	245.73	260.26	252.99
T_9(GA_3 75ppm + Rice husk)	259.06	276.96	268.01
T_{10}(NAA 20ppm +Black polyethylene)	240.40	256.40	248.40
T_{11}(NAA 40ppm +Black polyethylene)	237.13	248.03	242.58
T_{12}(NAA 20ppm + Transparent polyethylene)	235.40	238.66	237.03
T_{13}(NAA 40ppm + Transparent polyethylene)	209.50	217.83	213.66
T_{14}(NAA 20ppm + Paddy straw)	181.86	204.03	192.94
T_{15}(NAA 40ppm + Paddy straw)	169.06	183.90	176.48
T_{16}(NAA 20ppm + Rice husk)	157.20	174.73	165.96
T_{17}(NAA 40ppm + Rice husk)	154.93	171.36	163.14
CD at (P=0.05)	32.301	28.362	30.331
SEm±	11.162	9.801	10.481

Fig.No.-4.22.1: Effect of plant growth regulators and mulches on fruit weight par plant (g) at 90 DAT.



4.2.14: Dry weight of fruit (g)

The dry weight of fruits was recorded under various treatments and is represented in Table-4.23 with Fig. no. 4.23.1.

The maximum dry weight of fruit (0.83g) was found under T_3 (GA_3 75ppm + Black polyethylene), which was statistically comparable to T_2 (GA_3 50ppm + Black polyethylene) and T_5 (GA_3 75ppm + Transparent polyethylene) in the first year (2018-19). Treatment T_1 yielded the smallest dry weight of fruit (0.55g) Control.

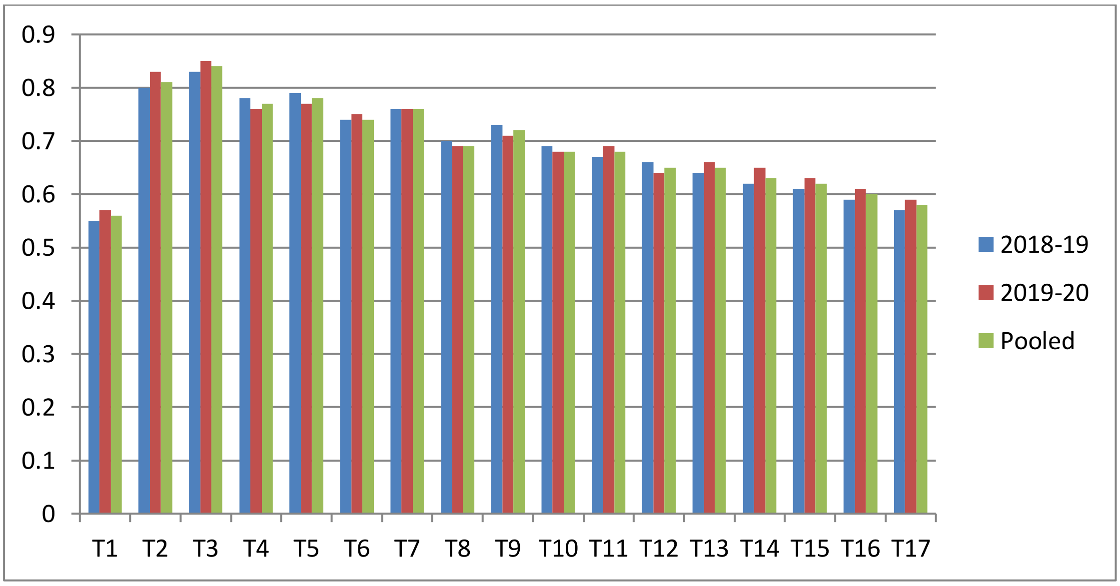
The maximum dry weight of fruit (0.85g) in T_3 (GA_3 75ppm + Black polyethylene) was statistically comparable to T_2 (GA_3 50ppm + Black polyethylene) and T_5 (GA_3 75ppm + Transparent polyethylene) in the second year (2019-20). The treatment T_1 control, on the other hand, produced the smallest dry weight of fruit.

According to the pooled analysis of the data, the maximum dry weight of fruit (0.84g) was recorded under T_3 (GA_3 75ppm + Black polyethylene), which was statistically comparable to T_2 (GA_3 50ppm + Black polyethylene), and T_5 (GA_3 75ppm + Transparent polyethylene), and the minimum dry weight (0.56g) was recorded under T_1 control.

Table-4.23: Effect of plant growth regulators and mulches on dry weight of fruit at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	0.55	0.57	0.56
T_2(GA_3 50ppm + Black polyethylene)	0.80	0.83	0.81
T_3(GA_3 75ppm + Black polyethylene)	0.83	0.85	0.84
T_4(GA_3 50ppm + Transparent polyethylene)	0.78	0.76	0.77
T_5(GA_3 75ppm + Transparent polyethylene)	0.79	0.77	0.78
T_6(GA_3 50ppm + Paddy straw)	0.74	0.75	0.74
T_7(GA_3 75ppm + Paddy straw)	0.76	0.76	0.76
T_8(GA_3 50ppm + Rice husk)	0.70	0.69	0.69
T_9(GA_3 75ppm + Rice husk)	0.73	0.71	0.72
T_{10}(NAA 20ppm +Black polyethylene)	0.69	0.68	0.68
T_{11}(NAA 40ppm +Black polyethylene)	0.67	0.69	0.68
T_{12}(NAA 20ppm + Transparent polyethylene)	0.66	0.64	0.65
T_{13}(NAA 40ppm + Transparent polyethylene)	0.64	0.66	0.65
T_{14}(NAA 20ppm + Paddy straw)	0.62	0.65	0.63
T_{15}(NAA 40ppm + Paddy straw)	0.61	0.63	0.62
T_{16}(NAA 20ppm + Rice husk)	0.59	0.61	0.60
T_{17}(NAA 40ppm + Rice husk)	0.57	0.59	0.58
CD at (P=0.05)	0.054	0.048	0.051
SEm±	0.019	0.017	0.018

Fig.No.-4.23.1: Effect of plant growth regulators and mulches on dry weight of fruit at 90 DAT.



4.3: Physico – Chemicals (Quality) Parameters

4.3.1: Reducing sugar (%)

Data furnished in Table-4.24.1 with Fig. No. 4.24.1 clearly indicated the variation from 3.44 to 5.03 percent reducing sugar of strawberries during 2018-19. The maximum reducing sugar of berries was recorded at (5.03%) in T_3 (GA_3 75ppm + Black polyethylene) followed by (5.02%) in treatment T_2 (GA_3 50ppm + Black polyethylene). The minimum reducing sugar (3.44%) content in strawberries was obtained from T_1 (Control) (No PGRs and no mulching).

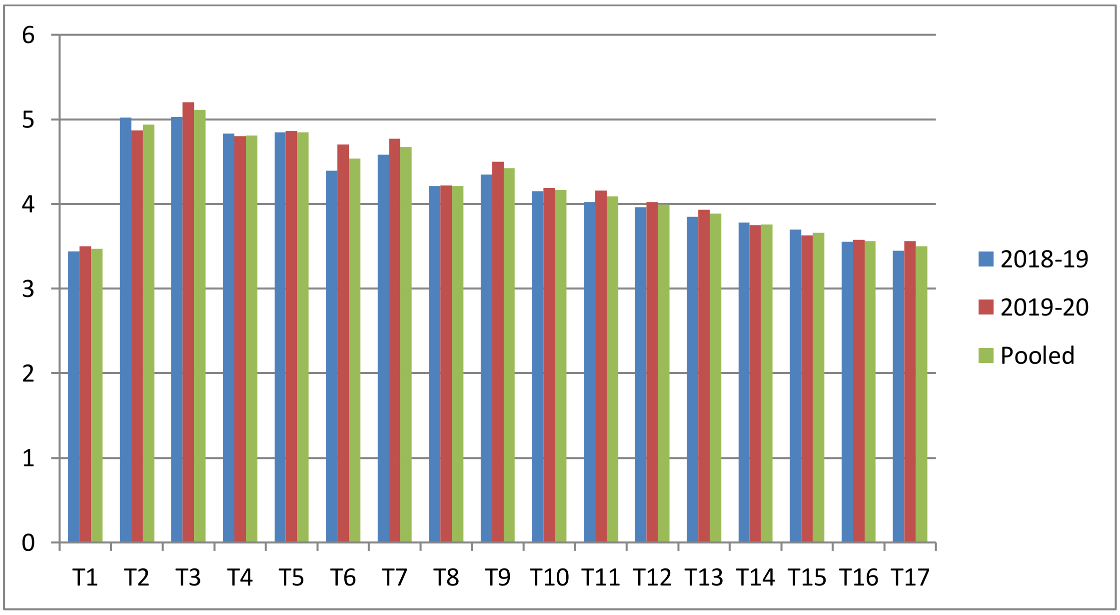
During the 2019-20 periods, it ranged from 3.50 to 5.20 percent. The highest reducing sugar content (5.20%) was found in fruit grown in T_3 (GA_3 75ppm + Black polyethylene), followed by (4.87%) in T_2 (GA_3 50ppm + Black polyethylene).The minimum reducing sugar (3.50%) content in strawberry fruits was obtained from T_1 (no PGRs and no mulching).

The average data of both years showed that maximum reducing sugar was recorded in fruits produced in T_3 (GA_3 75ppm + Black polyethylene) and the minimum value was ascertained in T_1 (no PGRs and no mulching).

Table-4.24: Effect of plant growth regulators and mulches on reducing sugar (%) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	3.44	3.50	3.47
T_2(GA_3 50ppm + Black polyethylene)	5.02	4.87	4.94
T_3(GA_3 75ppm + Black polyethylene)	5.03	5.20	5.11
T_4(GA_3 50ppm + Transparent polyethylene)	4.83	4.80	4.81
T_5(GA_3 75ppm + Transparent polyethylene)	4.85	4.86	4.85
T_6(GA_3 50ppm + Paddy straw)	4.39	4.70	4.54
T_7(GA_3 75ppm + Paddy straw)	4.58	4.77	4.67
T_8(GA_3 50ppm + Rice husk)	4.21	4.22	4.21
T_9(GA_3 75ppm + Rice husk)	4.35	4.50	4.42
T_{10}(NAA 20ppm +Black polyethylene)	4.15	4.19	4.17
T_{11}(NAA 40ppm +Black polyethylene)	4.02	4.16	4.09
T_{12}(NAA 20ppm + Transparent polyethylene)	3.96	4.02	3.99
T_{13}(NAA 40ppm + Transparent polyethylene)	3.85	3.93	3.89
T_{14}(NAA 20ppm + Paddy straw)	3.78	3.75	3.76
T_{15}(NAA 40ppm + Paddy straw)	3.70	3.63	3.66
T_{16}(NAA 20ppm + Rice husk)	3.55	3.58	3.56
T_{17}(NAA 40ppm + Rice husk)	3.45	3.56	3.50
CD at (P=0.05)	0.770	0.579	0.674
SEm±	0.377	0.283	0.330

Fig.No.-4.24.1: Effect of plant growth regulators and mulches on reducing sugar (%) at 90 DAT.



4.3.2: Non-reducing sugar (%)

The sugar content of non-reducing sugars was estimated from strawberry juice as presented in Table 4.25 with Fig. no. 4.25.1. During 2018–19, it varied from 2.93% to 4.43%, and during 2019–20, it ranged from 2.96% to 4.83%. The maximum non-reducing sugar was obtained under T_3 (GA_3 75ppm + Black polyethylene) (4.43%), followed by T_2 (GA_3 50ppm + Black polyethylene) (T_2 4.36%). The minimum non-reducing sugar was obtained in T_1 (Control) during 2018-19.

