Effect of Inorganic and Bio-fertilizers on Growth, Yield and Physico-chemical characters of Strawberry (*Fragaria x annanasa* L. Duch.) cv. Chandler in Central Uttar Pradesh

THESIS

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2018

Enrollment No.-301/13

Dedicated to

My Loving Parents

Shashank Verma...

DECLARATION

I, Shashank Verma, Enrollment No. -301/13, hereby declare that, I am a candidate for the degree of Doctor of Philosophy in Horticulture, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-vihar, Rae Bareli Road, Lucknow (U.P.), India and have carried out my research work entitled **"Effect of Inorganic and Bio-fertilizers on Growth, Yield and Physico – chemical characters of Strawberry (*Fragaria* x *annanasa* L. Duch.) cv. Chandler in Central Uttar Pradesh".** This thesis is submitted for the award of degree of Doctor of Philosophy in Horticulture is my original research work.

This thesis submitted to Babasaheb Bhimrao Ambedker 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.

(SHASHANK VERMA)

Place: B.B.A.U. Lucknow

Date: 13/07/18

CERTIFICATE

This is to certify that the thesis titled "**Effect of Inorganic and Bio-fertilizers on Growth, Yield and Physico– chemical characters of Strawberry (*Fragaria* x *annanasa* L. Duch.) cv. Chandler in Central Uttar Pradesh**" submitted by **Mr. Shashank Verma** 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 Ambedker 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

Place: Lucknow

Date: 13-07-2018

Co-Supervisor

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Date: 13/07/18

Shashank Verma

Place: B.B.A.U. Lucknow

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBEREVITIONS

ANOVA	:	Analysis of variance
CD	:	Critical Difference
cm	:	Centimetre
CV	:	Coefficient of variation
per se	:	As such with mean
et al.	:	and others
Fig	:	Figure
g	:	Gram
kg	:	Kilogram
m	:	Metre
Ha	:	Hectare
T	:	Ton
SE (d)	:	Standard error difference
S.Em	:	Standard error mean
Df	:	Degrees of freedom
RBD	:	Randomized Block Design
Vit-C	:	Ascorbic Acid
viz.	:	Namely
No.	:	Number

INTRODUCTION

Chapter I

INTRODUCTION

Strawberry is an important fruit crop whose cultivation has ample scope near the cities and belongs to the family Rosaceae. The commercial variety of strawberry *(Fragaria x ananassa Duch.)* has cultivated in about 75 countries**.** Strawberry *(Fragaria × ananassa Duch.)* is one the most popular soft fruits cultivated in plains as well as in the hills up to an elevation of 3000 m in humid or dry regions. Strawberry, an herbaceous perennial member of Rosaceae, is a widely relished fruit owing to its flavour, deliciousness, softness and rich source of mineral and nutrients. The crop is in great demand for fresh fruits as well as in the processing industries, particularly for flavour purposes. Maharashtra, Punjab, Haryana, Himachal Pradesh and Uttarakhand are the major states for its cultivation. In Jammu and Kashmir, the crop has assumed economic importance mainly due to the high returns per unit area. Among perennial crops, strawberries are an ideal model to study the nutrients transformations. This has been attributed to the production of berries within a few months of planting due to small plant size and establishment of more plots within uniform soils. Although strawberry cultivation is becoming popular in Jammu and Kashmir, but the farmers are continuing to grow them as a subsidiary crop. Due to lack of proper attention, farmers usually harvest smaller fruits and poor yields. In order to harvest higher yields and quality fruits, use of chemical fertilizers has contributed significantly. However, continuous and indiscriminate use of chemical fertilizers has caused serious damage to the soil ecosystem and Physico-chemical characteristics. Although, many organic options are available but high yield and better quality fruits cannot be expected from the sole application of organic manures or biological products. Therefore, a judicious combination of inorganic and organic fertilizers or bio-fertilizers may be helpful in increasing the fruit production in strawberry. Moreover, such efforts shall be helpful to maintain sustainable productivity and soil health. Amongst various available organic options, bio-fertilizers are agriculturally important beneficial micro-organisms which have ability to mobilize the nutritionally important elements. Moreover, they are cost effective and renewable. The total cultivated area of strawberry occupies about 12000 hectare of farmland in Egypt with a total production quantity of about 242,200 ton (FAO, 2012).

The cultivated strawberry (*Fragaria* × *ananassa* Duch.) is originated from the hybridization of two American species *Fragaria chiloensis* and *Fragaria virginiana* which was first developed in France in the 17^{th} century. All the cultivated varieties of strawberry are octaploid having chromosome number 2n =56 (Anonymous, 1956).

Organic agriculture is an alternative production system that decreases negative ecological balance. The system recommends organic and green manure, crop rotation, and soil protection to utilize on-site parasite and predators for biological control and to enhance biodiversity. In addition, organic agriculture aims not only to increase yield but also crop quality (Aksoy & Altindisli, 1998; Anon, 2007). In recent years, the organic cultivation techniques for berries have been developed and the cultivation technique of strawberry grown in organic systems have been reported in many papers (Gliesman *et al.,* 1996; Pranckietene & Pranckietis, 2000; Duagaard, 2001; Leskinen *et al.,* 2002; Forcella *et al.,* 2003; Prokkola *et al.,* 2003; Gurena & Born, 2007; Balci & Demirsoy, 2008). Prerequisites for a successful strawberry growing are climate, cultivars and soil (Albregts & Howard, 1980; Almaliotis *et al.,* 2002; Daugaard, 2001). Specific nutrient management practices are required for individual cultivars grown under widely different environmental conditions to ensure high yields and quality in fruits (May & Pritts, 1990). Fertilizers used in organic growing are applied at moderate levels and usually mixed into the soil. Strawberries require moderate applications of nitrogen and that the plant uses slight amounts of nitrogen during its growing period (Daugaard, 2001). However, macro and micro mineral elements such as N, P, K, Fe and Mn have a great importance in strawberry growing (May & Pritts, 1990; Kessel, 2003; Ersoy & Demirsoy, 2006). There are few reports indicating low yield in organic agriculture (Enke, 1988; Glissman *et al*., 1996; Pranckietiene & Pranckietis, 2000). Yield of strawberry plants are closely related to vegetative growing parameters such as leaf area, petiole length, petiole diameter, crown number, crown diameter, leaf dry weight, crown dry weight and root dry weight. For this reasons, growing parameters should be investigated in organic and conventional growing. The study aimed to compare organic and conventional strawberry growing systems in terms of contents of mineral elements such as N, P, K, Fe, Mn in strawberry plants and yield, and some growth parameters in Sweet Charlie and Camarosa strawberry cultivars.

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most delicious fruits of the world, which is a rich source of vitamins and minerals and has fabulous flavour and tantalizing aroma**.** Strawberry is one of the most important herbaceous perennial temperate fruit crops which belong to the family Rosaceae which can also be grown in tropical and sub tropical region of the world. Its successful cultivation requires an optimum day temperature of 22^{o} C to 23^{o} C and night temperature of 7^{o} C to 13^{o} C (Shoemaker, 1954).

Water is a major constituent (90%) of strawberry fruit. Ellagicacid is a naturally occurring plant phenol. It has been found to inhibit the cancer disease and asthma by the regular consumption of its fruits (Wange and Kzlogoz, 1998).

Strawberry fruits are in great demand for fresh market processing, industries as well as used in preserve and confectionaries purpose. Its popularity can be judged from the phenomenal increases in production during the recent years. During 2009, the world production of strawberry was 41,32,352 MT (Anonymous, 2009). Europe and North America accounts for 50% and 30% of total world production respectively. Among the European countries, France is the leading producer of the strawberry. In India, Maharastra is a leading state in production of strawberry fruits. It is also commercially grown in Haryana, Punjab, Uttar Pradesh, Jammu and Kashmir, Uttarakhand and lower hills of Himachal Pradesh. The excessive use of nitrogenous fertilizers and imbalanced use of other chemical fertilizers has resulted in yield saturation and detioration of health. Proper and regular incorporation of farm organic waste and bio inoculants are of utmost importance in maintaining the fertility as well as increasing the productivity of agricultural soils (Yadav, 2009).

Strawberry cultivation was mainly in India confined to Jeolikote, Nainital (Uttarakhand), Solan, Kullu (H.P.), Srinagar (J & K) but now its cultivation has been extended to subtropical regions namely, Gurgaon (Haryana), Pune (Maharashtra), Bangalore (Karnataka), Ghaziabad, Meerut, Saharanpur and Muzaffarnagar (U.P.) (Singh, 1992). The fully mature ripe fruits of strawberry attain attractive red colour, sweet-sour taste and a pleasant aroma (Mitra, 1991). Fruits are mostly eaten fresh and are consumed not for the food value but for the flavour. Besides dessert purposes, strawberries are processed into various value added products viz., canned strawberry, jam, jelly and ice-cream, (Hughes *et al.,* 1969). For good quality strawberry, its cultivation is affected by many factors i.e. soil, climate, irrigation, nutrition, mulching, growth regulators etc. Soil is an important factor for good quality fruits. Plants on sandy-loam, well-drained soil performs better and produce healthy and good quality fruits (Chindler *et al.,* 1995).

In India, strawberry was first introduced by the NBPGR Regional Research Station, Shimla (H.P.) in the early sixties. But the early effort to popularize its cultivation in Himachal Pradesh and Uttar Pradesh had received a setback an account of the poor adaptability of the cultivars, low returns per unit area and lack of technical know-how (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 Dawn, Camarosa, Red Coat, Addie, Swiss, Gorella, Jucunda, Sweet Heart, Mecharenj, Red Gro Florida-90, Elsanta, Brighton, Dilpans, Florida Go. However, some cultivars Sweet Charlie, Chandler and Selva have shown the promising result under Lucknow conditions. As far as global scenario is concerned Europe produces about $1/3^{rd}$ of the total strawberries of the world. Among different countries, Spain, Poland, Germany and France are the major strawberry producers of the world. USA, Mexico, Egypt, Japan, Italy, and Russian Federal also produce sizable 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). Commercial strawberries are successfully grown in a broad range of climates including temperate, grassland, Mediterranean, taiga and sub tropical. However, most of the current production is limited to the temperate and Mediterranean climates, located between latitudes $28^{o}$and 60^{o}. When growing strawberries in hot environments, attention must be paid to temperature and photo period patterns across the whole season, not just the summer. The strawberry is composed of several different meri stem that are regulated by the interaction between photoperiod and temperature (Darrow, 1996; Larson, 1994). No floral induction under short days in plant of strawberry held at 26/22^{O} and 30/26^{O}C day/ night temperature regimes. In warm climates, high air temperature probably plays an important role in restricting growth and fruit development by reducing photosynthetic activity and increasing respiration rate (Larson, 1994) observed. Nutrition is one of the most important aspects of crop production. Strawberry requires a number of minerals nutrients for proper growth and development.