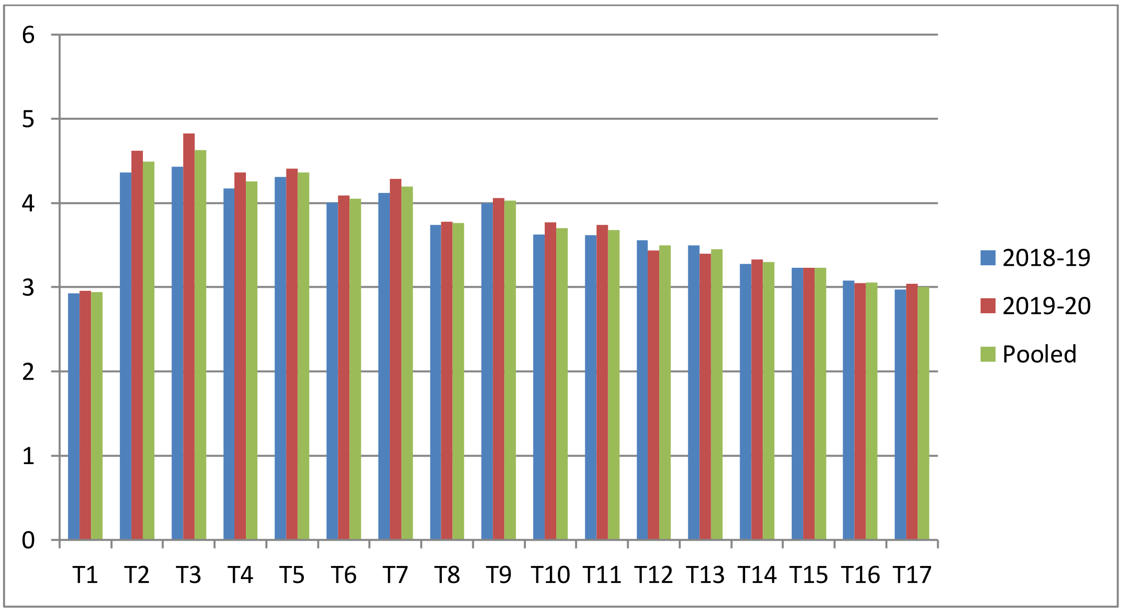
The maximum non-reducing sugar was obtained under T_3 (GA_3 75ppm + Black polyethylene) (4.83%), followed by T_2 (GA_3 50ppm + Black polyethylene) (4.62%). The minimum non-reducing sugar was obtained in T_1 (control) during 2019-20.

The maximum non-reducing sugar was found in fruits in both years, according to the mean value in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene), and the minimum value found in T_1 (control).

Table-4.25: Effect of plant growth regulators and mulches on non-reducing sugar (%) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	2.93	2.96	2.94
T_2(GA_3 50ppm + Black polyethylene)	4.36	4.62	4.49
T3(GA_3 75ppm + Black polyethylene)	4.43	4.83	4.63
T4(GA_3 50ppm + Transparent polyethylene)	4.17	4.36	4.26
T5(GA_3 75ppm + Transparent polyethylene)	4.31	4.41	4.36
T_6(GA_3 50ppm + Paddy straw)	4.01	4.09	4.05
T_7(GA_3 75ppm + Paddy straw)	4.12	4.29	4.20
T_8(GA_3 50ppm + Rice husk)	3.74	3.78	3.76
T_9(GA_3 75ppm + Rice husk)	4.00	4.06	4.03
T_{10}(NAA 20ppm +Black polyethylene)	3.63	3.77	3.70
T_{11}(NAA 40ppm +Black polyethylene)	3.62	3.74	3.68
T_{12}(NAA 20ppm + Transparent polyethylene)	3.56	3.44	3.50
T_{13}(NAA 40ppm + Transparent polyethylene)	3.50	3.40	3.45
T_{14}(NAA 20ppm + Paddy straw)	3.28	3.33	3.30
T_{15}(NAA 40ppm + Paddy straw)	3.23	3.23	3.23
T_{16}(NAA 20ppm + Rice husk)	3.08	3.05	3.06
T_{17}(NAA 40ppm + Rice husk)	2.97	3.04	3.00
CD at (P=0.05)	0.707	0.761	0.734
SEm±	0.244	0.263	0.253

Fig.No.-4.25.1: Effect of plant growth regulators and mulches on non-reducing sugar (%) at 90 DAT.



4.3.3: Total sugars (%)

Total sugar content varied significantly as per data projected in Table 4.26 with Fig. No. 4.26.1. During the period 2018–19, it ranged from 6.37% to 9.46%, with the maximum being in treatment combination T_3 (9.46%) (GA_3 75ppm + Black polyethylene), followed by (9.38%) in T_2 (GA_3 50ppm + Black polyethylene), which revealed the lowest total sugar content (6.37%) in T_1 (control) as compared to other treatments.

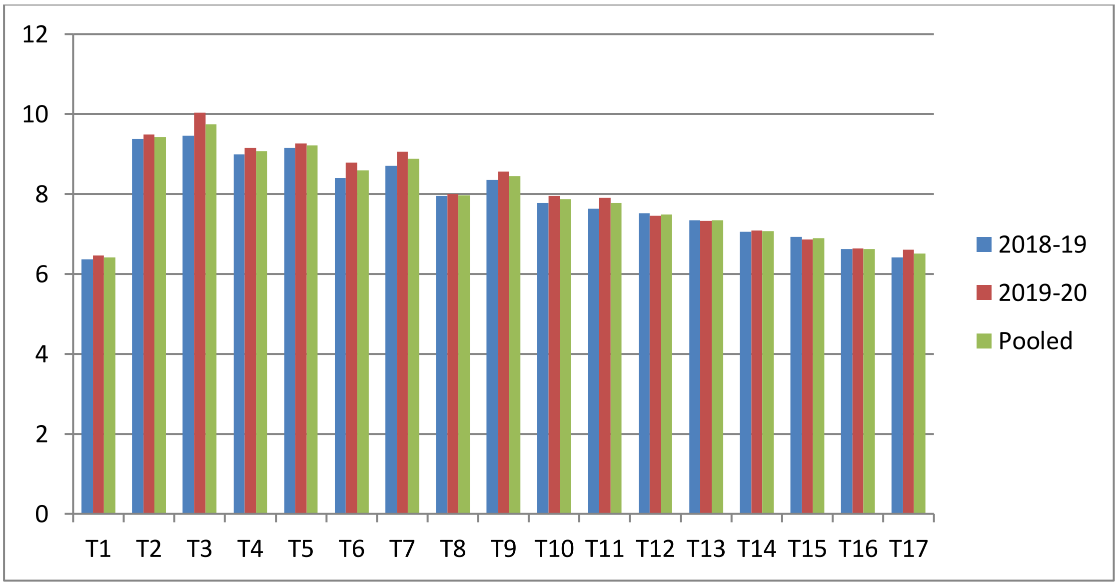
During the 2019-20 school years, it varied from 6.46% to 10.03%. The maximum total sugars were recorded in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (9.49%), and the minimum total sugars were obtained in T_1 (control).

The data varies from 6.41% to 9.74%. The pooled data clearly shows the maximum total sugars were recorded in berries under T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene) and the minimum value of assets (6.41) in treatment T_1 (control).

Table-4.26: Effect of plant growth regulators and mulches on total sugars (%) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	6.37	6.46	6.41
T_2(GA_3 50ppm + Black polyethylene)	9.38	9.49	9.43
T_3(GA_3 75ppm + Black polyethylene)	9.46	10.03	9.74
T_4(GA_3 50ppm + Transparent polyethylene)	9.00	9.16	9.08
T_5(GA_3 75ppm + Transparent polyethylene)	9.16	9.27	9.21
T_6(GA_3 50ppm + Paddy straw)	8.40	8.79	8.59
T_7(GA_3 75ppm + Paddy straw)	8.70	9.06	8.88
T_8(GA_3 50ppm + Rice husk)	7.95	8.00	7.97
T_9(GA_3 75ppm + Rice husk)	8.35	8.56	8.45
T_{10}(NAA 20ppm +Black polyethylene)	7.78	7.96	7.87
T_{11}(NAA 40ppm +Black polyethylene)	7.64	7.90	7.77
T_{12}(NAA 20ppm + Transparent polyethylene)	7.52	7.46	7.49
T_{13}(NAA 40ppm + Transparent polyethylene)	7.35	7.33	7.34
T_{14}(NAA 20ppm + Paddy straw)	7.06	7.08	7.07
T_{15}(NAA 40ppm + Paddy straw)	6.93	6.86	6.89
T_{16}(NAA 20ppm + Rice husk)	6.63	6.64	6.63
T_{17}(NAA 40ppm + Rice husk)	6.42	6.60	6.51
CD at (P=0.05)	1.375	1.163	1.269
SEm±	0.475	0.402	0.438

Fig.No.-4.26.1: Effect of plant growth regulators and mulches on total sugars (%) at 90 DAT.



4.3.4: Total Soluble Solids (ºBrix)

The data in Table 4.27 with Fig. No. 4.27.1 shows that there was a substantial difference in total soluble solids in strawberries between 2018-19 and 2019-20 due to different treatment combinations.

During the first year of 2018-19, it varied from 7.86 ºBrix to 12.33 ºBrix. T3 (GA3 75ppm + Black polyethylene) produced the most soluble solids (12.33 ºBrix), followed by T_2 (GA_3 50ppm + Black polyethylene) (11.73 ºBrix) and T_5 (GA_3 75ppm + Transparent polyethylene) (11.60 ºBrix).The fruits of minimum soluble solids (7.86 ºBrix) were found in T_1 (control).

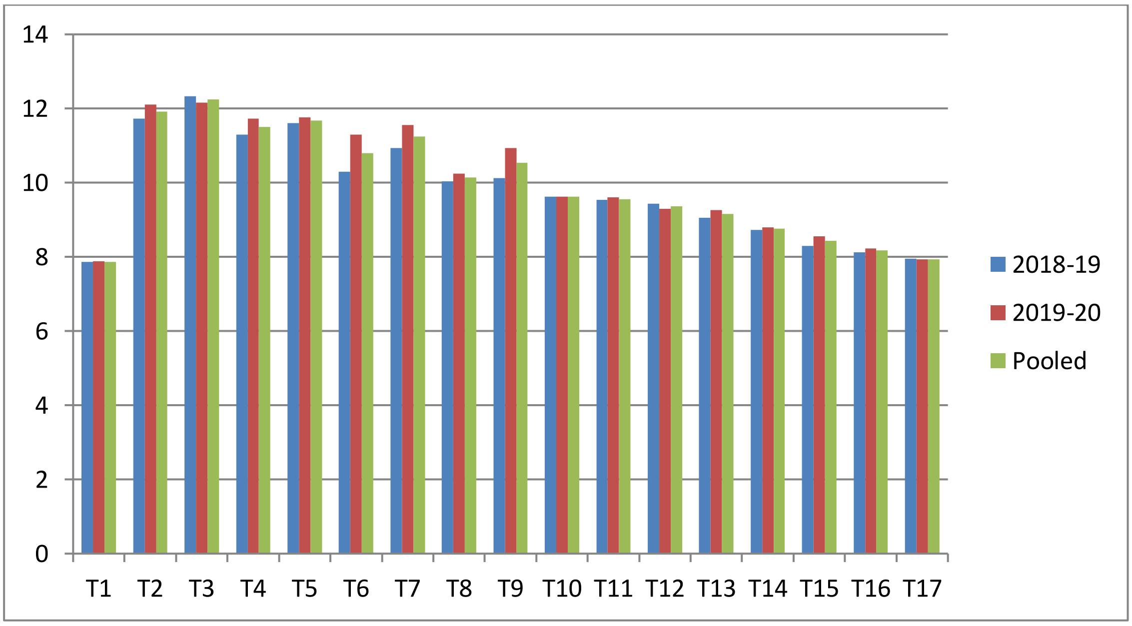
During the period 2019–20, it ranged from 7.88 ºBrix to 12.16 ºBrix. The fruits with the maximum soluble solids (12.16 ºBrix) were observed in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene) (12.10 ºBrix) and T_5 (GA_3 75ppm + Transparent polyethylene) (11.76 ºBrix). T_1 produced the fruits with the lowest soluble solids (7.88 ºBrix) (control).

The combined data clearly reveals that the highest soluble solids are found in T_3 (GA_3 75ppm + Black polyethylene), followed by T_2 (GA_3 50ppm + Black polyethylene) and T_5 (GA_3 75ppm + Transparent polyethylene), with a minimum under T_1 (control) (No PGRs and no mulching).

Table-4.27: Effect of plant growth regulators and mulches on total soluble solids (°Brix) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	7.86	7.88	7.87
T_2(GA_3 50ppm + Black polyethylene)	11.73	12.10	11.91
T_3(GA_3 75ppm + Black polyethylene)	12.33	12.16	12.24
T_4(GA_3 50ppm + Transparent polyethylene)	11.30	11.73	11.51
T_5(GA_3 75ppm + Transparent polyethylene)	11.60	11.76	11.68
T_6(GA_3 50ppm + Paddy straw)	10.30	11.30	10.80
T_7(GA_3 75ppm + Paddy straw)	10.93	11.56	11.24
T_8(GA_3 50ppm + Rice husk)	10.03	10.25	10.14
T_9(GA_3 75ppm + Rice husk)	10.13	10.93	10.53
T_{10}(NAA 20ppm +Black polyethylene)	9.63	9.62	9.63
T_{11}(NAA 40ppm +Black polyethylene)	9.53	9.60	9.56
T_{12}(NAA 20ppm + Transparent polyethylene)	9.43	9.30	9.36
T_{13}(NAA 40ppm + Transparent polyethylene)	9.06	9.26	9.16
T_{14}(NAA 20ppm + Paddy straw)	8.73	8.80	8.76
T_{15}(NAA 40ppm + Paddy straw)	8.30	8.56	8.43
T_{16}(NAA 20ppm + Rice husk)	8.13	8.23	8.18
T_{17}(NAA 40ppm + Rice husk)	7.96	7.93	7.94
CD at (P=0.05)	1.257	1.251	1.254
SEm±	0.434	0.432	0.433

Fig. No.-4.27.1: Effect of plant growth regulators and mulches on total soluble solids (°Brix) at 90 DAT.



4.3.5: Specific gravity of fruits

The specific gravity of fruits was measured under various treatments and is reported in Table-4.28 with Fig. No. 4.28.1

The maximum specific gravity of fruits (1.036) was found to be under T_3 (GA_3 75ppm + Black polyethylene), which was statistically comparable to T_2 (GA_3 50ppm + Black polyethylene) and T_5 (GA_3 75ppm + Transparent polyethylene) in the first year (2018-19). Under treatment T_1, however, the lowest specific gravity of fruits (1.015) was recorded (Control).

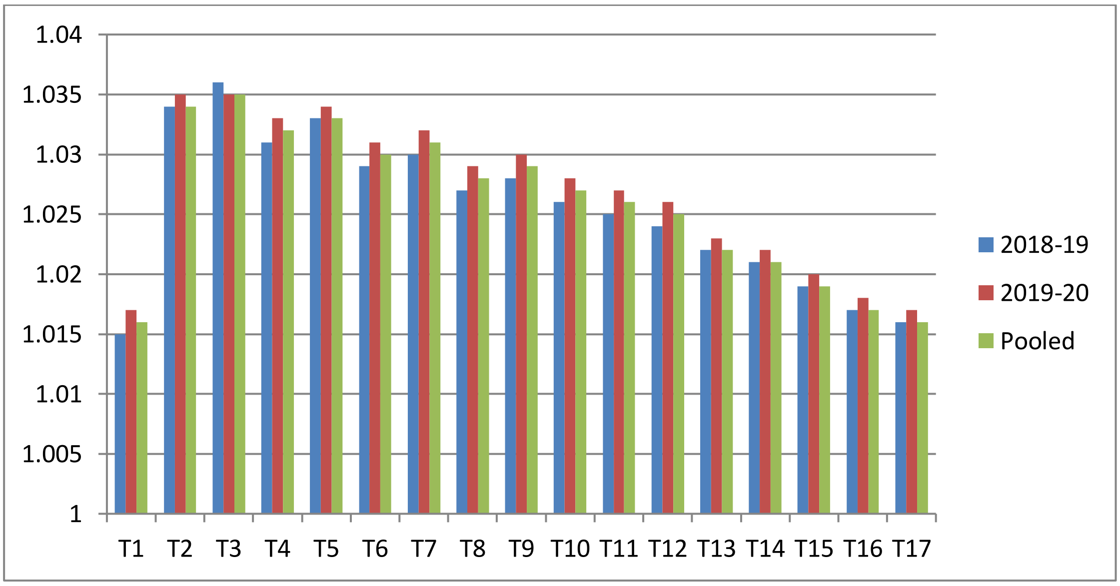
The largest specific gravity of fruits (1.035) was found in T_3 (GA_3 75ppm + Black polyethylene) in the second year (2019–20), which was statistically comparable to T_2 (GA_3 50ppm + Black polyethylene) and T_5 (GA_3 75ppm + Transparent polyethylene). The treatment T_1 control, on the other hand, had the lowest specific gravity of fruits.

The maximum specific gravity of fruits (1.035) was recorded under T_3 (GA_3 75ppm + Black polyethylene), which was statistically comparable to T_2 (GA_3 50ppm + Black polyethylene), T_5 (GA_3 75ppm + Transparent polyethylene), and T_1 (GA_3 75ppm + Transparent polyethylene), and the minimum specific gravity of fruits (1.016) was recorded under T_1 control, according to the pooled analysis of data.

Table-4.28: Effect of plant growth regulators and mulches on specific gravity of fruits at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	1.015	1.017	1.016
T_2(GA_3 50ppm + Black polyethylene)	1.034	1.035	1.034
T_3(GA_3 75ppm + Black polyethylene)	1.036	1.035	1.035
T_4(GA_3 50ppm + Transparent polyethylene)	1.031	1.033	1.032
T_5(GA_3 75ppm + Transparent polyethylene)	1.033	1.034	1.033
T_6(GA_3 50ppm + Paddy straw)	1.029	1.031	1.030
T_7(GA_3 75ppm + Paddy straw)	1.030	1.032	1.031
T_8(GA_3 50ppm + Rice husk)	1.027	1.029	1.028
T_9(GA_3 75ppm + Rice husk)	1.028	1.030	1.029
T_{10}(NAA 20ppm +Black polyethylene)	1.026	1.028	1.027
T_{11}(NAA 40ppm +Black polyethylene)	1.025	1.027	1.026
T_{12}(NAA 20ppm + Transparent polyethylene)	1.024	1.026	1.025
T_{13}(NAA 40ppm + Transparent polyethylene)	1.022	1.023	1.022
T_{14}(NAA 20ppm + Paddy straw)	1.021	1.022	1.021
T_{15}(NAA 40ppm + Paddy straw)	1.019	1.020	1.019
T_{16}(NAA 20ppm + Rice husk)	1.017	1.018	1.017
T_{17}(NAA 40ppm + Rice husk)	1.016	1.017	1.016
CD at (P=0.05)	0.002	0.002	0.002
SEm±	0.001	0.001	0.001

Fig. No.-4.28.1: Effect of plant growth regulators and mulches on specific gravity of fruits at 90 DAT.



4.3.6: Acidity (%)

The titratable acidity observations were recorded in strawberry cv. Chandler juice as formulated in Table 4.29 with Fig. No. 4.29.1. Revealed that there was significant variation from 0.53 to 0.84 percent during 2018-19. The plant which was nourished with treatment T_3 (GA_3 75ppm + Black polyethylene) produced the berries containing the minimum acid content, followed by T_2 (GA_3 50ppm + Black polyethylene). The fruit with the maximum acid content was recorded in T_1 (control).

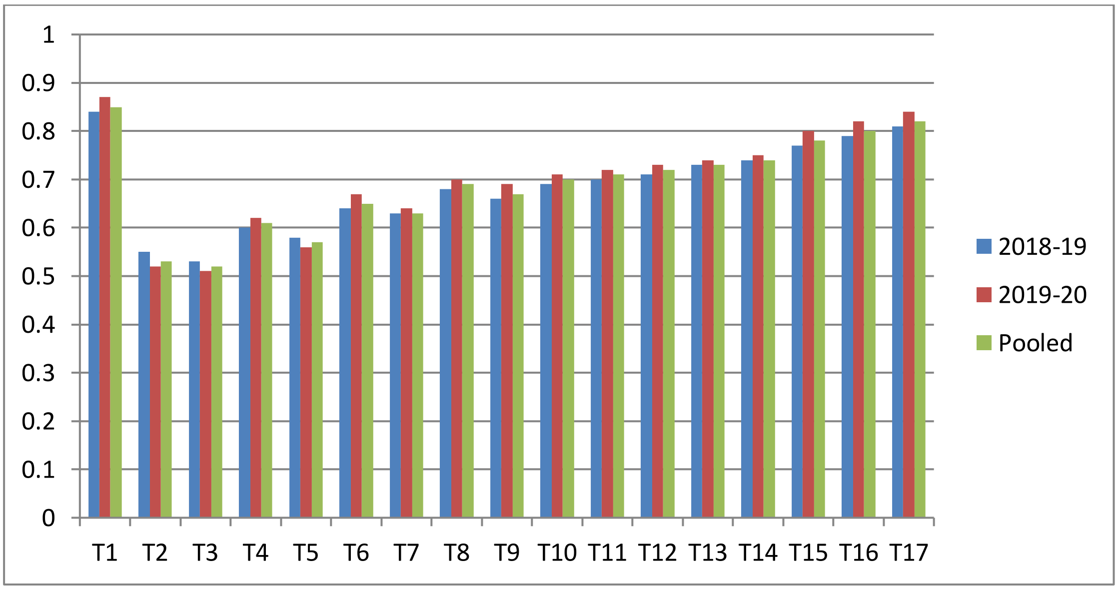
It ranged from 0.51 to 0.87 percent during the 2019-20 school years. The maximum acid (0.87%) in berries was observed in plants treated with T_1 (no PGRs and no mulching) followed by T_{17} (NAA 40ppm + rice husk).

The mean value of both years revealed that the minimum acid content was observed in T_3(GA_3 75ppm + Black polyethylene) followed by T_2(GA_3 50ppm + Black polyethylene) and the maximum acidity was observed in T_1 Control.

Table-4.29: Effect of plant growth regulators and mulches on acidity (%) at 90 DAT.

Treatment Combinations	2018-19	2019-20	Pooled
T_1 Control	0.84	0.87	0.85
T_2(GA_3 50ppm + Black polyethylene)	0.55	0.52	0.53
T_3(GA_3 75ppm + Black polyethylene)	0.53	0.51	0.52
T_4(GA_3 50ppm + Transparent polyethylene)	0.60	0.62	0.61
T_5(GA_3 75ppm + Transparent polyethylene)	0.58	0.56	0.57
T_6(GA_3 50ppm + Paddy straw)	0.64	0.67	0.65
T_7(GA_3 75ppm + Paddy straw)	0.63	0.64	0.63
T_8(GA_3 50ppm + Rice husk)	0.68	0.70	0.69
T_9(GA_3 75ppm + Rice husk)	0.66	0.69	0.67
T_{10}(NAA 20ppm +Black polyethylene)	0.69	0.71	0.70
T_{11}(NAA 40ppm +Black polyethylene)	0.70	0.72	0.71
T_{12}(NAA 20ppm + Transparent polyethylene)	0.71	0.73	0.72
T_{13}(NAA 40ppm + Transparent polyethylene)	0.73	0.74	0.73
T_{14}(NAA 20ppm + Paddy straw)	0.74	0.75	0.74
T_{15}(NAA 40ppm + Paddy straw)	0.77	0.80	0.78
T_{16}(NAA 20ppm + Rice husk)	0.79	0.82	0.80
T_{17}(NAA 40ppm + Rice husk)	0.81	0.84	0.82
CD at (P=0.05)	0.018	0.014	0.016
SEm±	0.005	0.004	0.004

Fig.No.-4.29.1: Effect of plant growth regulators and mulches on acidity (%) at 90 DAT.