Azotobacter represents the main group of heterotrophic, non symbiotic, gram negative, free living nitrogen-fixing bacteria. They are capable of fixing an average 20 kg N/ha/year. The genus *Azotobacter* includes 6 species, with *A. chroococcum* most commonly inhabiting in various soils all over the world (Mahato *et al*., 2009). Besides nitrogen fixation, *Azotobacter* also produces thiamine, riboflavin, indole acetic acid and gibberellins. When *Azotobacter* is applied to seeds, seed germination is improved to a considerable extent, so also it controls plant diseases due to above substances produced by *Azotobacter*. The exact mode of action by which *Azotobacter* enhances plant growth is not yet fully understood. Three possible mechanisms have been proposed: N_2 fixation; delivering combined nitrogen to the plant; the production of phytohormone- like substances that alter plant grow than morphology and bacterial nitrate reduction, which increase nitrogen accumulation in inoculated plants (Mrkovacki and Milic, 2001).

Organic fertilizers improve soil fertility by modifying soil structure, pH, biophysical conditions and availability of essential nutrients (Atiyeh *et al.,* 2002). Considering the future prospects of organic agriculture, studies were carried out to evaluate theinfluence of different organic amendments on growth related parameters, productivity and fruit quality ofstrawberry cv. Chandler.

The balanced application of organic manure, bio-fertilizers incorporated with inorganic fertilizers to get higher production. Bio-fertilizers are the organisms that enrich the nutrient quality of soil. Plants have a number of beneficial relationships with such organisms. Nutrient status of the soil is most important factor affecting the productivity of strawberry crops. The beneficial micro-organisms used as bio-fertilizers increase the growth of plants either by enhancing the availability of nutrients, releasing plant growth stimulating hormones. Bio-fertilizers are gaining increased attention to improve soil fertility and quality production of horticultural crops, due to hike in prices of chemical fertilizers and to minimize environmental pollution (Sindhu *et al.,* 2010). Modern day intensive crop cultivation results the huge application of chemical fertilizers which are not only in short supply but also expensive and pollute the environment, soil and water too. Therefore, the current emphasis is being given to explore the possibilities of supplementing the chemical fertilizers with organic fertilizers particularly bio-fertilizer of microbial origin.

Azotobacter species are free living bacteria which grow well on a nitrogen free medium and are an important source of bio-fertilizers. These bacteria utilize atmospheric nitrogen gas for their cell protein synthesis. This cell protein is then mineralized in soil after the death of the *Azotobacter* cells thereby contributing towards the nitrogen availability of the crop plants thus resulting in a strong symbiotic relationship. They also exudates some compounds like auxin, cytokinin and antibiotics improving growth and productivity of the crops (Forlain *et al.,* 1995).

Urea as an inorganic fertilizer contains 46% nitrogen. Nitrogen is a chlorophyll component, which promotes vegetative growth and green coloration of foliage. Nitrogen is essential during early growth, bud differentiation and flowering in strawberry (Albregts and Howard,1980).

Among perennial crops, strawberries are an ideal model to study the nutrients transformations. This has been attributed to the production of berries within a few months of planting due to small plant size and establishment of more plots within uniform soils.

Although, strawberry cultivation is becoming popular in India, but the farmers are continuing to grow them as a subsidiary crop. Due to lack of proper attention farmers usually harvest smaller fruits, use of chemical fertilizers has contributed significantly. However, and indiscriminate use of chemical fertilizers has caused serious damage to the soil ecosystem and Physico-chemical characteristics. Although, many organic options are available but high yield and better quality fruits cannot be expected from the sole application of organic manures or biological products. Therefore, a judicious combination of inorganic and organic fertilizers or bio-fertilizer is helpful in increasing the fruit production in strawberry. Moreover, such efforts shall be helpful to maintain sustainable productivity and soil health. Amongst various available organic options, bio-fertilizers are agriculturally important beneficial micro-organisms which have ability to mobilize the nutritionally important elements. Moreover, they are cost effective and renewable. Bio-fertilizers are also known to increase the yield of strawberry (Shiow and shin, 2002).

Bio-fertilizers are naturally occurring products with living micro-organisms which are resulted from the roots or cultivated soil and don't have any ill effect on plants, soil health and environment. Besides, their role in fixing atmospheric nitrogen and phosphorous solubilization, these are also helpful in stimulating the plant growth hormones. Bio-fertilizers viz. *Azotobacter*, PSB and *Azospirillum* fix atmospheric nitrogen and solubilize phosphorus to increase fertility of soil and increases number and biological activities. Bio-fertilizers are the derived product of living micro-organism that are capable to fixing atmospheric nitrogen and also convert insoluble phosphorus to soluble phosphorus for uptake of plants. Keeping this fact in view the present study was conducted to find out the effect of organic manures and bio-fertilizers on growth and quality of Strawberry cv. Chandler.

Bio-fertilizers consist mainly of beneficial micro-organisms that can release nutrients from raw materials and plant residues in the soil and make them available commercially where specific strains are used as biological fertilizers. They become recently, positive alternatives to chemical fertilizers because they help bring down the costs of chemical fertilizers especially N and P and improve soil fertility by maintaining the physical properties of the soil. They may help in improving crop productivity and quality by increasing the biological N fixation, the availability and uptake of nutrients and stimulating the natural hormones. They are safe for humans, animals and environment and using them is accompanied with reducing the pollution occurring in our environment (Walid *et al.,* 2014).

The flowers of most strawberry cultivars are hermaphroditic and self-pollinating. The resulting seeds are the achenes and form the true fruits, while the fruit receptacle constitutes the strawberry flesh. The receptacle is composed of an epidermal layer, a cortex and pith. The latter two layers are separated by vascular bundles that supply nutrients to the developing embryos (Hancock, 1999). Strawberry fruits have an initial phase of cell division and cell enlargement followed by a ripening phase during which important biochemical changes occur in the fruit (Montero *et al.,* 1996). Strawberry fruits represent the most competitive sink in the plant and accumulate 20%-40% of the total plant dry weight (Hancock, 1999). During the rapid period of fruit growth fruit dry weight accumulation may exceed the assimilatory capacity of the plant and continued fruit growth is maintained by translocation from other plant parts, as for example the roots (Hancock, 1999).

Maintenance of optimum nutritional status of strawberries is dependent on development of a favourable root environment and the availability of elements that are required for normal growth and development. Soil pH is a key factor in maintaining a favourable root environment. It not only affects root growth but influences availability of many nutrients. A pH range of 6.0 - 6.2 is generally considered ideal.

Essential elements for plant growth include the major elements nitrogen (N), phosphorus (P), and potassium (K); the secondary elements calcium (Ca), magnesium (Mg), and sulphur (S); and the micronutrients iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B) and molybdenum (Mo). Major elements are required in greatest quantity. Nitrogen is the most important of these elements and has the most profound influence on yield and quality. Secondary elements are required in the next greatest quantity. They play significant roles in photosynthesis, cell wall development, and protein production.

Micronutrients are required at very low quantities but are essential for normal growth and development. They generally serve as catalysts for chemical reactions in the plants. Even though micronutrients are required in small quantities, excess quantities of these elements can become toxic (Ulrich *et al.*, 1980).

Nitrogen is one of the most critical nutrients in strawberry production. Using routine plant analysis to determine the nutritional status plus the infield nitrogen test helps us maintain adequate N levels from planting, over wintering, during spring growth, blooming, fruit development, ripening, harvest and on into dormancy. It has been concluded that the earlier in the growing season that a nitrogen deficiency occurs, and the longer it lasts, the greater is the loss of harvestable fruit.

Over fertilization of nitrogen however can be detrimental. Often a grower will apply nitrogen as cheap insurance and this may only create quality problems and in some cases promote excessive leaf growth that depresses yields.

Imbalance and inadequate fertilizer application gradually reduces their response efficiency. The results of numerous field experiments in different parts of India have indicated 'fertilizer-induced unsustainability of crop productivity'. The integrated nutrient supply including the use of chemical fertilizers with organic manures like green manure, FYM, compost, bio-fertilizers etc. helps not only in bridging the existing wide gap between the nutrient removal and supply but also in insuring balanced nutrient proportion, by enhancing nutrient response efficiency, and maximizing crop productivity of desired quality.

Among the free living nitrogen fixing bacteria, *Azotobacter* is the most intensively investigated genera. The isolated culture of *Azotobacter* fixes about 10 mg/gm N of carbon source under *in-vitro* conditions. Apart from its ability to fix atmospheric nitrogen, *Azotobacter* is also known to synthesize biologically active growth promoting substance such as Indol Acetic Acid (IAA), Gibrellic Acid (GA) and B-vitamins in culture media.

Farm yard manure is being used from ancient times as a supplement of nutrition and improves soil physical conditions. Farm yard manure contains lots of living micro and macro organisms like bacteria, fungi and insects etc. These organisms involved in several oxidation-reduction reactions, which release several useful nutrients and stimulate the production of hormones and enzymes required by the plants for their optimum growth and development. Farmyard manure has been the sources of various soil borne pathogens and weed infestation, hence influences cost of cultivation. To overcome these drawbacks Vermicompost is being recommended as a supplement of soil in the recent years.

Strawberry is nitrogen (N) sensitive crop. The yield and quality of strawberry fruits is strongly affected by plant N status (May and Pritts, 1990). However, synchronizing N supply with the N demand of strawberries in organic systems is a challenge due to unpredictability of N mineralization from organic fertilizers and soil organic matter. In addition, under the winter-planting annual system, strawberry transplanting is immediately followed by the rainy season when N leaching potential is high. To meet the strawberries N demand, growers intensify their use of commercial organic fertilizers that are relatively soluble. This practice has received criticism as "high-input organic agriculture", which may not convey environmental benefits commonly associated with organic farming.

Strawberry can be grown in wide climatic conditions, ranging from temperate to tropical climate. Since, its cultivation is greatly influenced by specific regional adaptation due to photoperiodic and temperature requirement, its cultural practices are highly variable. Among the different climatic factors, temperature and day length affect considerably the growth, plant morphology and yield (Pathak 1970; Pathak and Singh, 1971). Stolen formation, petiole length leaf area and yield increase with increase in photoperiod (Arney 1953; Heide 1977; Yanagi and oda, 1993) though the effects are cultivar-specific.

Growth and development of strawberry is highly sensitive to variations in air and soil temperature. An optimum growing season temperature of 15º C has been reported for most of the Strawberry cultivars and species (Larson, 1994). Roberts and Kenworthy (1956) have found range between 20º and 26º C, the ambient temperature for proper growth. Plants grow very fast in plains its start bearing within three months of planting, and in hills it takes 9-12 months to bearing. However, the fruit quality is very good in hills as compared to plains.

Bio-fertilizers are known to increase the yield of strawberry (Shiow and Shin, 2002). In view of the above, the present investigation was undertaken to study impact of inorganic fertilizers and bio-fertilizers on soil quality, growth and yield of strawberry. N, P, K and Ca are important mineral elements in strawberry growing (Blatt *et. al.,* 1982, Kessel, 2003). Strawberry *(Fragaria x ananassa Duch.)* is one of the most important soft fruit of the world after grapes.