Economics:

Tables 32 and 33 show the cost of cultivation, cost of production, and net profit (Rs/ha) for various treatments. In 2018-19, the selling price of strawberry fruit was Rs 70/-per kg, while in 2019-20, it was Rs 72/-per kg.

The T_3 (GA_3 75ppm + Black polyethylene) was clearly the best treatment in terms of net profit in the first and second years, with Rs. 1838812/-and Rs. 1982920/-per hectare, respectively. In this regard, T_2 (GA_3 50ppm + Black polyethylene) was the next most successful treatment. T_1 yielded the smallest net profit (control). The treatment T_3 (GA_3 75ppm + Black polyethylene) had the best benefit: a cost ratio of 2.66 in 2018–19 and 2.86 in 2019–20, followed by T_2 (GA_3 50ppm + Black polyethylene).

Based on the data, T_3 (GA_3 75ppm + Black polyethylene) application was found to be the most advantageous treatment for improving net profit and benefit: cost ratio in strawberry.

Table- 30 Economics of different treatments of plant growth regulators and mulches on strawberry cv. Chandler. (2018-2019)

Treatment Combinations	Total cost of cultivation (Rs)/ha	Total yield q/ha	Gross income (Rs/ha)	Net profit (Rs/ha)	B:C ratio
T_1 Control	426182	90.96	636720	210538	0.49
T_2(GA_3 50ppm + Black polythene)	665287	336.08	2352560	1687273	2.53
T_3(GA_3 75ppm + Black polythene)	688748	361.08	2527560	1838812	2.66
T_4(GA_3 50ppm + Transparent polythene)	632664	304.14	2128980	1496316	2.36
T_5(GA_3 75ppm + Transparent polythene)	656125	321.50	2250500	1594375	2.42
T_6(GA_3 50ppm + Paddy straw)	531421	248.59	1740130	1208709	2.27
T_7(GA_3 75ppm + Paddy straw)	557507	264.56	1851920	1294413	2.32
T_8(GA_3 50ppm + Rice husk)	545304	224.29	1570030	1024726	1.87
T_9(GA_3 75ppm + Rice husk)	571363	238.87	1672090	1100727	1.92
T_{10}(NAA 20ppm +Black polythene)	608613	219.43	1536010	927397	1.52
T_{11}(NAA 40ppm +Black polythene)	605790	209.70	1467900	862110	1.42
T_{12}(NAA 20ppm + Transparent polythene)	570740	191.65	1341550	770810	1.35
T_{13}(NAA 40ppm + Transparent polythene)	569676	175.68	1229760	660084	1.15
T_{14}(NAA 20ppm + Paddy straw)	472122	143.04	1001280	529158	1.12
T_{15}(NAA 40ppm + Paddy straw)	471924	136.10	952700	480776	1.01
T_{16}(NAA 20ppm + Rice husk)	490362	129.15	904050	413688	0.84
T_{17}(NAA 40ppm + Rice husk)	486673	115.27	806890	320217	0.65

Table- 31 Economics of different treatments of plant growth regulators and mulches on strawberry cv. Chandler. (2019-2020)

Treatment Combinations	Total cost of cultivation (Rs)/ha	Total yield q/ha	Gross income (Rs/ha)	Net profit (Rs/ha)	B:C ratio
T_1 Control	424947	98.60	709920	284973	0.67
T_2(GA_3 50ppm + Black polythene)	667580	352.06	2534832	1867252	2.79
T_3(GA_3 75ppm + Black polythene)	691880	371.50	2674800	1982920	2.86
T_4(GA_3 50ppm + Transparent polythene)	634956	313.17	2254824	1619868	2.55
T_5(GA_3 75ppm + Transparent polythene)	658391	325.67	2424816	1766425	2.68
T_6(GA_3 50ppm + Paddy straw)	519714	249.98	1799856	1280142	2.46
T_7(GA_3 75ppm + Paddy straw)	545773	265.95	1914840	1369067	2.50
T_8(GA_3 50ppm + Rice husk)	533570	235.40	1694880	1161310	2.17
T_9(GA_3 75ppm + Rice husk)	560522	248.59	1789848	1229336	2.19
T_{10}(NAA 20ppm +Black polythene)	610879	229.15	1649880	1039001	1.70
T_{11}(NAA 40ppm +Black polythene)	608082	222.20	1599840	991758	1.63
T_{12}(NAA 20ppm + Transparent polythene)	573872	198.59	1429848	855976	1.49
T_{13}(NAA 40ppm + Transparent polythene)	571942	189.57	1364904	792962	1.38
T_{14}(NAA 20ppm + Paddy straw)	460388	151.37	1089864	629476	1.36
T_{15}(NAA 40ppm + Paddy straw)	460216	145.12	1044864	584648	1.27
T_{16}(NAA 20ppm + Rice husk)	478628	136.10	979920	501292	1.04
T_{17}(NAA 40ppm + Rice husk)	474965	123.60	889920	414955	0.87

CHAPTER-5
RESULT AND DISCUSSION

RESULT AND DISCUSSION

The present research work, entitled **"Effect of plant growth regulators and mulches on growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler",** was carried out at the Horticulture Research Farm-1, Babasaheb Bhimrao Ambedkar University, Vidya Vihar Rae Bareli Road, Lucknow (U.P.) during 2018-19 and 2019-20 respectively. The results are discussed in the light of literature available and research works reported by earlier workers on strawberry and other related fruit plants, Relevant and logical explanation have been given wherever possible.

Plant height (cm)

During the investigation, it was revealed that using different types of mulch and PGRs in combination resulted in a significant increase in plant height. The most effective combination for retaining maximum plant height was (GA_3 75ppm + Black polyethylene), followed by (GA_3 50ppm + Black polyethylene) and (GA_3 75ppm + Transparent polyethylene). The application of mulching and PGR treatments may have resulted in a more congenial root zone environment due to lower weed populations, ideal soil moisture levels, increased nutrient availability, and favourable soil temperature, as well as regulated strawberry plant growth by causing cell elongation and a corresponding increase in petiole length by GA_3 application. These findings are in agreement with those of Aulakh and Sur (1999) in pomegranate, Mohanty*et al.,* (2000) in mandarin, Sharma and Sharma (2003) in strawberry, Siliguree*et al.,* (2003) in strawberry, mandarin, Khokhar*et al.,* (2004) and Sharma *et al.,* (2004) in strawberry.

Leaves characters

The maximum number of leaves per plant, the length of leaves, the length of petiole, and the length of leaves with petiole were all observed in this study in (GA_3 75ppm + Black polyethylene), followed by (GA_3 50ppm + Black polyethylene), and (GA_3 75ppm + Transparent polyethylene). The possible reason for the maximum number of leaves is the ability of gibberellins to stimulate the process of cell division and expansion in epidermal and parenchymal cells, which has been well documented (Bist *et al.,* 2018). Such activities in the meristematic tissue of leaf primordial in GA_3 treated plants might be higher, and perhaps a greater number of leaves with a broader leaf lamina and petiole of longer length. A higher concentration of GA_3 increases the above mechanisms many-folds. Earlier findings also suggested that exogenous application of GA_3 induced a higher number of leaves (Kaur*et al.*, 2009) with large leaves and petioles (Sharma and Singh, 2009) in strawberries. However, a very high concentration of GA_3 (125 mg^{l-1}) resulted in slightly stunted growth in strawberry plants. Since then, application of GA_3 at a high concentration is reported to have an inhibitory action on plants (Hedden and Sponsel, 2015).

Plant spread

In terms of plant spreading in both the N-S and E-W directions, the combination of (GA_3 75ppm + Black polyethylene) was the most effective, with (GA_3 50ppm + Black polyethylene) and (GA_3 75ppm + Transparent polyethylene) following closely behind. Increased cell division, cell elongation, and a corresponding rise in petiole length, improved soil hydrothermal regimes, improved moisture conservation, and weed suppression by GA_3 and black and transparent polyethylene mulching could all contribute to the maximum spread. In strawberry, Sharma *et al.* (2004), Singh *et al.* (2004), and Singh and Asrey (2005) found similar results.

Plant fresh and dry weight (g)

In this study, the GA_3 75ppm + Black polyethylene treatment yielded the highest plant fresh weight and plant dry weight when compared to the other treatments. The maximum fresh weight and dried weight of the plant may be raised. Other morphological characteristics such as plant fresh and plant dry weight rise in tandem with the increase in plant height and number of leaves per plant of strawberry plants. As a result, the observed yield appeared to be related to the principal effect on strawberry plant fresh and dry weight growth. In strawberries, Sharma *et al.* (2004), Singh *et al.* (2004), and Singh and Asrey (2005) found a similar effect.

Flowering

In the current investigation, with the application of NAA 20ppm + Black polyethylene, followed by NAA 40ppm + Black polyethylene, and NAA 20ppm + Transparent polyethylene), the minimum days taken to first flowering, 50 percent flowering, days taken to initial fruit set, days taken to 50 percent fruit set, and days taken to first harvesting were recorded in the current investigation. Because auxin and particularly NAA induce flowering by stimulating florigen, which drives from the petiole to the growing tip and converts vegetative bud to flowering bud, and fruit set refers to the change in the ovary leading to the development of the fruit, the possible reasons for the minimum days taken to first flowering, 50 percent flowering, days taken to initial fruit set, days taken to 50 percent fruit set, and days taken to first harvesting are that auxin and particularly NAA induce flowering by stimulating florigen, which drives from the petiole to the growing tip, 50 percent flowering by stimulating florigen, These modifications are frequently caused during NAA-induced pollination and fertilisation. The findings are in line with Thakur *et al.,* 1991; Diwedi*et al.,*20002 and Kumar *et al.,* 20011.

The number of flowers and fruits par plant

In this study, (GA_3 75ppm + Black polyethylene) had the most flowers and fruits per plant, as well as the most fruit picking, which was comparable to (GA_3 50ppm + Black polyethylene) and (GA_3 75ppm + Transparent polyethylene). Hormone application enhanced the development of different inflorescences and stimulated flowering, resulting in more flowers and fruits per plant. According to Thakur *et al.* (1991), Gupta and Acharya (1993), Khokhar*et al.* (2004), Singh and Singh (2009), Ali and Gaur (2007), and Kumar *et al.* (2012), mulching provided ideal soil moisture and temperature due to the application of GA_3 and black polyethylene mulch in strawberry.

Length and width of fruit

In this study, the application of GA_3 (75ppm + Black polyethylene) produced the longest and widest fruit, followed by GA_3 (50ppm + Black polyethylene) and GA_3 (75ppm + Transparent polyethylene). The application of mulching and PGR treatments, which result in optimum soil moisture level, enhanced availability of nutrients continuously, and cell elongation of fruit, with consequently increased fleshy receptacle and achenes, might be the source of the increasing length and width of fruit. In strawberry, Kumar *et al.* (1996), Khokar*et al.* (2004), Singh *et al.* (2005), and Ali and Gaur (2007) found similar observations.

Yield and berry character

In this study, the maximum fruit weight per berry, per plant fruit volume, and dry weight of fruit were compared to the other treatments (GA*3* 75ppm + Black polyethylene). Increased flowering and fruit set, as well as higher fruit weight and size, could explain the maximum fruit weight. The results are consistent with those of Kumar *et al.* (1996), Khokhar*et al.* (2004), Singh and Asrey (2005), and Singh *et al.* (2006) in strawberry, and they are similar to those of Al-Madhagi*et al.* (2012). Nor *et al.* (2014) also reported increased fruit volume with the foliar application of GA3 in strawberry.

Sugars

During the course of the investigation, it was found that the use of different types of mulching and PGRs in combination caused a significant increase in sugars (total, reducing, and non-reducing sugars). The most effective combination was (GA_3 75ppm + Black polyethylene), which was followed by (GA_3 50ppm + Black polyethylene) and (GA_3 75ppm + Transparent polyethylene). Increases in sugar content, for example, might be due to hormone-induced fast transformation of starch into sugar in the presence of enzymes in plastic mulch-planted plants. In strawberry, Hasan*et al.* (2000), Ghosh and Bauri*et al.* (2003) in mango, and Pandee*et al.* (2005) in sugar, all agreed.

Total Soluble Solids (ºBrix)

(GA3 75ppm + Black polyethylene) had the highest total soluble solids, followed by (GA3 50ppm + Black polyethylene) and (GA3 75ppm + Transparent polyethylene).It may be due to the application of GA_3 with black polyethylene mulching, the number of enzymes might have been stimulated. TSS may have been raised as a result of the physiological process that degraded starch and increased metabolic activity during the transformation of available starch to sugar. Wang and Galletta (1998) and Hasan*et al.* (2000) in strawberry, Ghosh and Bauri (2003) in mango, and Shirgure*et al.* (2003) in mandarin, were of the same view in respect of TSS.

Acidity (%)

The total acidity was lowest in the application of (GA_3 75ppm + Black polyethylene), followed by (GA_3 50ppm + Black polyethylene) and (GA_3 75ppm + Transparent polyethylene), with the highest acidity in the application of (GA_3 75ppm + Transparent polyethylene) (control). The increase in total acidity in fruit could be due to larger plants with more leaves, which have increased photosynthetic activity and carbohydrate accumulation in the presence of optimal soil moisture. Their metabolic involvement in regulating vital, physiological, and biochemical processes also appears to increase total acidity in fruit. This is consistent with Wang *et al.* (1996). Similar findings were reported by Hancock (1999) and Hasan*et al.* (2000).

Economics

As far as economics associated with the trail is concerned, the treatment (GA_3 75ppm + Black polyethylene) gave maximum net profit and the benefit cost ratio was 2.66 in 2018-19 and 2.86 in 2019-20 as per the cost of cultivation and net profit calculation. This might be due to the higher yield. Kumar, *et al.* (2012).

CHAPTER-6
SUMMARY AND CONCLUSION

CHAPTER-6

SUMMARY AND CONCLUSION

The current investigation, entitled **"Effect of plant growth regulators and mulches on growth, yield and quality of strawberry (Fragaria x ananassa Duch.) cv. Chandler"** was carried out at Horticulture Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow, (U.P.) during the winter season of 2018-19 and 2019-20 respectively. The experimental consisted of 17 treatments with 3 replication of variety chandler in Randomized Block Design. The silent features of the experiment are summarized below:-

1. The maximum plant height was noticed by the application of GA_3 75ppm + Black polyethylene i.e. T_3 which was at per with T_2 i.e. GA_3 50ppm + Black polyethylene. The minimum plant height was observed in control T_1 i.e. no plant growth regulators and no mulching.

2. The maximum number of leaves was studied in the application of GA_3 75ppm + Black polyethylene i.e. T_3 which was at par with T_2 i.e. GA_3 50ppm + Black polyethylene. The minimum number of leaves was assessed in control T_1 i.e. no plant growth regulators and no mulching.

3. The superior leaf length was observed in the treatment T_3 i.e. of GA_3 75ppm + Black polyethylene T_2 i.e. GA_3 50ppm + Black polyethylene whereas, minimum leaf length in T_1 (Control) i.e. no plant growth regulators and no mulching.

4. In terms of length of petiole was highest in treatment T_3 i.e. GA_3 75ppm + Black polyethylene as par with treatment T_2 GA_3 50ppm + Black polyethylene but lowest observation found in treatment T_1 (Control) i.e. no plant growth regulators and no mulching.

5. In, the highest length of petiole-bearing leaves was reported in the Treatment T_3 i.e. GA_3 75ppm + Black polyethylene followed by treatment T_2 i.e. GA_3 50ppm + Black polyethylene but minimum length of length found in treatment T_1 (Control) i.e. no plant growth regulators and no mulching.

6. In North-South direction the maximum spreading was observed in treatment T_3 i.e. GA_3 75ppm + Black polyethylene at par with treatment T_2 i.e. GA_3 50ppm + Black polyethylene, minimum spreading in T_1 (Control) i.e.no plant growth regulators and no mulching.

7. In case of East-West direction the highest spreading of plant examined in treatment T_3 i.e. GA_3 75ppm + Black polyethylene at par with treatment T_2 i.e. GA_3 50ppm + Black polyethylene, and minimum spreading in T_1 (Control) i.e.no plant growth regulators and no mulching.

8. Treatment T_3 (GA_3 75ppm + Black polyethylene) had the highest plant fresh weight, followed by treatment T_2 (GA_3 50ppm + Black polyethylene). In the (Control) group, the minimum fresh weight of the plant was recorded, i.e. no plant growth regulators or mulching.

8. The superior plant dry weight was observed in treatment T_3 i.e. GA_3 75ppm + Black polyethylene at par with treatment T_2 i.e. GA_3 50ppm + Black polyethylene whereas, minimum plant dry weight in T_1 (Control) i.e. no plant growth regulators and no mulching.

9. The minimum days taken to first flower in T_{10} i.e.(NAA 20ppm +Black polyethylene) at par with T_{11} i.e. .(NAA 40ppm +Black polyethylene)but maximum days recorded in T_1 (Control) i.e. . No plant growth regulators and no mulching.

10. Number of flowers was maximum in T_3 i.e. GA_3 75ppm + Black polyethylene at par T_2 i.e. GA_3 50ppm + Black polyethylene and minimum number of flowers was observed in T_1 (Control) i.e. no plant growth regulators and no mulching.

12. Days taken to 50% flowering was minimum assess in treatment T_{10} i.e. (NAA 20ppm +Black polyethylene) at par with T_{11} i.e. .(NAA 40ppm +Black polyethylene).Maximum days taken to flowering was observed in T_1 (Control).

13. The shortest time it took for the fruit to develop was noted in treatment $T_{10 i.e.}$ (NAA 20ppm +Black polyethylene) at par with T_{11} i.e. (NAA 40ppm +Black polyethylene). Maximum days taken to fruit set were observed in T_1 (Control).

14. Days taken to 50% fruit set was minimum in treatment T_{10} i.e. (NAA 20ppm +Black polyethylene) at par with T_{11} i.e. (NAA 40ppm +Black polyethylene).Maximum days taken to fruit set was observed in T_1 (Control).

15. Number of fruits was maximum in T_3 i.e. GA_3 75ppm + Black polyethylene at par T_2 i.e. GA_3 50ppm + Black polyethylene and minimum number of fruits was observed in T_1 (Control) i.e. no plant growth regulators and no mulching.

16. In case of days taken to first harvesting minimum days was assess in treatment T_{10} i.e. (NAA 20ppm +Black polyethylene) followed by T_{11} i.e. .(NAA 40ppm +Black polyethylene). A maximum day taken to first harvesting was observed in T_1 (Control).

17. The highest number of fruits were picked in T_3 (GA_3 75ppm + Black polyethylene) compared to T_2 (GA_3 50ppm + Black polyethylene) and the lowest number of fruits were picked in T_1 (Control) (no plant growth regulators and no mulching).

18. The highest length of fruits was assess in the treatment T_3 i.e. GA_3 75ppm + Black polyethylene followed by T_2 i.e. GA_3 50ppm + Black polyethylene and minimum length of fruits was observed in T_1 (Control) i.e. no plant growth regulators and no mulching.

19. The width of fruit was maximum in T_3 i.e. GA_3 75ppm + Black polyethylene at par with T_2 i.e.GA_3 50ppm + Black polyethylene and minimum fruit width was observed in T_1 (Control) i.e. no plant growth regulators and no mulching.

20. The maximum fruit volume observed in T_3 i.e. GA_3 75ppm + Black polyethylene followed by T_2 i.e.GA_3 50ppm + Black polyethylene and minimum fruit volume was observed in T_1 (Control) i.e. no plant growth regulators and no mulching.

21. Fruit weight par berry was superior in the treatment T_3 i.e. GA_3 75ppm + Black polyethylene followed by T_2 i.e.GA_3 50ppm + Black polyethylene and minimum Fruit weight was observed in T_1 (Control) i.e. no plant growth regulators and no mulching.

22. The maximum fruit weight per plantassess in the treatment T_3 i.e. GA_3 75ppm + Black polyethylene followed by T_2 i.e.GA_3 50ppm + Black polyethylene and

minimum fruit weight per plant was observed in T_1 (Control) i.e. no plant growth regulators and no mulching.

23. In case of dry weight of fruit the highest dry weight was recorded in treatment T_3 i.e. GA_3 75ppm + Black polyethylene followed by T_2 i.e.GA_3 50ppm + Black polyethylene and minimum dry weight of fruit was observed in T_1 (Control) i.e. no plant growth regulators and no mulching.

24. Total, Reducing and Non-reducing sugar was maximum in treatment T_3 i.e. GA_3 75ppm + Black polyethylene followed by T_2 i.e.GA_3 50ppm + Black polyethylene. In view of minimum values of sugars was noticed in T_1 (Control) i.e. no plant growth and no mulching.

25. The highest T.S.S. reading was observed in treatment T_3 i.e. GA_3 75ppm + Black polyethylene followed by T_2 i.e.GA_3 50ppm + Black polyethylene. In view of minimum reading was noticed in T_1 (Control) i.e. no plant growth and no mulching.

26. The maximum value of specific gravity was observed in treatment T_3 i.e. GA_3 75ppm + Black polyethylene followed by T_2 i.e.GA_3 50ppm + Black polyethylene. In view of minimumspecific gravity was noticed in T_1 (Control) i.e. no plant growth and no mulching.

27. The acidity was recorded minimum in treatment T_3 i.e. GA_3 75ppm + Black polyethylene, maximum acidity was find out in treatment T_1 (Control) i.e. no plant growth and no mulching.

CONCLUSION

Based on the results of the study, the application of T_3 (GA_3 75ppm + Black polyethylene) performed better in terms of growth, yield, and quality of strawberry cv. Chandler found greater performance followed by T_{10} (NAA 20ppm + Black polyethylene) except for days taken to first flower, days taken to 50% flowering, days taken to initial fruit set, days taken to 50% fruit set and days taken to first harvesting.

As a result, the usage of plant growth regulators and mulches may be recommended for increased crop yield and overall strawberry improvement.

Therefore the treatment T_3 i.e. GA_3 75ppm + Black polyethylene may be recommended for higher yield and as well as higher return in strawberry variety Chandler under Lucknow condition.

BIBLIOGRAPHY

BIBILIOGRAPHY

Abbotty, J.D. and Gough, R.E. (1992). Comparison of winter mulches of several strawberry cultivars.*J.Small Fruits Vitic.*1:51-58.

Ali, Angerj and Gaur, G.S. (2007). Effect of different mulches on growth, flowering, yield and quality of strawberry (Fragaria x ananassa Duch.) cv. Sweet Charli, The *Asian Journal of Horticulture,***2**(1): 149-151.