It gives quickest returns in shortest possible time, as its fruit is the first of the season's home-grown supplies to reach the market. Among the various factors which contribute in growth and yield of strawberry, nutrition is one of the most important aspects of crop production and accounts for about one third of the total cost of production. The phyto-hormones extracted from FYM help the plant to grow more luxuriously even with reduced doses of chemical fertilizers. Nitrogen availability is affected by higher percentage of nitrogen through urea in association with nitrogen fixing culture has been documented (Saraf and Tiwari 2004).

Bio-fertilizers are microbial preparations containing living cells of different micro-organisms which have the ability to mobilize plant nutrients in soil from unusable to usable form through biological process. They are environmental friendly and play significant role in crop production. Previollsly it is mainly used for field crops but now-a-days it is used for fruit crops also. Bio-fertilizer are able to fix 20-200 kg N ha/year, solubilize P in the range of 30-50 kg per year and mobilizes P, Zn, Fe, Mo to varying extent. Bio-fertilizers are use in live formulation of beneficial micro-organism which on application to seed, root or soil, mobilize the availability of nutrients particularly by their biological activity and help to build up the lost micro flora and in turn improve the soil health in general. Thus the use of bio-fertilizer is increasing day by day due to increase in the price of chemical fertilizers, its beneficial effect on soil health and increase in production of crop (Hazarika and Ansari 2007).

Plants face several environmental stresses and mostly evolve various mechanisms that cope with these stress factors. These stress factors have been classified into abiotic and biotic factors. Soil/plant relations, weeds, nutrient deficiency, Mycorrhizae, salinity etc. are some of the stress factors. Vesicular Arbascullar Mycorrhizae (VAM) fungi were reported by several researchers as enhancer of root systems and they are known to support stronger, healthier, higher-yielding plants through increased nutrient acquisition (Miller, 2000), reduce levels of water stress (Auge, 2001), lower disease incidence (St-Arnaud*et al.,* 1995), and increase phyto-hormone production (Shaul-Keinan *et al.,* 2002). However, the current perception is that these obligate symboint play no or little role in soils where nutrient availability is higher (Olsen *et al.,* 1999). Conventional agriculture practices for high-value crops in most countries often include abundant fertilization leading to nutrient accumulation in the soils. In particular accumulates in soils with a P fertilization history (Zhang *et al.,* 1995). Cultivated strawberry was originally claimed to benefit for Vesicular Arbascullar Mycorrhizae inoculation only when soil phosphorus is limiting for plant growth (Holevas, 1966).Vesicular Arbascullar Mycorrhizae (VAM) of the phylum *Glomeromycota* live in symbiosis with a majority (over 80%) of land plants (Smith and Read, 1997). Higher yield and quality fruits were harvested with a fertilizer dose of 150 kg N with 75 kg P_2O_5/ ha (Joolka *et al.,* 1986). The combination of 100kg N + 60kg Kg and 100 kg N + 40 kg K ha^{-1} increased plant height, number of leaves, leaf area and runner production (Kapanski and Kawecki 1994).

Organic farming is considered an important factor of the Polish and EU strategy for the development of the agricultural sector and the production of organic fruits is increasing in the last years (Anon, 2007). There is a great variability in the nitrogen availability from different sources of organic fertilizers (Pang and Letey 2000).

Among the various factors which contribute towards the growth and yield of strawberry, nutrition is the important aspect of crop production (Umar *et al.,* 2008).

The Strawberry (*Fragaria X ananassa* Duch.), a member of the rose family, is not really a berry but a false fruit and consists of many tiny individual fruits embedded in a fleshy scarlet receptacle. The brownish or whitish specks, commonly considered seeds, are the true fruits known as achene. Strawberries are an excellent source of vitamin C, a good source of folate and potassium, and are relatively low in calories. Strawberry is one of the most widely appreciated fruits and it has attained a premier position in the fresh fruit market and processing industries of the world (Sharma and Sharma, 2003). Integrated nutrient management includes the use of inorganic and organic sources of nutrients to ensure balanced nutrient proportions by enhancing nutrient response efficiency and maximizing crop productivity of desired quality. It also helps to minimize the existing gap between nutrient removal through continuous use of chemical fertilizers and supply through slow release of fertilizers. It is widely reported that the extensive use of chemical fertilizers adversely affects soil health and results in decreased crop productivity and quality (Macit *et al.,* 2007, Singh *et al.,* 2009).

Organic products are being famous for all people around the world. Due to the great global market demand, production of organic foods has rapidly increased in the past decades. On this basis organic agriculture has become a great choice as means of organic product producing. Organic cultured strawberries produced higher vegetative growth in compare to conventionally cultured strawberries produced (Abu-Zahra and

Tahboub 2008). There has recently been increased interest in the environmentally friendly, sustainable and organic agricultural practices in the world (Esitken *et al.,* 2006). El-Araby *et al.,* 2003 reported that strawberry cv. Camarosa, planted in sandy soil was significantly affected by organic fertilizer. (Abo Sedera *et al.,* 2010) noticed that supplying the plants with mineral fertilizers at 125% of the recommended dose and spraying the plants with amino acids or humic acid at the high level of them resulted in the highest TSS, vitamin C, reducing and total sugars as well as anthocyanin concentration except total acidity which was the highest in fruits produced from the control treatment. Bio-fertilizers play a very important role in improving soil fertility by fixing atmospheric nitrogen, both in association with plant roots and without it, solubilise insoluble soil phosphates and produce plant growth substances in the soil. They are in fact being promoted to harvest the naturally available biological system of nutrient mobilization (Venkatashwarlu, 2008). Shehata *et al.,* (2011) studied the effect of soil addition of compost and foliar fertilizer with Humic and/or amino acids on growth and yield of strawberry cv. Festival. Strawberry production is in constant increase, primarily due to increasing consumption of the fruit and its high profitability. Intensive farming practices that result in high yield and quality also require extensive use of chemical fertilizers, which are costly and create environmental problems. Therefore, there has been a recent, growing interest in various bio-fertilizers (microbe inoculants). The category of bio-fertilizer most commonly refers to products containing soil micro-organisms increasing the availability and uptake of mineral nutrients for plants (like rhizobia and mycorrhizal fungi) according to the definition proposed by (Vessey, 2003). The effect of EM on the vegetative growth of three strawberry cultivars. They found that EM was the most Effective treatment in stimulating shoot and root growth in the strawberry cultivar `Honeoye' (Glinicki *et al.,* 2011). They also, revealed that NPK fertilization applied to strawberry plants together with EM-farming can withstand the positive effect on strawberry plant growth, which was gained with single microbial inoculation. Fertilizers with enhance phosphorus and potassium content may be beneficial for berry quality improvement. In recent years concern about both the prevention of environmental pollution and food safety has developed (Masny *et al.,* 2004). Foliar application of fertilizers is more ecologically should than fertilization of the soil. There are special preparations for use in organic farms. Less information is available about the effect of recently widely used composite fertilizers. For berry formation, higher amounts of phosphorus and potassium are required (Lienten and Misotten 1993).Yadav *et al.,* (2004) the aim of this research was designed in order to optimize integrated plant nutrient supply (IPNS) through balanced fertilization of organic, inorganic and microbial inoculants in strawberry cv. Chandler. The aim of this research was designed in order to optimize integrated plant nutrient supply (IPNS) through balanced fertilization of organic, inorganic and microbial inoculants in strawberry cv. Chandler.

Keeping in view of the above present investigation **"Effect of Inorganic and Bio-fertilizers on Growth, Yield and Physico -chemical characters of Strawberry (*Fragaria* x *annanasa* L. Duch.) cv. Chandler in Central Uttar Pradesh"**carried out with the following objectives:

1. To find out the effect of Inorganic and Bio-fertilizers on vegetative growth of Strawberry.
2. To assess the effect of Inorganic and Bio-fertilizers on fruit yield of Strawberry.
3. To ascertain the effect of Inorganic and Bio-fertilizers on Physico–chemical characteristics of Strawberry.
4. To work out the effect of Inorganic and Bio-fertilizers on benefit: cost ratio of Strawberry.

REVIEW OF LITERATURE

Chapter II

REVIEW OF LITERATURE

Growth Characters

A.K. ***et al., (*****2012)** the data of both the years of experiment were analyzed which clearly shows that combined application of *Azotobacter* at 7 kg/ha + Vermicompost at 30 tonnes/ha significantly increased the height of plant (19.45 and 17.65 cm, respectively), number of leaves (63.60 and 59.60, respectively), number of crowns (7.28 and 6.27, respectively), number of runners (5.34 and 4.32, respectively) per plant, whereas maximum number of flowers (67.48 and 64.51, respectively) and fruits set (39.21 and 36.19, respectively) per plant with increased duration of harvesting (71.04 and 69.02 days, respectively) and minimum number of days taken to produce first flower (56.15 and 54.15 days, respectively) and fruit set (6.44 and 5.94 days, respectively) with significantly more yield (324.38 and 320.39 g/plant, respectively) were also observed in *Azotobacter* at 6 kg/ha + Vermicompost at 30 tonnes/ha applied plants.

Anil ***et al.,*** **(2015)** application of Vermicompost + Azotobacter + PSB + AM produced maximum plant height (20.26 cm); plant spread (25.64 cm), number of leaves (54.30) and leaf area (97.87 cm^2) $plant^{-1}$, whereas all the growth characters were found minimum in control. Earliest flowering (50.39 days) and maximum number of runners (7.12) $plant^{-1}$ were reported in Vermicompost + AM, while minimum runners (3.27) were recorded in Vermicompost alone treated plants. Duration of harvesting (66.80 days) was highest in treatment (Vermicompost + PSB + AM), while number of flowers (64.23) and number of fruit set (50.63) $plant^{-1}$ were recorded highest in Vermicompost + Azotobacter + PSB + AM treatment. Days to fruit set (6.30 days) were minimum in Vermicompost + Azotobacter. All the characters were found minimum in control. Maximum yield (311.26 g) $plant^{-1}$ was recorded with Vermicompost + Azotobacter + PSB + AM, and minimum in control (136.59 g).

Afroz ***et al.,*** **(2016)** the highest values of plant height (25.60 cm), number of leaves (21.66), flowers (125.33), fruits (12.35),destroyed fruits (11), fruit weight

(215.10 g) plant^{-1} and fruit length (4.16 cm), fruit diameter (3.41cm), individual fruit weight (17.85 g) and fruit yield (11.50 t ha^{-1}) were found in treatment of 115,40,110 and 25 kg ha^{-1} N,P,K,S, respectively. Among the fertilizers, the single effect of N (115 kg ha^{-1}), P (40 kg ha^{-1}), K (110 kg ha^{-1}) and S (25 kg ha^{-1}) gave maximum growth and yield of strawberry. The highest concentration of N, P, K and S were found in shoot and fruit of strawberry when N, P, K and S fertilizers were used 140, 60, 135 and 35 kg ha^{-1}, respectively.

Blatt (1981) strawberries have been shown to be only slightly or even not affected by the N form of fertilisers supplied in the field.

Chavez and Ferrera - Cerrato (1990) also reported root colonization of some strawberry cultivars, after VAM inoculation by the endophytes varied from 25 to 75%, but there was no relation to the extent of fungal colonization with plant growth.

Changotra *et al.,* (2017) in the present study revealed that plant treated with 2.80 t/ha vermicompost showed significant increase in plant height, leaf area, number of leaves per plants, number of flowers, number of fruits per plant and fruit set per cent in strawberry. Similarly plant treated with 2.80 t/ha vermicompost also showed significant effect on physico-chemical properties of fruits. Fruits showed maximum fruit weight, fruit size, TSS, TSS: acid, total sugars, reducing sugars, ascorbic acid content, organoleptic rating, and minimum acidity with application of 2.80 t/ha vermicompost. Hence it concluded that vermicompost has significant effect on the vegetative growth and quality of strawberry.

Chol *et al.,* (2000) found that nitrogen uptake increase the fresh weight and recommended 80-110 mg per liter of concentration of nitrogen to achieve highest crop growth in 'Nyoho' strawberry.

Claussen and Lenz (1999) showed that the application of inorganic N fertilizer with ammonium chloride (OIF) restrained the growth of roots.

Darrow and Waldo (1932) studied that nitrogen (Urea), especially if applied in the spring, has a tendency to increase number of leaves and leaf area per plant of strawberry.

Dar *et al.,* (2013) the present study was aimed to investigate the impact of major nutrients N, P and K on plant height, plant spread, number of leaves, petiole length and fruit yield of strawberry cv. Sweet Charlie. The experiment was carried out at Research Farm, Horticulture Department, AAIDU, Allahabad (India) during winter season 2006–07. The application of 100 kg N + 80 kg K/ha resulted in maximum growth and yield improvement in strawberry followed by 100 kg N treatment and 80 kg P + 80 kg K/ha treatment. The study revealed that strawberry crop requires optimum NPK to harness maximum yield.

Demirsoy *et al.,* (2012) this study aimed to determine the effects of organic and conventional growing on contents of some nutrient elements, nitrogen (N), phosphorous (P), potassium (K), iron (Fe), and manganese (Mn), yield and some growth parameters such as leaf area, petiole length, petiole diameter, crown number, crown diameter, leaf, root dry weight in 'Sweet Charlie' and 'Camarosa' strawberry cultivars. This study consisted of two strawberry cultivars ('Camarosa' and 'Sweet Charlie'), two growing systems (organic and conventional growing) and two different mulches (black and floating sheet).

E. Malusa *et al.,* (2016) different kinds of soil micro-organisms belonging to several taxa of the bacteria, fungi, and possibly, protozoa kingdoms, colonizing the rhizosphere or the plant tissues and promoting plant growth (PGPM), can be utilized for the production of microbial based fertilizers (bio-fertilizers). However, their application in agricultural practice is still hindered by several factors.

Edyta *et al.,* (2015) effects on plant height, leaf surface area, leaf fresh and dry weight, the degree of mycorrhizal colonization in the roots, and on the number of spores of Arbascullar mycorrhizal fungi in the rhizosphere of strawberry plants.

Elisa *et al.,* (2008) early spring growth of perennial strawberry (*Fragaria* × *ananassa* Duch.) plants is supported by the carbohydrate and nitrogen (N) reserves accumulated from the previous growing season. The limitations of these reserves on the initial spring growth and yield of perennial strawberries have not been studied in detail, particularly the influence of N reserves. Differential N fertigation (0 to 20 mM) was applied to potted strawberries during the growing season and a supplemental foliar urea application was applied to a portion of the plants in the fall to modify reserve N during dormancy. Plant N content and spring vegetative growth the year after fertigation increased nearly twofold with increasing N fertigation. Photosynthesis per unit leaf area also increased up to 10 mM of fertilizer N and then stabilized through 20 mM. Foliar urea application in fall further increased total plant N content and size, decreased carbohydrate concentration, and also decreased yield in plants with the most total N.

Gaur and Deepak (2003) carried out that application of 200 kg N/ha resulted in the maximum plant height (19.90 cm), maximum number of leaves per plant (23.15), maximum average number of flowers per plant (3.95), fruit set (68.35%), fruit length (2.56 cm), fruit width (2.04 cm), number of fruits per plant (16.7) and average fruit weight (7.90 g).

Greer (2002) reported that excessive use of fertilizer in strawberry results reduced yield, excessive vigour, soft fruit, poor colour and potential contamination of ground and surface water. He also estimated that nitrogen use efficiency by the strawberry plants is 8-20% of the applied nitrogen fertilizers.

Godara and Awasthi (2008) revealed from his study that the number of leaves and number of flowers plant of peach increased significantly with inoculation of *Azotobacter* strains as compared to untreated *Azotobacter* strains.

Gupta and Tripathi (2012) examined that the combined application of *Azotobacter* 6 kg per ha and Vermicompost 30 tonnes per ha significantly increased the height of plant (19.45 cm), number of leaves (63.60), number of runners per plant (5.34) and maximum number of flowers (64.51).

Haynes *et al.,* (2008) the effects of increasing rates of N (as urea) and K on vegetative growth, nutrient uptake, and fruit yield and quality of strawberries (*Fragaria* × *ananassa* Duch.) was investigated in a field trial. In the first and second seasons there were small increases in plant growth and yields with the low rate of N but higher rates caused marked reductions in both growth and yields. With the high N rates accumulation of high levels of ammonium and soluble salts in the soil during spring of the first season was thought to have initially inhibited plant growth. Following nitrification of the accumulated ammonium, soil acidification occurred and consequently toxicities of Al and Mn limited strawberry growth at high N rates. In the second and third seasons there was a positive growth and yield response to the addition of K in the no-N and low-N treatments although rate of K had no influence. Increasing rates of K generally increased concentrations of leaf K and decreased those of Mg and Ca. Additions of K had no effect on chemical parameters of fruit quality. However, increasing rates of N raised concentrations of α-amino acid-N and applied N tended to raise concentrations of polyphenols and reduce those of ascorbic acid. Applications of N had variable effects on titratable acidity and sugar contents of fruit and year-to-year differences in quality parameters were generally greater than those caused by N additions.

Husam *et al.,* (2015) the highest height plant (9.17 cm) was recorded in T_{12} (N.P.K40:40:40) and the highest No. leaves per plant (9.53) was recorded in T_{12} (N.P.K40:40:40), number of flowers per plant (2.20) was recorded in T_{12} (N.P.K40:40:40*)*.

Huil *et al.,* (2008) the effect of bio-fertilizer on the growth, yield and fruit quality of replanted strawberry were discussed. The results can be summarized as following: the bio-fertilizer could significantly improve vegetating growth, yield and fruit quality of successive strawberry. The yield of strawberry was most significantly improved applying 37.5 kg/hm^2 bio-fertilizer in all treatments. The prophase and total yield respectively increased 14.82% and 6.74%compared with the soil without bio-fertilizer (control). Applying bio-fertilizer could significantly promoted the quality of strawberry, including sugar/acid ratio, soluble solids and VC content of fruit of strawberry. Its sugar/acid ratio, soluble solids and VC content were respectively improved 11.5%, 20.0%, 17.2% and 30.2% compared with control.

Iqbal (2009) studies that the strawberry plants attained the height of 21.24 cm with 28.16 cm plant spread, 74.95 cm2 leaf area, fruit size (37.62 x 28.01mm) and fruit weight (15.87g) with the application of 25 per cent nitrogen through FYM augmented with *Azotobacter* and was at par with the plants supplied with cent per cent nitrogen in the form of urea in combination with *Azotobacter*.

Jeeva *et al.,* (1988) reported that the application of *Azospirillum* inoculation in banana with graded levels of N fertilizers (100, 75, 50 Kg) of the standard rates was investigated. Inoculation + highest dose of N (100%) enhanced the height and girth of pseudostem, number of leaf and leaf area.

Kumar *et al.,* (2014) claimed the maximum plant height, maximum number of leaves, spread of plant, number of flowers, length diameter ratio of fruits and average number of fruit per plant in strawberry was recorded with the application of 100 kg N/ ha.

Lai *et al.,* (2005) reported that under field conditions, application of fertilizers containing inorganic N significantly inhibited root growth during the seedling stage.

Manejo *et al.,* (2015) strawberry (*Fragaria* x *ananassa*) is a crop that has rapid growth and is highly influenced by fertilization. Due to its development speed, the plant needs to absorb sufficient macro-nutrients in order to meet its demand. The objective of this research was to evaluate growth and yield of strawberry under different doses of nitrogen (N), phosphorus (P) and potassium (K) fertilization. The treatments, using Box's central composite design, were distributed in randomized blocks with four replicates and consisted of five N doses (0.16, 0.37, 0.88, 1.4 and 1.6 g $plant^{-1}$) and five P doses (0.3, 0.58, 1.2, 1.8 and 2.1 g $plant^{-1}$), in the presence (1.67 g $plant^{-1}$) and absence of K. Seedlings of the cultivar 'Oso Grande' were cultivated in 10-L pots. The analysed variables were: plant height, fresh fruit mass, number of leaves, number of fruits, total soluble solids and titratable acidity. The fertilization with N and P increased the values for most of the studied variables. At the highest doses of N and P, K stimulated plant yield.

M. Y. Zargar *et al.,* (2008) maximum number of primary flowers (8.00/plant), number of secondary flower (10.00/plant), total number of flowers (18.00/plant), number of primary fruits (7.00/plant), number of secondary fruits (10.0/plant), total number of fruits (17.00/plant) and leaf phosphorus (0.30%) and available phosphorus (11 kg ha-1) were recorded under nitrogen (225 kg ha-1) + phosphorus (150 kg ha-1) + PSB.

Nam *et al.,* (2006) observed that plant height, number of flowers and number of runner's influences by N, P, K and Ca.

Neeraj *et al.,* (2015) find that the maximum plant height (23.95 cm), leaves plant-1 (12.67), primary branches plant-1 (10.50), secondary branches plant-1 (27.35), first flowering (61.06 days), flowers plant-1 (15.33), first fruit setting (72.80 days) and fruits plant-1 (8.33) were recorded by the application of cent per cent Vermicompost + PSB (T_5) followed by treatments comprising of Vermicompost + *Azospirillum* (T_6) where plant attained height (23.50 cm), leaves plant-1 (11.67), primary branches plant-1 (10.25), secondary branches plant-1 (26.95), first flowering (63.06 days), flowers plant-1 (14.67), first fruit setting (73.50 days) and fruits plant-1 (7.67). T_5 was found to be statistically at par with T_6.

Niskanen and Dris (2002) conducted nutritional status study on strawberries grown on coarse textured and medium to high humus content soils having on an average fertility was good for soil pH, P, B and Cu and satisfactory for K, Ca, Mg and Mn. They reported mean nutrient concentration as N-19.1, P-2.8, K-15.0, Mg-2.7, Ca -9.3 and B-0.05 g/kg dry matter.

Neuweiler *et al.,* (1996) increase in fruit weight was also reported with the increasing nitrogen application in strawberry.

Pandit *et al.,* (2015) recorded application of *Azotobacter* 5 kg per ha in strawberry cv. Chandler resulted that total number of flowers per plant (23.09), total number of fruits per plant (21.37), fruit length (1.29 cm) obtained from *Azotobacter* treated plants.