AI-Madhagi, I.A.H., S.M.Z. Hasa, A.B. Ahamad, A.M. Zain and W. A.B. Yusuf (2012). The influence of exogenous hormone on the flowering and fruiting of strawberry (*Fragaria x ananassa* Duch.).*Journal of Biology, Agriculture and Healthcare,***2**(4): 46-52.

Asadi, Z., M. Jafarpour, A.R. Golparvar and A.M. Khani, (2013). Effects of GA3 application on fruit yield, flowering and vegetative characteristics on early yield of strawberry cv. Gaviota.*Int. J. Agric. Crop Sci.,***5**(15): 1716-1718.

Asrey, R., Jain, R. K., & Singh, R. A. J. B. I. R. (2003). Effect of plant growth regulators on growth and survival of strawberry runners under semi arid region of Punjab. *Indian Journal of Plant Physiology*, **8**(2), 196-198.

Aulakh, P. S., & Sur, H. S. (1999). Effect of mulching on soil temperature, soil moisture, weed population, growth and yield in pomegranate. *Progressive Horticulture*, **31**(3/4), 131-133.

Bist, T.S. Rawat, L. Chakra borty, B. and Yadav, V. (2018). Recent advances in use of plant growth regulators (PGRs) in fruit crops - A review.*International Journal of Current Microbiology and Applied Sciences.***7**(5): 1307-1336.

Beech, M.G., C. And Wickenden, M.F. (1988). Effect of paclobutrazol on the growth and yield of strawbeyy (Fragaria x ananassa Duch.).*J. Hort. Sci.* 63(4): 595.

Banday, F.A., Sofi, S.A. and Hafiza, A. (2005). Effect of growth regulators on physic-chemical characters and yield attributes of strawberry. *Applied Bio. Res.,***7**(1/2):27-30.

Bhautkar MY. (1994). Effects of growth regulators on the growth and yield of strawberry. *Journal of Maharashtra Agricultural Universities***19**(2): 295-296.

Bhutkar, M.Y. (2001). Effect of plant growth regulators on growth and yield of strawberry. *J. Maharashtra Agric. Univ.,***19**(2): 295-296.

Borthakur, P. K., & Bhattacharya, R. K. (1992). Effect of organic mulches on soil organic matter content and soil pH in guava plantation. *South Ind. Hort*, **40**, 352-354.

Brain, P. W., & Hemming, H. G. (1955). The effect of gibberellic acid on shoot growth of pea seedlings. *Physiol. Plant*, **8**, 669-681.

Camcaro, M.P., Ojeda, M., Mogollon, N. And Gimenez, A, (2013). Effect of substrates and gibberellic acid on growth, production and quality of strawberry (*Fragaria x ananassa* Duch.) cv. Camarosa. Bio agro, **25**(1): 31-38.

Castro, P.R.C., Manami, K. and Vello, N.A. (1976). Effects of growth regulators on the fruiting of strawberry cultivar Monte Alegre. [*Anais da E. S. A. Luis de Queiroz*]. 33: 67-76.

Csukasi, F., Osorio, S., Gutierrez, J. R., Kitamura, J., Giavalisco, P., Nakajima, M., & Medina-Escobar, N. (2011). Gibberellic biosynthesis and signalling during development of the strawberry receptacle. *New Phytologist*, **191**(2), 376-390.

Dale, A., Elfiving, D.C. AND Chandler, C.K. (2006). Benzyladenine and gibberellic acid increases runner production in strawberries. *Horti. Sci.,***31**(7): 1190-1194.

Das, D. K., Prakash, N. S., & Bhalla-Sarin, N. (1999). Multiple shoot induction and plant regeneration in litchi (Litchi chine sis Sonn.). *Plant Cell Reports*, **18**(7), 691-695.

Dwivedi, M.P., Negi, K.S., Jindal, K.K. and Rana H.S. (2000). Influence of photoperiod and bio-regulators on vegetative growth of strawberry. *Adv. Hort. & Forestry*, **7:** 29-34.

EI-Shabasi, M.S.S.., Ragab, M.E., EI-Oksh, I.I. and Osman, Y.M.M. (2009). Responser of strawberry plants to some growth regulatorsof strawberry plants to some growth regulators. *Acta Horti.,* **842**: 725-728.

Ghosh, S. N., & Bauri, F. K. (2003). Effect of mulching on yield and physiochemical properties of mango fruits cv.'. Himsagar'grown in rain fed laterite soils. *Orissa J. Hort*, **31**(1), 78-81.

Gupta, R, and Acharya, C.L. (1993) Effect of mulch induced hydrothermal regime on root growth, water use efficiency, yield and quality of strawberry. *Journal of the Indian Society of Soil Science.* 41(1): 17-25.

Hafiz, M.A. and Hanan, I.A. (2005). Effect of different concentration of gibberellic acid on growth and of strawberry.*Sarhad J. Agri.,***6**(1): 57-59.

Hedden, P. and Sponsel, V. (2015). A century of gibberellin research. *Journal of Plant Growth Regulation*.**34**(4): 740-760.

Hassan G.I., Godara A.K., Kumar J., HucheheA.d. (2009). Effect of different mulches on yield and quality of Oso Grande' strawberry, *Indian J. Agric. Sci*. **70:** 184-185.

Hazarika, T. K., Ralte, Z., Nautiyal, B. P., & Shukla, A. C. (2015). Influence of bio-fertilizers and bio-regulators on growth, yield and quality of strawberry (*Fragaria× ananassa*). *Indian Journal of Agricultural Sciences*, **85**(9), 1201-5.

Ikram, S., & Qureshi, K. M. (2016). Effect of chilling and gibberellic acid on vegetative growth and runner production of strawberry under tunnel conditions in Pothowar. *Journal of Agricultural Research (03681157)*, **54**(3).

Ingle, H. V., Rathod, N. G., & Patil, D. R. (2001). Effect of growth regulators and mulching on yield and quality of Nagpur mandarin. *Annals of Plant Physiology*, **15**(1), 85-88.

Isamabdulbaset, H.A. Zain Hassan, S.M., Ahmad, A.Z., Abdullah, M.Z., and Yusuf, A. (2012). The influence of exogenous hormone on the flowering and fruiting of strawberry (*Fragaria× ananassa* Duch.).*J. Bio., Agri. And Healthcare*, **2**(4): 46-52.

Jain, R.A. and Singh, R.K.R. (2004). Effect of pre-harvest chemical treatments on shelf life of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler. *India J. Agric. Sci.*,**74**(9): 485-487.

Jamal Uddin, A. F. M., Hassan, M. J., Islam, M. S., Ahsan, M. K., & Mehraj, H. (2012). Strawberry growth and yield responses to gibberellic acid concentrations. *Journal of Experimental Biosciences*, **3**(2), 51-56.

Jamal Uddin, A. F. M., Hosanna, M. J., Islam, M. S., Ahsan, M. K., & Mehraj, H. (2012). Strawberry growth and yield responses to gibberellic acid concentrations. *Journal of Experimental Biosciences*, **3**(2), 51-56.

Jasrotia, R.K. Parshant, S.S., Rafiq, B. And Raina, S.V. (2014). Influence of gibberellic acid and blossom removal on flowering and yield of strawberry (*Fragaria x ananassa* Duch.) cv. Belrubi. *Int. J. Agric. Sci.*,**10**(1):272-275.

Jasrotia, R.K., Parshant, S.S., Rafiq, B. And Raina, S.V. (2014). Influence of gibberellic acid and blossom removal on flowering and yield of strawberry (*Fragaria x ananassa* Duch) cv. Belrubi. *Int. J. Agric. Sci.*,**10**(1): 272-275.

Kale, L., Skeel, R., Bhandarkar, M., Brunner, R., Gursoy, A., Krawetz, N., & Schulten, K. (1999). NAMD2: greater scalability for parallel molecular dynamics. *Journal of Computational Physics*, **151**(1), 283-312.

Kour, R. And Singh, S. (2009). Impact of mulching on growth, fruit yield and quality of strawberry (*Fragari x ananassa* Duch.), *Asian Journal of Horticulture*, **49**(1): 63-64

Kumar, J., Rana, S.S., Verma, H.S. and Jindal, K.K. (1996). Effect of various growth regulators on growth, yield and fruit quality of strawberry cv. Tioga.Haryana Journal of Horticultural Sciences. 25(4): 168-171

Kaufman, E., & Libek, A. (2000). The occurrence of arthropods in strawberry plantation depending on the method of cultivation. In *Proceedings of the International Conference Fruit Production and Fruit Breeding, Tartu, Estonia, 12-13 September*,2000 (pp. 204-208). Estonian Agricultural University.

Kęsik, T., & Maskalaniec, T. (2003). Wpływściółkowaniaplantacjinawzrost, kwitnienie i owocowanie truskawki (*Fragaria x ananassa* D.). *In* Annals *Universitatis Mariae Curie-Sklodowska.Sectio epee.Horticulture* (Vol. **13**, pp. 243-248).

Khan, M. A., Sastry, S. V., Vaithiyalingam, S. R., Agarwal, V., Nazzal, S., & Reddy, I. K. (2000). Captopril gastrointestinal therapeutic system coated with cellulose acetate pseudo latex: evaluation of main effects of several formulation variables. *International journal of pharmaceutics*, **193**(2), 147-156.

Khokhar UU; Prashad J and Sharma MK (2004) Influence of growth regulators on growth, yield and quality of strawberry cv. Chandler.*Haryana J Hort Sci***33** (3/4): 186-188.

Khunte S.D., Kumar A, Kumar V, Singh S, Sarvanan S. (2014). Effects of plant growth regulators and organic manure on physic-chemical properties of Strawberry cv. Chandler.*International Journal of Scientific Research and Education.;* **2**(7):1424-1435.

Kumar, R., & Tirpathi, V. K. (2009). Influence of NAA, GA3 and boric acid on growth, yield and quality of strawberry cv. Chandler. *Progressive Horticulture*, **41**(1), 113-115.

Kumar, R., & Tirpathi, V. K. (2009). Influence of NAA, GA3 and boric acid on growth, yield and quality of strawberry cv. Chandler. *Progressive Horticulture*, **41**(1), 113-115.

Kumar, R., Saravanan, S., Bakshi, B. And Sharma, R.M. (2013). Influence of gibberellic acid and blossom removal on fruit quality of strawberry (*Fragaria x ananassa* Duch.) cv. Belrubi. *Indian J.Horti.***26**(1): 137-139.

Kumar, R., Saravanan, S., Bakshi, P., & Srivastava, J. N. (2011). Influence of plant growth regulators on growth, yield and quality of strawberry (*Fragaria x ananassa* Duch) cv. Sweet Charlie. *Progressive horticulture*, **43**(2), 264-267.

Kumar, R., Sharma, N., Jamwal, M., Sarma, R.M. and Singh, D.B. (2012). Production and economics studies of PBRs treated strawberry (*Fragaria* ×

ananassa) cv. Sweet Charli. AM-*Euras.J.Agric. & Environ. Sci.*,**12**(12): 1543-1547.

Kumar, S., Sharma, I. P., & Raina, J. N. (2005). Effect of levels and application methods of irrigation and mulch materials on strawberry production in north-west Himalayas. *Journal of the Indian Society of Soil Science*, **53**(1), 60-65.

Lolaei A, N. Teymouri1, R. Bemana1, A. K. Pour, and S. Aminian. (2013). Effect of Gibberellic on Vegetative and Sexual Growth and Fruit Quality of Strawberry *(Fragaria ×ananassa* Duch. cv. Selva and Queen Elisa) *Int. J. Agri Crop Sci*. **5** (14), 1508-1513.