Pathak *et al.,* (2002) who found integration of 75 per cent nutrient supply through chemical fertilizers and 25 per cent through organic source in Maize-wheat cropping system gave yield equal to as obtained by application of cent per cent nitrogen, phosphorus and potassium. The existence of favourable nutritional environment under the influence of bio-fertilizers, FYM and inorganic fertilizers had a positive influence on vegetative and reproductive growth, which ultimately led to realization of higher yield.

Rana and Chandel (2003) used bio-fertilizers and nitrogen to strawberry cv. Chandler and found that *Azotobacter* inoculated plants attained maximum plant height (24.92 cm), number of leaves (26.29), leaf area (96.12 cm^2), and number of runners (18.70) per plant as compared to other treatments. They further observed that the application of *Azotobacter* in combination with 60 kg N per ha produced maximum leaf area (102.50 cm^2) over all other treatments.

Ray *et al.,* (1996) reported that the combined application of 200gm N + 50 gm P_2O_5 + 200 gm K_2O per plant with the combination of F.Y.M. promoted growth of plant.

Rayees *et al.,* (2015) the data regarding the different growth parameters observed at 30, 45, 60, 90, 105, 120 days after planting, yield parameters at 45, 60, 90, 120, 135, 150 days after planting and their quality parameters clearly indicate that the application of integrated sources of nutrients significantly affect the vegetative, reproductive and yield characteristics of the strawberry plant.

Rubee *et al.,* (2013) observed that the maximum height of the plant (5.83cm, 8.31 cm, 12.61 cm, 14.83 cm, 17.44 and 19.25cm), number of leaves per plant (5.81, 10.27, 13.66, 16.86, 18.04 and 18.80cm), length of leaves (6.34cm, 6.96cm, 7.32cm, 8.00cm 8.32cm and 8.80cm) and width of leaves (5.16cm, 6.58cm, 7.86cm, 8.93cm, 10.20cm and 10.94cm) were recorded in the treatment T_{12} - *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%) + FYM.

Sahoo *et al.,* (2005) reported that the application of *Azotobacter* (6 Kg per hac.) and *Azospirillum* (5 Kg per hac.) in strawberry cv. Sweet Charley during Rabi season resulted that the maximum number of leaves, plant height and number of branches per plant.

Sandeep *et al.,* (2012) studies on influence of bio-fertilizers and micronutrients on growth characters of strawberry cultivar chandler and reported that maximum plant height (27.69 cm), plant spread (36.12 cm) and number of leaves

(16.66) was observed in application of VAM at 12 kg per ha along with *Azotobacter* at 10 kg per ha followed by application of VAM at 12 kg per ha sprayed with boron at 2000 ppm per which recorded plant height 23.66cm per plant, 32.87cm plant spread and 15.33 number of leaves.

Sara *et al.,* (2015) in this regard, studies were conducted using six different organic amendments on strawberry (*Fragaria ananassa* Duch.) cv. Chandler which included T_1 = planting media (soil + silt + farm yard manure); T_2 = planting media + 400 mgl^{-1} humic acid; T_3 = planting media + 200 g kg^{-1} leaf manure; T_4 = planting media + 200 4g kg^{-1} Vermicompost; T_5 = planting media + 200 g kg^{-1} plant fertilizer and T_6 = planting media + 200 g kg-1 bio-compost during 2011-12 at PMAS-Arid Agriculture University, Rawalpindi. Treatment T_1 (soil + silt + FYM) induced positive influence on plant height (15.21 cm), canopy spread (20.37 cm),crown diameter (1.47 cm), fresh weight of plant (10.71 g), number of runners per plant (2), total number of flowers (58), total number of fruits (42), fruit size (3.04 cm), fruit weight per berry (8.82 g) while T (soil + silt + 4200 g-1 kg Vermicompost) improved fresh leaf weight (0.92 g), number of leaves (6.67), leaf area (43.07 cm^2) and days required for first bloom (96.67). Leaf manure based treatment (T) enhanced root length (20.11 cm), $T_{3,}$ T_4 improved quality parameters like total solid soluble (TSS) (8.88) and ascorbic acid contents (64 mg) while T improved total sugar contents in fruits (6.82%).

Sharma *et al.,* (2011) found that the plant height and number of leaves, fruit weight and other chemical characters significantly affected by phosphorus, zinc.

Sharma and Gupta (1998) the results in the present study on yield due to integration of 25 per cent nitrogen through FYM + 75 per cent nitrogen through urea + *Azotobacter* and also with application of cent per cent nitrogen through urea+ *Azotobacter* are similar.

Simonne *et al.,* (2001) determined that there was significant cultivar by N rate interaction for marketable fruit weight of 'Camarosa' and 'Sweet Charlie' strawberries, with varying response of both cultivars throughout the season to N rates from 0.57 to 1.14 kg/ha per day.

Singh *et al.,* (2015) observed plant height (14.83, 15.86 cm), plant spread (19.69, 18.76 cm), number of leaves per plant (37.84, 38.82), leaf area (88.01, 88.81), numbers of runners per plant (3.27, 4.72) and numbers of flower per plant (47.06, 49.15) with the application of Vermicompost at 10 tonnes per ha and *Azotobacter* at 7 kg per ha in strawberry, respectively. Whereas, combined application of Vermicompost (10 tonnes/ha) and *Azotobacter* (7 kg/ha) significantly increased the plant spread (22.11 cm), number of leaves per plant (52.17), leaf area (96.70), numbers of runners per plant (5.38) and numbers of flower per plant (53.83).

Singh *et al.,* (2012) noticed plant height (18.07 cm) and runners per plant (4.83) in strawberry cv. Senga Sengana by the application of Vermicompost (5 tonnes per ha). Whereas combined application of Vermicompost (5 tonnes per ha) and *Azotobacter* (20 g) per plant resulted plant height (19.37 cm) and number of runners per plant (5.66).

Tripathi *et al.,* (2015) study the influence of *Azotobacter*, Vermicompost on growth, flowering, yield and quality of strawberry cv. Chandler. There were nine treatments comprising two levels each of *Azotobacter* (6 and 7 kg/ha) and Vermicompost (20 and 30 t/ ha) and their combinations along with one control, replicated thrice in randomized block design. Five kg of FYM was applied as a basal dose in all the treatments including control. All the doses of *Azotobacter* and Vermicompost were applied at the time of planting in the field. The data of both the years of experiment were pooled and analyzed. The combined application of *Azotobacter* at 7 kg/ha + Vermicompost at 30 t/ha significantly increased the height of plant (18.70 cm), number of leaves (61.60), crowns (6.77) and runners (4.83) per plant, whereas, maximum number of flowers (56.69), fruits set (25.87) per plant with increased duration of harvesting (66.80 days) and minimum number of days taken to produce first flower (55.17 days) and fruit set (6.19 days) with significantly more yield (322.38 g/plant) were observed with *Azotobacter* at 6 kg/ha + Vermicompost at 30 t/ha applied plants. Plants fertilized with *Azotobacter* at 6 kg/ha + Vermicompost at 30 t/ha also produced the berries with maximum length (4.76 cm), width (2.49 cm), weight (8.75 g), volume (5.97 cc), TSS (9.80 ^{0}Brix), total sugars (9.23%), ascorbic acid (54.72 mg/100 g edible portion) with minimum titratable acidity (0.50%) in comparison to other treatments under plains of central Uttar Pradesh.

Tripathi and Babu (2008) observed that application of *Azotobacter* at 6 kg per ha significantly increased the height of plant, number of leaves, crown, runners, number of flowers and fruits per plant.

Tripathi *et al.,* (2010) found that the soil application of 7 kg per ha. *Azotobacter* significantly increased the plant height (16.05 cm), number of leaves (54.75), number of runners (4.39).

Umar *et al.,* (2009) determined the positive effect of organics, FYM, in integration with urea and *Azotobacter* on strawberry cv. Chandler. They reported that maximum height of plant (21.24 cm), plant spread (28.16 cm), leaf area (74.9 cm^2) was in 100% N (Urea) + *Azotobacter* treated plants.

Umar *et al.,* (2010) have reported that application of 25% nitrogen through subabul + 75% nitrogen in the form of urea augmented with bio fertilizer resulted in maximum plant height (20.9 cm), plant spread (27.8 cm) leaf area (70 cm^2), fruit size(38.4 x 28.9mm), T.S.S (6.836 ^{0}Brix), Total sugar(4.85%), fruit weight(16.9 g), yield(385.2 q/ha).

Verma and Rao (2013) conducted an experiment to see the effect of integrated nutrient management on growth, yield of strawberry cv. Chandler and nutrient status of soil under mid hill conditions of Uttrakhand with twelve treatment combinations comprising of inorganic fertilizers (N: P: K), bio-fertilizers (*Azotobacter* and PSB) and organic manures (FYM and Vermicompost) replicated thrice with 20 plants per replication in randomized block design. Treatment receiving *Azotobacter* + PSB + Vermicompost + 50% recommended dose of NPK recorded highest plant height plant spread, leaf area per plant. Plant supplied with *Azotobacter* + PSB + Vermicompost + 50% RDF registered earliest in flowering and fruit maturity and highest number of flowers per plant and flowering duration.

Wange *et al.,* (1996) observed that the application of *Azospirillum* in strawberry increased the numbers of leaves, number of buds, number of fruits per plant and they also reported that inoculation of P.S.B. in strawberry cv. Chandler increased height of plant, number of flowers, number of leaves and number of buds per plant.

Wang (1996) summarized that inoculation of *Azotobacter* in strawberry cv. Sujata increased number of leaves, buds, flowers and fruits per plant.

Wang and Lin (2002) with various soils medium reported that compost significantly enhance the plant growth and fruit quality when used as soil supplement in strawberry plants. Adding half strength of Peter nutrient solution (50% fertilizer) to a mixture of 50% soil + 50% compost was very effective in significantly increasing plant dry weight to approximately double that of the control (without compost). Compost and fertilizer also significantly enhanced leaf chlorophyll content.

Yadav *et al.,* (2009) concluded from his work that the majority of plant growth parameters of strawberry like number of flowers, number of fruits, number of runners, and fruit yield were recorded maximum in *Azotobacter* inoculated treatments with 50% nitrogen substitution by Vermicompost and remaining 50% through inorganic fertilizers.

Yadav *et al.*, (2010) studies the integrated nutrient supply on strawberry and reported that treatment having half dose of nitrogen through Vermicompost and remaining half dose of nitrogen through inorganic source inoculated with *Azotobacter* results the maximum number of runners (11.33) plant^{-1}.

Yusuf *et al.,* (2003) carried out a field experiment in Azad Kashmir in Pakistan during 1999-2001 to determine the effect of single or combined application of NPK (150:100:100 kg) per ha and Vermicompost 5 tonnes on the field of strawberry cv. Tuft. Combined application of NPK (150:100:100 kg) per ha with Vermicompost 5 tonnes per ha resulted in the highest number of leaves, number of flowers, fruit set and number of fruits per plant.

Zargar *et al.,* (2008) noticed that combination of nitrogen (225 kg ha^{-1}), phosphorus (150 kg ha^{-1}) and *Azotobacter* showed highest values of average fruit weight (19g), plant height (40.66cm), significantly affected number of primary flowers (8.0), number of secondary flowers (10.00), total number of flowers per plant (18.00), number of primary fruits per plant (7.00), number of secondary fruits (10.00) and total number of fruits (17.0).

Yield Characters

The data on fruit weight (g), achene number and yield (q/ha) has been presented in the result. The results reveal that the application of cent per cent nitrogen was applied in the form of urea along with *Azotobacter* resulted in maximum fruit weight (16.49 g), number of achiness (363.13) and yield (372.89 q/ha). The results were, however, statistically at par with those obtained when 25 per cent of nitrogen was applied in the form of FYM + 75 per cent through urea + *Azotobacter*.

Atif Yasseen Mahadeen (2009) concluded that application of NPK-fertilizer in combination with organic fertilizer tended to increase fruit yield in comparison with the application of each of them alone. The highest strawberry yield (27.62 ton/ha) was obtained by the application of 40 tons of organic fertilizer with 60 kg NPK-fertilizer/ha while the lowest strawberry yield (21.76 ton/ha) was obtained in untreated plot. Addition of 0 and 20 kg/ha NPK fertilizer without organic fertilizer produced significantly lower strawberry yield compared with other treatment combinations. It was clearly evident that all treatments that received organic fertilizer recorded higher strawberry yield when compared with untreated plots with organic fertilizer, which indicated the importance of organic fertilizer. Number of fruits per plant was significantly decreased by adding organic fertilizer (40 ton/ha) even with combination of chemical fertilizer. On the other hand, average fruit weight was significantly increased with addition of organic fertilizer with or without chemical fertilizer the percent increase in average fruit weight due to organic fertilizer application was about 24% higher when compared with the application of NPK-fertilizer alone.

Chelpinski *et al.*, (2010) in an experiment carried out in 2006-2007, influence of different fertilizers on yield and quality of cv. Kent strawberry fruit was determined. Two combinations were tested, each consisting of 3 types of fertilizers. The control plants remained unfertilized. In both combinations, two types of multi-component fertilizers were used (T – 5% N, 5% P_2O_5, 15% K_2O and O – 10% N, 5% P_2O_5, 10% K_2O) as well as one rate of ammonium nitrate to provide 50 kg N ha^{-1} in the first combination and 70 kg N ha^{-1} in the second one. The usage of multi-component fertilizers, especially O type resulted in an increase of cv. Kent strawberry yield. The fruit collected from the control plants and the ones fertilized with ammonium nitrate weighed less than berries obtained from plants fertilized with multi component fertilizers.

Chelpinski *et al.,* (2010) in our studies, only fruit length was significantly affected by fertilizer type, whereas growing year had no significant effect on morph metric traits studied. As regards chemical properties of strawberry fruits, the two-year study on effect of bio- fertilizer and chemical fertilizers revealed a stimulating effect of bio-fertilizers, particularly PGPR 2, on SS, TA, TS and RS, which in all probability was owing to highly intensive mineralizing processes in soil and increased activity of plant root and its physiological functions. On the other hand, the two-year application of chemical fertilizer exhibited an inhibitory effect, which is indicated by low values of SS, TS and RS, which can be associated with changes in organic matter content of the growth substrate. This was also in agreement with the reports of on use of chemical fertilizers in strawberry 'Kent' where SS, TS, RS, TA, SC were greatly affected by the fertilizers.

Clay *et al.,* (1984) strawberries have been shown to be only slightly or even not affected by the N form of fertilisers supplied in the field.

David *et al.,* (2008) inoculation with AM fungi increased yield 17C/r over in inoculated controls. 5.5 Vs. 4.7 kg per ten plant sampling unit, respectively. Inoculation had no significant effect on whole season mean fruit weight, indicating an average increase of 3.6 fruit per plant for inoculated plants over uninoculated plants. Utilization of AM fungus inoculums produced on-farm as an amendment to horticultural potting media for the production of seedlings later planted has the potential for significant increases in crop yields.

Dar *et al.,* (2000) the experiment was conducted to study the effect of various organic fertilizer combinations on growth, yield and quality of strawberry (*Fragaria* × *ananassa* Duch) cv. Sweet Charlie comprising eight inorganic fertilizer treatment combinations including the control. The treatment nitrogen 100 kg + potassium 80 kg per hectare recorded maximum no. of leaves (8.34), plant spread (27.52 cm), petiole length (6.14 cm), plant height (11.50 cm), no. of flowers/plant (4.45), fruit length (1.40 cm), specific gravity (1.20), ascorbic acid (55.85 mg/100 g), pH (3.15) and yield/plant (367.60 g).

El – Hamid *et al.,* (2006) observed that application of P.S.B. (5 Kg/ha) in strawberry resulted increased size, firmness and yield (252 g/plant).

Gariglio *et al.,* (2000) observed N treatments significantly increases yield of strawberry over the control. Yield increased to increasing N rates from 0 to 53 kg/ ha, this response was an increase in fruit number but not in fruit weight.

Geoffrey *et al.,* (1993) effects and interactions of soil-applied P, B, and Zn on yield and its components were examined in the field at two ph levels with 'Earliglow' strawberries *(Fragaria* × *ananassa* Duch.).

Ghaderi and Talaie (2008) showed that application of manure along with urea had a significant effect on total fruit yield, and prevention of weight, fruit decay as well as leaf specific mass. Fruit quality is a combination of appearance, flavour, texture and nutritional value.

Gunes *et al.,* (2009) phosphorus (P)-solubilizing bacteria and fungi can increase soil-P availability, potentially enhancing crop yield when P is limiting. We studied the effectiveness of *Bacillus* FS-3 and *Aspergillus* FS9 in enhancing strawberry (*Fragaria* × *ananasa* cv. Fern) yield and mineral content of leaves and fruits on a P-deficient calcareous Aridisol in Eastern Anatolia, Turkey. The 120 d pot experiment was conducted in three replicates with three treatments (*Bacillus FS-3, Aspergillus* FS9, control) and five increasing rates of P addition (0, 50, 100, 150, and 200 kg P ha^{-1}). Fruit yield and nutrient content of fruits and leaves and soil P pools were determined at the end of the experiment. Phosphorus-fertilizer addition increased all soil P fractions. Strawberry yield increased with P addition (quadratic function) reaching a maximum of 94 g pot^{-1} at 200 kg P ha^{-1} in the absence of P-solubilizing micro-organisms. At this yield level, *Bacillus* FS-3 and *Aspergillus* FS9 inoculation resulted in P-fertilizer savings of 149 kg P ha^{-1} and 102 kg P ha^{-1}, respectively. Both micro-organisms increased yields beyond the maximum achievable yield with sole P-fertilizer addition. Micro-organism inoculation increased fruit and leaf nutrient concentrations (N, P, K, Ca, and Fe) with the largest increases upon addition of *Bacillus* FS-3. We conclude that *Bacillus* FS-3 and*Aspergillus* FS9 show great promise as yield-enhancing soil amendments in P-deficient calcareous soils of

Turkey. However, moderate additions of P fertilizer (50–100 kg ha^{-1}) are required for highest yield.

Gunes ***et al.,*** **(2009)** reported similar results in their study of effects of phosphate-solubilising micro-organisms (Bacillus FS-3, Aspergillus FS9) on strawberry yield and nutrient concentrations.

Gupta and Tripathi (2012) examined that the combined application of *Azotobacter* 6 kg per ha and Vermicompost 30 tonnes per ha significantly increased the yield (324.38 g/plant), berries with maximum length (5.01 cm), berries with maximum width (2.64 cm), weight (9.02 g) and volume (6.12 cc).

Ghoneim ***et al.,*** **(2003)** found that field investigations were conducted during the summer seasons of 1999/2000 and 2000/2001 to study the responses of strawberry plants cv. "Camarosa" to different levels of nitrogen (0, 200,300 and 400kg N fed.-1), organic manure (0, 15, 20 and 25 m3 fed. -1) and biofertilizer treatments (inoculation with or without "Halex-2") as well as their interactions on yield potentials and fruit quality of strawberry.

Hansen (1969) in strawberry who reported increased rate of translocation of photosynthetic products from leaves to developing fruits increased fruit weight.

Hammam (2003) reported that application of P.S.B. in Banana cv. William banana increased bunch weight (33 Kg), number of fingers (19) and average finger weight (114 g).

Hargreave ***et al.,*** **(2015)** asses that the organic and conventional nutrient amendments on strawberry cultivation on Fruit yield and quality.

Husam ***et al.,*** **(2015)** observed yield per plant (200.00) was recorded in T_2 (N. P. K 120: 40: 40), yield Tonnes / hac (12.00) was recorded in T_2 (N. P. K 120: 40: 40).

Iqbal umar ***et al.,*****(2009)** reported that the application of cent per cent nitrogen was applied in the form of urea along with *Azotobacter* (T_{11}) resulted in maximum fruit weight (16.49 g), number of achene (363.13) and yield (372.89 q/ha).

Jain *et al.,* (2015) the experiment conducted during the year 2013-14 and 2014-15 with 21 treatments included combinations of organic and microbial sources of nutrients (Compost, Poultry manure, Vermicompost, FYM, *Azotobacter* and PSB) replicated thrice with 18 plants per replication in Randomized Block Design. Observations were recorded for vegetative growth, fruit yield, and quality of fruit parameters. In different combinations organic manure and bio-fertilizers the treatment T_{15} (Vermicompost + Poultry manure +PSB +*Azotobacter*) was recorded highest plant height (16.19 cm), plant spread (24.68 cm), number of leaves plant^{-1} (15.79) and leaf area index (77.26 cm^2) and T_{17} (Vermicompost + FYM + PSB+ *Azotobacter*) was recorded highest petiole length (8.81cm). Plant supplied with T_{15} (Vermicompost + Poultry manure+ PSB+ *Azotobacter*) registered earliest in flowering (40.68 days) and T_{17} (Vermicompost+ FYM + PSB+ *Azotobacter*) highest number of flowers per plant (13.42). The maximum fruit weight (12.86 g), number of fruits plant^{-1} (11.78), quality TSS (7.05 °Brix) and Ascorbic acid (53.42 mg/100 g fruit pulp) and yield (112.63 g plant^{-1}) were recorded with plants treated with a T_{15} (Vermicompost+ Poultry manure +PSB +*Azotobacter*) followed by T_{18} (Poultry manure+ compost+ PSB+ *Azotobacter*) and T_{17} (FYM+ Vermicompost + PSB+ *Azotobacter)* treatment. The highest yield and best quality fruit were recorded in the combination of T_{15} (Vermicompost + Poultry manure+ PSB+ *Azotobacter*).

Joolka *et al.,* (1986) recommended fertilizer dose of 150 kg N with 75 kg P, K 205 per ha observed higher yield of strawberry.

Jugens (1990) conducted a trial with foliar spray of 10 minerals and deficiency symptoms of each like N, P, K, Mg, Ca, Mn, B, Fe and Zn were describe foliar feeding with as foliar combi – stipp, which contains N, Mg, Ca, B, Mn and Zn increase the fruit yield, fruit weight, fruit firmness and storage stability.