Lourduraj, A. C., Sreenarayanan, V. V., Rajendran, R., Ravi, V., Padmini, K., & Pandiarajan, T. (1996). Effect of plastic mulching on tomato yield and economics. *South Indian Horticulture*, **44,** 139-142.

Lucchesi, A. A., & Minami, K. (1980). The use of growth regulators in strawberries: influence on the growth cycle and final productivity. *Anais da Escola Superior de Agriculture" Luiz de Queiroz"*, **37**, 485-515.

Matsuane, C., Oseni, T. O., & Masarirambi, M. T. (2016). Effects of crop bio life on the growth, fruit yield and quality of strawberry (*Fragaria× ananassa*) in a Sub-tropical environment. *UNESWA Journal of Agriculture (UJA)*.

Montero, T., Molla, E., Martin Cabrejas, M.A. and Andreu, F.J. (2001). Effect of gibberellic acid on strawberry (phenylalanine ammonialyase) and TAL (tyrosine ammonialyase) enzyme activities. *J. Sci. Of food and Agri.*,**77**(2): 230-234.

Mohanty, S., Sonkar, R.K. and Marathe, R.A. (2002). Effect of mulching on Nagpur mandarin cultivation in drought prone region of Central India.*Indian Journal of Soil Conservation;***30**(3): 286-289.

Moor U., Karp, K., & Põldma, P. (2004). Effect of mulching and fertilization on the quality of strawberries.

Nor, S.S., Razifzh, M.R., Mamat, A.S. and Adzemi, M.A. (2014). Application of gibberellic acid in stem cutting of dsabon fruit (Hylocereuspolyrhizus) Effect on fruit quality and yield at harvest. *Journal of Biology Agriculture and Halthcare*,**4**(21): 51-55.

Ozguven, A. I., & Kaska, N. (1993). The effect of GA on the precocity of strawberry crowns in Adana-Turkey. *Acta Horticulture*, **345**, 73-79.

Ozguven, A. I., & Kaska, N. (1993). The effect of GA on the precocity of strawberry crowns in Adana-Turkey. *Acta Horticulture*, **345**, 73-79.

Ozgüven, A. I., & Yilmaz, C. (2002). The effect of gibberellic acid treatments on the yield and fruit quality of strawberry (*Fragaria* x *ananassa*) cv. Camarosa. In *IV International Strawberry Symposium* **567** (pp. 277-280).

Palei, S., Das, K., Sahoo, K., Dash, D. K., & Swain, S. (2016). Influence of plant growth regulators on strawberry Cv. Chandler under Odisha condition. *Int. J. Sci. Res*, *7*, 9945-9948.

Pande, K. K., Dimri, D. C., & Kamboj, P. (2005). Effect of various mulches on growth, yield and quality attributes of apple. *Indian Journal of Horticulture*, **62**(2), 145-147.

Pankov, V. V. (1992). Effect of growth regulators on plant production of strawberry mother plants. *Scientia horticulture*, **52**(1-2), 157-161.

Patra, R.K., Debnath, S., Das, B.C. and Hassan, M.A. (2004). Effect of mulching on growth and fruit yield of guava cv. Sardar.*Orissa J. Hort*., **32**(2):38-42.

Pérez de Camacaro, M., Mogollón, N., Ojeda, M., Giménez, A., and Colmenares, C. (2009). The effect of gibberellic acid on the growth and flowering of strawberry (*Fragaria* × *ananassa* Duch.)'Chandler' vitroplants.*Acta Hort.***842**, 793–796

Phadung, T., Nilnond, S., Phavaphutanon, L., & Thongpae, S. (2005). Effects of irrigation and mulching materials on growth, yield and berry quality of'Perlette'grape. In Proceedings of 43rd Kasetsart University Annual Conference, Thailand, 1-4 February, 2005.Subject: Plants (pp. 459-466). Kasetsart University.

Prasad, M., Minz, M., Kumar, R. And Das, B. (2012). Effect of mulching and PGRss on growth, yield and economics of strawberry (*Fragaria × ananassa*) cv. Douglas. *J. Iteracamedicia***, 16**(1): 44-45

Prasad.Minz, M., Jha, K.K., Kumar, R. And Das, B. (2013). Studies on the effect of mulching and PGRs on physic-chemical characters and post-harvest performance of strawberry (Fragaria x ananassa Duch.) cv. Douglas.*Interacadmicia*,**17**(1): 11-16.

Qirui, W.(2005). Effects of mulching on flowering and fruit set in sweet cherry trees. *Journal of Fruit Science*, **22**(6), 719-721.

Rajbahar, Y.P., Singh, B., Singh, G., Singh, D.K. and Kumar, M. (2015). Studies on the effect of growth regulators and vermi-compost on growth and yield of different cultivars of strawberry (*Fragaria x ananassa* Duch.).*Asian J. Hort.*,**10**(2): 222-231.

Roussos, P. A., Denaxa, N., & Damvakaris, T. (2009). Strawberry fruit quality attributes after application of plant growth stimulating compounds. *Scientia Horticulture*, **119(**2), 138-146.

Sharma, R.R. and R. Singh (2009). Gibberellic acid influences the production of malformed and button berries and fruit yield and quality in strawberry (*Fragaria x ananassa* Duch.). *Scientia Horticulture*,**119**(4): 430-433.

Singh A, Singh J.N., (2009). Effect of bio-regulators on growth, yield and nutrient status of strawberry cv. Sweet Charlie.*Indian J. Horti.***66**(2): 220-240.

Siligure, P.S., R.K. Sankar, S. Singh and P. Panigrahi (2003). Effect of different mulches on soil moisture conservation, weed reduction, growth and yield of drip irrigated Nagpur mandarin (*Citrus reticulate*). *Indian Journal of Agricultural Sciences*,**73**(3): 148-152.

Singh, R., Asrey, R., Kumar, S. (2006) Effect of plastic tunnel and mulching on growth and yield of strawberry. *Ind. J. Horti.* 63(1): 18-20.

Saima, Z., Sharma, A., Umar, I., & Wali, V. K. (2014). Effect of plant bio-regulators on vegetative growth, yield and quality of strawberry cv. Chandler. *African journal of agricultural research*, **9**(22), 1694-1699.

Sánchez Blanco, M. J., Torrecillas, A., León, A., & Del Amor, F. (1989). The effect of different irrigation treatments on yield and quality of Verna lemon. *Plant and Soil*, **120**(2), 299-302.

Sekhar, R.S., Mehta, K., Kumari, S, and Kaisi, K. (2016). Effect of growth regulators on growth and yield of strawberry (*Fragaria x ananassa* Duch.) cv. Chandler.*Environ. & Ecology,* **34** (3B): 1247-1250.

Sharma, R. R., & Sharma, V. P. (2003). Mulch type influences plant growth, albinism disorder and fruit quality in strawberry (*Fragaria× ananassa* Duch.). *Fruits*, **58**(4), 221-227.

Sharma, R. R., & Sharma, V. P. (2004). Plant growth and albinism disorder in different strawberry cultivars under Delhi conditions. *Indian Journal of Horticulture*, **61**(1), 92-93.

Shirgure, P. S., Singh, S., Panigrahi, P., & Sonkar, R. K. (2005). Evaluation of mulches for improving bearing in acid lime. *Indian Journal of Soil Conservation*, **33(**1), 62-66.

Singh, A. And Singh, J.N. (2005). Flowering, fruiting and yield responses to plant bio-regulators of strawberry cv. Sweet Charli.*Enviro. And Ecology*, **23**(S4): 714-716.

Singh, O. P., & Phogat, K. P. S. (1983). Effect of plant growth regulators on strawberry. *Progressive Horticulture Journal*, **15,** 64-68.

Singh, R., & Asrey, R. (2005). Growth, earliness and fruit yield of micro-irrigated strawberry as affected by planting time and mulching in semi-arid regions. *Indian journal of horticulture*, **62**(2), 148-151.

Singh, R., Bhandari, A. R., & Thakur, B. C. (2004). Effect of mulching on in-situ soil moisture, growth, yield and economics of plum fruit trees under rain fed condition in mid hills of Himalayas. *Journal of the Indian Society of Soil Science*, **52**(4), 411-414.

Srivastava, A. K., Shirgure, P. S., & Singh, S. (2003). Differential fertigation response of Nagpur mandarin (Citrus reticulate Blanco) on an alkaline Inceptisol under the sub-humid tropical climate of Central India. *Tropical agriculture-London then Trinidad-*, **80**(2), 97-104.

Srivastava, R. P., & Singh, L. (1969). Effect of growth substances on the quality of litchi. *Hort. Sci*, **1**(2), 1-6.

Srivastava, R., Pathak, V. M., & Rao, V. V. (1988). Flat band potential of as-grown n-MoSe2 single crystal electrodes. *physical status solid (a)*, **110**(1), 293-299.

Thakur, A. S., Jindal, K. K., & Sud, A. (1991). Effect of growth substances on vegetative growth, yield and quality parameters in strawberry. *Indian Journal of Horticulture*, **48**(4), 286-290.

Tarara, J.M. (2000). Microclimate modifications with plastic mulch.*Hort Science.***35**(2):169-180.

Thakur, S., Mehta, K. And Sekhar, R.S. (2015). Effect of GA_3 and plant growth promoting rhizobacteria on growth, yield and fruit quality of strawberry (*Fragaria x ananassa* Duch.) cv. Chandler.*Int. J. Advance RES.*,**3**(11): 312-317.

Tirpathi, V. K., & Shukla, P. K. (2010). Influence of plant bio-regulators, boric acid and zinc sulphate on yield and fruit characters of strawberry cv. Chandler. *Progressive Horticulture*, **42**(2), 186-188.

Tiwari, A.K., Saravanan, S. And Lall, D. (2017). Influence of different plant growth regulators on vegetative growth and Physico-chemical properties of strawberry (*Fragaria× ananassa*) cv. Chandler. *Plant Archive*,**17**(1): 367-370.

Van Koot, I., & Wiertz, G. (1947). Onderzoek naar de afstervings temperature van enkele voor de plantengroel schadelijke bodem-organismen. *Tijdschrift over Plantenziekten*, **53(**5), 121-133.

Verma, M. L., Bhardwaj, S. P., Thakur, B. C., & Bhandari, A. R. (2005). Nutritional and mulching studies in apple. *Indian Journal of Horticulture*, **62**(4), 332-335.

Viasus-Quintero, G., Álvarez-Herrera, J., & Alvarado-Sanabria, O. (2013). Efecto de la application de gibberellins' y 6-bencilaminopurina en la production y calidad de fresa (*Fragaria x Ananassa* Duch.). *Bioagro*, **25**(3), 195-200.

Vishal, V. C., Thippesha, D., Chethana, K., Maheshgowda, B. M., Veeresha, B. G. and Basavraj, A. K. (2016). Effect of Various Growth Regulators on Vegetative parameters of strawberry (*Fragaria x ananassa* Duch.) Cv. Sujatha. *Res. J. Chemical and Env. Sci*., **4**(4): 68- 71.

Wang, S. Y., Galletta, G. J., Camp, M. J., & Kasperbauer, M. J. (1998). Mulch types affect fruit quality and composition of two strawberry genotypes. *Hort Science*, **33**(4), 636-640.

Weidman, R. W., & Stang, E. J. (1983). Effects of gibberellins (GA4+ 7), 6-benzyladenine (6-BA) and Promalin (GA4+ 7+ 6-BA) plant growth regulators on plant growth, branch crown and flower development in'Scott'and'Raritan'strawberries. *Advances in strawberry production (USA)*.

Wang, H., G> Cao and R.L. Prior (1996). Total antioxidant properties of fruits. *Journal of Agriculture and Food Chemistry,***44:** 701-705.

Yadav, A., Pratap, B., Shivam, Kumar, A. And Patro, A. (2018). Assess the effect of micro-nutrient and plant growth regulators and quality parameters of strawberry cv. Chandler. *The Pharma Innovation J.*, **7**(1): 303-305.