Khayyat *et al.,* (2007) fruit set and quality in strawberry cv. Selva were influenced by salinity (NaCl) and supplementary calcium and potassium (CaSO , CaCl , K SO) treatments applied to the root medium of plants growing in 4 2 2 4 soilless culture under heated greenhouse conditions. Yield components such as primary fruit weight and fresh fruit weight (at harvest time) and fruit number were higher in control and there were no significant differences between control and NaCl (35 mM) + CaSO (10 mM). Primary fruit weight and fresh fruit weight (at harvest time) 4 were decreased by salinity, even by CaSO or CaCl or K SO. Total acidity was higher in NaCl + CaCl (5 mM) 4 2 2 4 2 treatment compared to others. Total soluble solid and vitamin C were higher in NaCl + CaSO (10 mM) treatment 4 compared to other treatments. TSS/TA ratio was higher in NaCl + K SO (10 mM) treatment compared to others. 2 4 our results suggest that in saline conditions, CaSO application cause increase in fruit yield and quality of 4 strawberry.

Kachwaya *et al.,* (2015) study the performance of different levels of fertigation and soil fertilization on growth, yield, fruit quality and leaf nutrients content of strawberry *(Fragaria × ananassa* Duch.*)*. The experiment was laid out in randomized block design with five fertigation treatments, viz. (T_1) recommended dose of NPK through soil, (T_2) recommended dose of NPK through drip, (T_3) ¾ of recommended dose of NPK through drip, (T_4) ½ of recommended dose of NPK through drip and (T_5) 1/3 of recommended dose of NPK through drip and each treatment was replicated five times. The healthy runners of cv. Chandler were planted at a spacing of 25 cm × 50 cm in well prepared beds of 2 m × 2 m size in the last week of September 2011 and 2012 as the crop was taken as annual crop. The results revealed that fertigation with recommended dose of NPK gave significantly higher plant height (24.23 cm), leaf area (129.20 cm^2), fruit yield (35.64 tonnes/ha) as compared to fertigation with ½ and 1/3 of recommended dose of NPK and soil fertilization, but was found at par with ¾ recommended dose of NPK fertigation treatment. The maximum fruit length (42.49 mm), fruit breadth (31.74 mm) and fruit weight (19.87 g) was also recorded in fertigation with full recommended dose of NPK. The values of TSS (9.88^{o}B), total sugar (9.44%), anthocyanin (0.249 OD) and ascorbic acid (53.39 mg/100g) was significantly higher in fertigation with recommended dose of NPK treatment as compared to lower levels of fertigation and soil fertilization. The plants fertigated with full and ¾ recommended dose of NPK also had higher leaf nutrients content. Fertigation with ¾ of recommended dose of NPK registered 60 per cent higher fertilizer use efficiency over soil fertilization with full recommended dose of NPK and also resulted in 25 per cent saving of fertilizers without any adverse effect on growth, yield and fruit quality.

Lammer and Lareau (1997) demonstrated that 'Chandler' strawberry fruit weight and number increase was observed with higher N rates.

Locascio and Martin (1985) found 100% N application through urea before planting of strawberry significantly increased the marketable fruit number and fruit weight.

Lutfi and Murat (2009) with regard to the generative potential, results suggested that only strawberry yield per plant was affected by the applied bio-fertilizers and the chemical fertilizer and also recorded a significant yield increase in 'Selva' strawberry with the use of PGPR (foliar + root application).

Magge (1963) the increased weight of berries with nutrient application might have first improved the internal nutritive condition of plant leading to increased growth and vigour associated with photosynthesis and translocation of assimilates in the fruits.

Miquelao *et al.*, (1994) observed that 36 % more runner's production in strawberry cv. Chandler by the application of urea than the unfertilized control plants.

Marizana *et al.*, (2013) reported that the bio – fertilizer like *Azotobacte*r and *Bacillus* spp. improves the total yield and quality of strawberry.

Nowsheen *et al.*, (2015) the experiment comprised of five organic nutrient treatments with different combinations of FYM, *Azotobacter*, PSB, mustard oil cake, poultry manure, wood ash, *Azospirillum* including the recommended doses of N, P and K through chemical fertilizer as control. Treatment combination of poultry manure + *Azotobacter* + wood ash + phosphorus solublizing bacteria + mustard oil cake significantly improved growth, yield and quality of strawberry. Observations recorded on different growth parameters depicted that maximum plant height (23.39cm), plant spread (24.21 cm) and runners/plant (13.03) were in treatment poultry manure + *Azotobacter* + wood ash + phosphorus solublizing bacteria + mustard oil cake along with maximum yield (238.95 g/plant) and different physical characters of fruits in respect of length (3.95cm), diameter (3.11cm), volume (20.39 cm^3), weight (11.11g) and chemical characters viz. total sugars (7.95%), total soluble solids (9.01^{o}B), acidity (0.857%) and TSS/acidity ratio (11.12).

Nazir *et al.,* (2006) the maximum (7.00) number of runners/ plant was recorded in the treatment T_{12} - *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%) + FYM which was statistically significant over control (T_1) while the minimum (4.06) was recorded in treatment- T_4. Increased number of runners per plant might be due to the increased growth of plant in the form of height, number of leaves and leaf area, which accumulated more photosynthetic and thereby increased runners per plant.

Nestby *et al.,* (2004) reported that proper nutrition, cultivar specificities, weather conditions, cultural practices and water supply have an immediate effect on strawberry fruit. Chemical fertilizers also increased strawberry yield, as they ensure optimal nutritional status in plants.

Nowsheen *et al.,* (2006) reported that application of P.S.B. (5 Kg/ha) in strawberry cv. Senga Sengana resulted highest yield (230.95g/plant). They further reported observed that application of Azotobacter (4 kg/ha) on strawberry cv. Senga Sengana resulted highest yield (235.90 g/ha).

Neuweiler *et al.,* (1996) the increase in fruit weight was also reported with the increasing nitrogen application in strawberry.

Pandey and Mishra (1983) recorded that 75-100 kg nitrogen, 80-120 kg phosphorus and 50-75 kg potash per ha results in best growth, highest fruit yield and better quality in strawberry.

Pesakovic *et al.,* (2013) the present studies were conducted on 'Senga Sengana' strawberry under greenhouse conditions. Plants were treated with the three different fertilizers, i.e. liquid inoculums of diazotrophic bacteria *Klebsiella planticola* (PGPR1), liquid inoculums combined of *Azotobacter, Derxia* and *Bacillus* genera (PGPR2) and Multi KMg fertilizer. The application of PGPR1 gave the highest total number of micro-organisms, Ammonifiers, Actinomycetes and Oligonitrophils. Fertilizers did not affect the number of fungi and Azotobacter. In terms of generative potential, fertilizers had a significant effect on yield per plant. The highest yield (0.52 kg per plant) was recorded in plants treated with PGPR1. The analysis of morphometric and chemical properties revealed a significant influence of fertilizers on chemical properties of 'Senga Sengana' fruits.

Rana *et al.,* (2003) reported that application of *Azotobacter* on Strawberry cv. Chandler produced maximum yield (73.12q/ha), fruit length (35.94mm), fruit width (22.91mm) and fruit weight (9.11g).

Rashmi *et al.,* (2010) studies on effect of organic manures and inorganic fertilizers in mulberry. Among the different treatments tested on mulberry plant they reported that significantly higher nutrient contents *i.e.* nitrogen (3.23%), phosphorus (1.50%), potassium (1.80%), calcium (3.00%), magnesium (0.61%) and zinc (0.186 ppm) were recorded in the leaves obtained from treatment T11 (10 kg per ha each of *Azospirillum brasilense* and *Aspergillus awamori* + 20 per cent recommended N through each of compost, green manure (*Glyricidia maculata*), castor cake, vermicompost and fertilizer + remaining P and K through fertilizers).

Singh and Saravanan (2012) recorded highest number of fruits/plant (29.13), fruit yield/plant (417.73 g), fruit yield/ha (37.59 tonnes), fruit length (3.94 cm), fruit diameter (3.12 cm), specific gravity (1.380), T.S.S (7.36 0Brix), juice content (92.34%), titrable acidity (0.876%) and vitamin- C (59.12 mg/100 g).

Santos *et al.,* (2009) observed that the first set of studies consists of two trials conducted during 2005-06 and 2006-07 growing seasons. N rates were 0.5, 0.7 and 0.9 kg/ha per day (75, 105, 135 kg/ha per season). During the first set of studies, canopies of "Strawberry Festival" were 30% and 10% wider that "Winter Dawn" at 6 and 12 weeks, whereas N rates linearly increased canopy diameter of both cultivars.

Santos and Whidden (2007) observed that the N fertilizers improved the yield and as well as quality of strawberry fruits.

Sharma *et al.,* (2004) strawberries (*Fragaria ×ananassa* Duch.) grown in alfisols of semiarid areas in India results in suboptimal yields. Low organic carbon and low phosphorus (P) availability, in addition to high P fixation, affects P availability drastically, even when it is applied externally. The benefit to the yield of micro propagated strawberry *Fragaria × ananassa* 'Pajaro' through inoculation with Arbascullar mycorrhizal (AM) fungi and P application was examined in a field experiment. AM response was evaluated at four doses of P (50, 100, 150, and 200 kg P ha^{-1}) in a high P-fixing capacity and P-deficient alfisol. At harvest, all inoculated plants, except those at the highest level of applied P (200 kg·ha^{-1}), had larger fruit yields per plant, unit mass, number of runners, higher shoot dry matter, and shoot P content. However, the AM response as measured by yield varied with P concentration. Inoculated plants had a significantly greater fruit yield when grown at 150 kg P ha^{-1}, and the yield was comparable with uninoculated plants grown at 200 kg P ha^{-1}. The external P requirements were 71 kg ha^{-1} for mycorrhizal and 106 kg ha^{-1} for non mycorrhizal strawberry plants to obtain 90% of the maximum fruit yield. In terms of P fertilization, this corresponds to a savings of 35 kg ha^{-1}. The percent mycorrhizal root length colonization, both in inoculated and non inoculated plants, was not found to differ significantly with P application.

Singh *et al.,* (2010) reported fruit length (27.42mm), fruit diameter (25.92mm),fruits per plant (9.15), fruit weight (8.45g) and berry yield (4.54tonnes) per ha with the application of *Azotobacter chroococcum* at 1 litre broth per 1000 runners of strawberry cv. Senga Sengana.

Singh *et al.,* (2012) noticed fruit weight (8.10 g) and fruit yield (6.05 tonnes per ha) in vstrawberry cv. Senga Sengana by the application of Vermicompost (5 tonnes per ha). Whereas combined application of Vermicompost (5 tonnes per ha) and *Azotobacter* (20 g per plant) resulted berry weight of 8.48 g and fruit yield 6.39 tonnes per ha.