Yadav, I., Singh, J., Meena, B., Singh, P., Meena, S., Neware. (2017). 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.*Chem. Sci. Rev. Lett.,***6**(21): 589-594.

APPENDICES

APPENDICES

Appendix-1

Analysis of variance of plant height (cm) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Replications	2	12.800			
Treatments	16	155.273	9.705	16.443	0.00000
Error	32	18.886	0.590		
Total	50	186.959			

Appendix-2

Analysis of variance of plant height (cm) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	3.218			
Treatments	16	182.420	11.401	17.990	0.00000
Error	32	20.281	0.634		
Total	50	205.918			

Appendix-3

Analysis of variance of number of leaves at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.396			
Treatments	16	151.911	9.494	9.764	0.00000
Error	32	31.117	0.972		
Total	50	183.423			

Appendix-4

Analysis of variance of number of leaves at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.719			
Treatments	16	257.459	16.091	13.878	0.00000
Error	32	37.102	1.159		
Total	50	296.282			

Appendix-5

Analysis of variance of length of leaves (cm) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.070			
Treatments	16	29.298	1.831	6.676	0.00000
Error	32	8.777	0.274		
Total	50	38.145			

Appendix-6

Analysis of variance of length of leaves (cm) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.326			
Treatments	16	26.183	1.636	27.746	0.00000
Error	32	1.887	0.059		
Total	50	28.396			

Appendix-7

Analysis of variance of length of petiole (cm) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.887			
Treatments	16	33.290	2.081	5.276	0.00003
Error	32	12.619	0.394		
Total	50	46.797			

Appendix-8

Analysis of variance of length of petiole (cm) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.376			
Treatments	16	39.162	2.448	6.750	0.00000
Error	32	11.604	0.363		
Total	50	52.142			

Appendix-9

Analysis of variance of length of leaves with petiole(cm) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.622			
Treatments	16	119.197	7.450	8.914	0.00000
Error	32	26.745	0.836		
Total	50	146.564			

Appendix-10

Analysis of variance of length of leaves with petiole (cm) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	3.120			
Treatments	16	112.103	7.006	20.175	0.00000
Error	32	11.113	0.347		
Total	50	126.337			

Appendix-11

Analysis of variance of plant spread N-S (cm) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	6.511			
Treatments	16	197.075	12.317	5.050	0.00005
Error	32	78.052	2.439		
Total	50	281.637			

Appendix-12

Analysis of variance of plant spread N-S (cm) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	5.518			
Treatments	16	212.638	13.290	12.716	0.00000
Error	32	33.443	1.045		
Total	50	251.599			

Appendix-13

Analysis of variance of plant spread E-W (cm) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	2.033			
Treatments	16	195.282	12.205	13.010	0.00000
Error	32	30.021	0.938		
Total	50	227.336			

Appendix-14

Analysis of variance of plant spread E-W (cm) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.373			
Treatments	16	210.909	13.182	20.156	0.00000
Error	32	20.928	0.654		
Total	50	232.210			

Appendix-15

Analysis of variance of plant fresh weight (g) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	259.569			
Treatments	16	31376.157	1919.010	25.651	0.00000
Error	32	2446.431	76.451		
Total	50	34082.157			

Appendix-16

Analysis of variance of plant fresh weight (g) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1430.465			
Treatments	16	33199.302	2074.956	4.039	0.00038
Error	32	16439.778	513.743		
Total	50	51069.545			

Appendix-17

Analysis of variance of plant dry weight (g) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	11.473			
Treatments	16	3861.106	241.319	12.306	0.00000
Error	32	627.516	19.610		
Total	50	4500.095			

Appendix-18

Analysis of variance of plant dry weight (g) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	56.745			
Treatments	16	2985.832	186.615	46.382	0.00000
Error	32	128.750	4.023		
Total	50	3171.328			

Appendix-19

Analysis of variance of days taken to first flower at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.216			
Treatments	16	162.353	10.147	12.432	0.00000
Error	32	26.118	0.816		
Total	50	189.686			

Appendix-20

Analysis of variance of days taken to first flower at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	4.392			
Treatments	16	122.706	7.669	11.719	0.00000
Error	32	20.941	0.654		
Total	50	148.039			

Appendix-21

Analysis of variance of number of flower per plant at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.922			
Treatments	16	1044.510	65.282	57.902	-0.00000
Error	32	36.078	1.127		
Total	50	1082.510			

Appendix-22

Analysis of variance of number of flower per plant at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.529			
Treatments	16	1096.157	68.510	114.557	-0.00000
Error	32	19.137	0.598		
Total	50	1116.824			

Appendix-23

Analysis of variance of days taken to 50% flowering at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	2.929			
Treatments	16	130.438	8.152	8.873	0.00000
Error	32	29.400	0.919		
Total	50	162.767			

Appendix-24

Analysis of variance of days taken to 50% flowering at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	10.037			
Treatments	16	106.529	6.658	7.425	0.00000
Error	32	28.693	0.897		
Total	50	145.259			

Appendix-25

Analysis of variance of days taken initial of fruit set at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.274			
Treatments	16	18.219	1.139	4.261	0.00024
Error	32	8.553	0.267		
Total	50	27.064			

Appendix-26

Analysis of variance of days taken initial of fruit set at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.003			
Treatments	16	16.830	1.052	4.621	0.00011
Error	32	7.283	0.228		
Total	50	24.116			

Appendix-27

Analysis of variance of days taken 50% of fruit set at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	2.863			
Treatments	16	136.353	8.522	10.302	0.00000
Error	32	26.471	0.827		
Total	50	165.686			

Appendix-28

Analysis of variance of days taken 50% of fruit set at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.471			
Treatments	16	142.314	8.895	13.643	0.00000
Error	32	20.863	0.652		
Total	50	163.647			

Appendix-29

Analysis of variance of number of fruits per plant at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.745			
Treatments	16	1075.922	67.245	92.533	0.00000
Error	32	23.255	0.727		
Total	50	1099.922			

Appendix-30

Analysis of variance of number of fruits per plant at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.471			
Treatments	16	1082.000	67.625	84.765	-0.00000
Error	32	25.529	0.798		
Total	50	1108.000			

Appendix-31

Analysis of variance of days taken to first harvesting at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	2.803			
Treatments	16	364.099	22.756	4.851	0.00007
Error	32	150.098	4.691		
Total	50	517.000			

Appendix-32

Analysis of variance of days taken to first harvesting at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	3.830			
Treatments	16	184.416	11.526	3.988	0.00043
Error	32	92.481	2.890		
Total	50	280.727			

Appendix-33

Analysis of variance of number of picking at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	2.039			
Treatments	16	1190.627	34.272	37.894	-0.00000
Error	32	21.961	0.904		
Total	50	1214.627			

Appendix-34

Analysis of variance of number of picking at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	3.098			
Treatments	16	1176.039	73.502	182.304	-0.00000
Error	32	12.902	0.403		
Total	50	1192.039			

Appendix-35

Analysis of variance of fruit length (cm) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.978			
Treatments	16	9.803	0.613	3.098	0.00315
Error	32	6.329	0.198		
Total	50	18.110			

Appendix-36

Analysis of variance of fruit length (cm) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.059			
Treatments	16	7.173	0.448	3.192	0.00253
Error	32	4.494	0.140		
Total	50	12.726			

Appendix-37

Analysis of variance of fruit width (cm) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.790			
Treatments	16	8.337	0.521	2.495	0.01353
Error	32	6.683	0.209		
Total	50	16.810			

Appendix-38

Analysis of variance of fruit width (cm) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.962			
Treatments	16	8.020	0.501	3.468	0.00134
Error	32	4.625	0.145		
Total	50	13.606			

Appendix-39

Analysis of variance of fruit volume (cc) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.606			
Treatments	16	58.701	3.669	5.403	0.00003
Error	32	21.729	0.679		
Total	50	81.036			

Appendix-40

Analysis of variance of fruit volume (cc) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.722			
Treatments	16	55.695	3.481	7.699	0.00000
Error	32	14.468	0.452		
Total	50	71.885			

Appendix-41

Analysis of variance of fruit weight per berry (g) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.519			
Treatments	16	58.638	3.665	5.295	0.00003
Error	32	22.148	0.692		
Total	50	81.305			

Appendix-42

Analysis of variance of fruit weight per berry (g) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.712			
Treatments	16	56.863	3.554	7.521	0.00000
Error	32	15.121	0.473		
Total	50	73.696			

Appendix-43

Analysis of variance of fruit weight per plant (g) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	6.392			
Treatments	16	1286.745	80.422	119.100	-0.00000
Error	32	21.608	0.675		
Total	50	1314.745			

Appendix-44

Analysis of variance of fruit weight per plant (g) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1727.883			
Treatments	16	139280.806	8705.050	30.208	0.00000
Error	32	92.21.592	288.175		
Total	50	150230.280			

Appendix-45

Analysis of variance of dry weight of fruit (g) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.001			
Treatments	16	0.121	0.008	7.231	0.00000
Error	32	0.034	0.001		
Total	50	0.155			

Appendix-46

Analysis of variance of dry weight of fruit (g) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.001			
Treatments	16	0.128	0.008	9.650	0.00000
Error	32	0.027	0.001		
Total	50	0.156			

Appendix-47

Analysis of variance of reducing sugar (%) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.755			
Treatments	16	13.714	0.857	4.031	0.00039
Error	32	6.805	0.213		
Total	50	21.274			

Appendix-48

Analysis of variance of reducing sugar (%) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.181			
Treatments	16	14.344	0.896	7.468	0.00000
Error	32	3.841	0.120		
Total	50	18.366			

Appendix-49

Analysis of variance of non-reducing sugar (%) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.931			
Treatments	16	11.729	0.733	4.099	0.00034
Error	32	5.723	0.179		
Total	50	19.382			

Appendix-50

Analysis of variance of non-reducing sugar (%) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	1.156			
Treatments	16	14.545	0.909	4.384	0.00019
Error	32	6.635	0.207		
Total	50	22.336			

Appendix-51

Analysis of variance of total sugars (%) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	4.098			
Treatments	16	48.827	3.052	4.505	0.00014
Error	32	21.675	0.677		
Total	50	74.600			

Appendix-52

Analysis of variance of total sugars (%) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	2.091			
Treatments	16	53.695	3.356	6.927	0.00000
Error	32	15.502	0.484		
Total	50	71.289			

Appendix-53

Analysis of variance of total soluble solids (ºBrix) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.155			
Treatments	16	94.110	5.882	10.392	0.00000
Error	32	18.112	0.566		
Total	50	112.376			

Appendix-54

Analysis of variance of total soluble solids (ºBrix) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.412			
Treatments	16	109.968	6.873	12.268	0.00000
Error	32	17.928	0.560		
Total	50	128.308			

Appendix-55

Analysis of variance of specific gravity of fruits at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	-0.000			
Treatments	16	0.002	0.000	73.921	0.00000
Error	32	0.000	0.000		
Total	50	0.002			

Appendix-56

Analysis of variance of specific gravity of fruits at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	-0.000			
Treatments	16	0.002	0.000	70.671	-0.00000
Error	32	0.000	0.000		
Total	50	0.002			

Appendix-57

Analysis of variance of acidity (%) at 90 days after planting 2018-19

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.000			
Treatments	16	0.389	0.024	199.768	-0.00000
Error	32	0.004	0.000		
Total	50	0.393			

Appendix-58

Analysis of variance of acidity (%) at 90 days after planting 2019-20

Source of Variation	DF	Sum of Squares	Mean Squares	F- Calculated	Significance
Replications	2	0.000			
Treatments	16	0.440	0.028	216.715	0.00000
Error	32	0.004	0.000		
Total	50	0.444			