Singh *et al.,* (2015) projected that fruit yield of strawberry per plant (159.13, 164.90 g) with the application of Vermicompost at 10 tonnes per ha and *Azotobacter* at 7 kg per ha, respectively. Whereas, combined application of Vermicompost (10 tonnes/ha) and *Azotobacter* (7 kg/ha) significantly increased the fruit yield per plant (210.90 g).

Tabatabaei *et al.,* (2006) the effect of ammonium : nitrate (NH_4:NO_3) ratio in nutrient solution on growth, photosynthesis (Pn), yield, and fruit quality attributes in hydroponically grown strawberry (*Fragaria* × *ananassa* Duch) cv. 'Camarosa' and 'Selva' was evaluated. There were four nutrient solutions of differing NH_4:NO_3 ratios as follows: 0:100, 25:75, 50:50, and 75:25. Plants grown in solution with 75% NH_4 had lower leaf fresh and dry weights and leaf area than those with 25% NH_4 in both cultivars.

Umar *et al.,* (2010) observed significantly increased fruit size (28.9mm),fruit weight(19.6 g) and fruit yield (385.2 q/ha) with the application of 25% nitrogen through subabul + 75% nitrogen through urea in strawberry cv. Chandler.

Verma and Rao (2013) found that the maximum fruit weight, number of fruits per plant, yield per plant (181.84 g), marketable yield per plant (145.47 g) and yield per hectare (101.02 q) were recorded with plants treated with *Azotobacter* + PSB + Vermicompost + 50% RDF followed by *Azotobacter* + PSB + FYM + 50% RDF treatment. The application of *Azotobacter* + PSB + Vermicompost + 50% RDF was found to more effective in decreasing the electrical conductivity (0.02 dSm−1) and pH (6.27) of soil. The organic carbon (1.95%), available nitrogen (314.64 kg ha^{-1}), phosphorous (17.56 kg ha^{-1}) and potassium (306.33 kg ha^{-1}) were recorded significantly higher in soil after harvest of the crop in treatment receiving *Azotobacter* + PSB + Vermicompost + 50% RDF.

Wasi Amiri *et al.,* (2011) examined that effect of bio-inoculants (*Azotobacter)* on growth of strawberry 'Sujatha' resulted to increase in plant height, number of leaves per plant and leaf area.

Physico-chemical Characters

In the present investigation the total soluble solids were recorded highest on applying cent per cent nitrogen through FYM + *Azotobacter* or with 25 per cent nitrogen through FYM + 75 per cent nitrogen through urea + *Azotobacter* recording total soluble solids of 6.81 ^{o}Brix in both the treatments . Total sugars were also higher in these treatments. In the present investigation nitrogen from different sources might have increased the vigour of strawberry plants including increased leaf area with higher synthesis of assimilates due to enhanced rate of photosynthesis. Such effects have been attributed to increased rate of translocation of photosynthetic products from leaves bearing developing fruits **(Magge, 1963)** thereby increasing total sugars. Improved T.S.S. with applied organic manure (FYM) is in line with reports of **Pereira and Mitra (1999)** in guava.

The acidity of the strawberry was not affected with the various treatments tried in the present study however it increased with increase in concentration of urea as source of nitrogen. Highest acidity (0.77 %) was under treatment with cent per cent nitrogen applied through urea + *Azotobacter*. The present findings are in line with **Ahlawat and Yamdagni (1988)** who reported increase in acidity of grapes with nitrogen application. The increase in acidity might be due to synthesis of more organic acids as a result of improved foliage which might have kept the berry temperature lower by shading them and thus resulting in lower loss of acids in respiration.

Andersson *et al.,* (2012) effects on soluble solids and sugars were also previously reported. The glucose, sucrose and malic acid content of the berries were in the same range as previously. There are studies showing that strawberries are better pollinated in organic than in conventional farms.

Ali *et al.,* (2003) reported that combined application of nitrogen (150 kg), Phosphorus (100 kg) and F.Y.M. (20 ton) per ha. Maximum Resulted in Total Soluble Solids and ascorbic acid.

Asami *et al*., (2003) observed that application of Vermicompost and organic fertilizers increased vitamin- C in strawberry.

Badiyala and Bhutani (1990) had recorded total soluble solids (8.13%) and lowest acidity with the fertilizer schedule consisting of 150 kg N 75 kg P and 50 kg K per ha. in strawberry cv. Tioga in mild hills areas (palampur) of Himanchal Pradesh.

Dadashpour and Jouki (2012) this study was conducted during 2008-2009 to investigate the influence of different organic nutrient combinations on yields and quality of strawberry cv. Kurdistan in Iran. The experiment comprised of five organic nutrient treatment combinations including the recommended dose of N, P and K through chemical fertilizer as control. Treatment N_2 (manure + Azotobacter + wood ash + phosphorus solublizing bacteria + oil cake) improved significantly quality of fruit about diameter (3.11cm), length (3.95 cm), volume (20.397 cm^3), weight (11.11g), total sugars (7.95%), total soluble solids (TSS) (9.01 °Brix), acidity (0.857), TSS: acidity ratio)(11.12) and yields (238.95 g/plant.

Debnath and Ricard (2009) find the data on molecular markers, anthocyanin contents and antioxidant activities are increasingly used in breeding programs of many horticultural crops. Inter simple sequence repeat (ISSR) analysis, anthocyanin contents and antioxidant activities were used to characterize 10 strawberry (*Fragaria* x *ananassa* Duch.) cultivars and nine breeding lines. Fifteen primers generated 240 polymorphic ISSR-PCR bands. Cluster analysis by the unweighted pair-group method with arithmetic averages (UPGMA) revealed a substantial degree of genetic similarity among the genotypes ranging from 45% to 73% that were in agreement with the principal coordinate (PCO) analysis. Wide genetic diversity was observed among the strawberry genotypes for anthocyanin contents and antioxidant activities. The ISSR analysis together with data for antioxidant activities and anthocyanin contents in strawberries could be used for germplasm management and more efficient choices of parents in current strawberry breeding programs.

Derevyanchuk (1977) confirmed that strawberry grown on dark gray forest soil. Application of urea (N) gave the highest yields compared with several other N forms.

El – Hamid (2006) reported that application of P.S.B. on strawberry resulted increased in T.S.S., Total Sugar, and Ascorbic Acid and Juice percentage.

Ertuk *et al*., (2010) this study was conducted to examine the effect of inoculation of plant growth-promotion Rhizobacteria (PGPR) on phonological data, total yield and fruit quality characteristics of strawberry (*Fragaria x ananassa* Duch) cv. 'Fern' during 2006 and 2007. All bacterial root inoculations significantly increased yield per plant (1.98–20.85%), average fruit weight (3.05–19.26%) and first quality fruit ratio (10.30–32.05%) compared to control, whereas the bacterial inoculations did not affect leaf area, first flowering and harvest dates in strawberry cv. 'Fern'. The bacteria also increased soluble solid content (SSC) and vitamin C in strawberry cv. 'Fern'. The vitamin] C contents of fruits ranged from 47.41 mg 100 g^{-1} (control) to 53.88 mg 100 g^{-1} (RC05), while SSC values varied between 10.16% (control) and 12.83% (RC01). Results of this study show that RC19 (*Bacillus simplex*), RC05 (*Paenibacillus polymyxa*), and RC23 (*Bacillus* spp.) have the potential to increase the yield and growth of strawberries.

Gupta and Tripathi (2012) recorded total soluble solid (10.31 ^{0}Brix), total sugars (9.73%), ascorbic acid (56.52 mg/100g edible pulp) with minimum titratable acidity (0.52%) with combined application of *Azotobacter* at 7 kg/ha + Vermicompost at 30 tonnes/ha.

Gupta *et al.,* (2001) the growth parameter viz., Plant height, plant spread, number of leaf/plant and petiole length. Different organic manures and bio-fertilizer viz., FYM poultry manure, Sheep manure, Azotobacter, Phosphobacter, Vermicompost are taken for the better growth and yield of strawberry. It was calculate that T_2 Azotobacter 5 kg ha^{-1} + Phosphobacter 5 kg ha$^{- 1}$ + FYM 25 t ha^{-1} is the best for plant height, plant spread, no. of leaf/plant and petiole length etc. and for maximum yield and more profit.

Guohui *et al.,* (2001) effects of Arbascullar Mycorrhizae (AM) fungi, Glomus mosseae (Nicol.Gerd.), Trappe, Glomus in-traradices SchenckSmith, Glomus vermiform (Karsten) Berch on the yield and quality of strawberry grown in pots filled with replanted soil were investigated under greenhouse conditions. Results showed that there were significant differences in colonization percentage of AM fungal species in various stages. The growth, weight per fruit, number of fruit and yield per plant grown in both sterilized and non-sterilized soil were increased by AM fungal colonization. The blossom date was 4-12 days and the ripening date 4-6 days earlier compared to the control. The yield per plant was increased by 27.6%-39.5% and improved the earlier yield of strawberry treated with AM fungi. The contents of VC and sugar were enhanced, while the titratable acid content in the fruit was reduced by AM fungus colonization. Among the AM fungi, Glomus vermiform was the most effective.

Giusti and Wrolstad (2001) anthocyanin pigment content has a critical role in the color quality of many fresh and processed fruits and vegetables. Thus, accurate measurement of anthocyanin, along with their degradation indices, is very useful to food technologists and horticulturists in assessing the quality of raw and processed foods. Since many natural food colorants are anthocyanin derived (e.g., grape-skin extract, red-cabbage extract, purple-carrot extract), the same measurements can be used to assess the color quality of these food ingredients. In addition, there is intense interest in the anthocyanin content of foods and nutraceuticals because of possible health benefits such as reduction of coronary heart disease.

Haynes and Goh (1987) opined that the effect of N applications on titratable acidity and sugar content of strawberry fruits are inconsistent and vary from year to year.

Hassan *et al.,* (2015) the experimental included12 treatments resulted from the combination between three levels of organic sources plus one level of inorganic fertilizers and three treatments of Effective micro-organisms (EM), Bio-fertilizer and the control treatment (without bio- fertilizers). Results show that using 100% of the recommended dose of N, P and K as mineral fertilizers and compost significantly affected most of plant growth characters expressed as plant height , number of leaves/ plant , crown diameter, leaf area, dry weight / plant, chemical composition (N, P and K) of plant foliage, total fruit yield and its components, i.e., early fruit yield, exportable fruit yield, marketable fruit yield and total fruit yield and physical fruit quality i.e., average fruit length, diameter, weight and firmness and chemical constituents of fruit, i.e., T.S.S.%, vitamin C, titratable acidity, anthocyanin and total sugars. It was clearly evident that all treatments that received 100%of the recommended dose (organic sources or inorganic fertilizers) recorded higher values in all studied measured plant and fruit traits, as compared with compost at a rate of 50% of recommended dose. Results indicated also that bio-fertilization increased plant growth characters, chemical composition, total fruit yield and its components, physical quality and chemical constituents of fruit, i.e., TSS%, vitamin C, titratable acidity, anthocyanin and total sugars. On the other hand, chemical composition (N, P and K) of plant foliage, physical fruit quality as well as average length, diameter and weight of fruits were not statistically affected by bio-fertilization.

Husam *et al.,* (2015) observed that maximum T.S.S. found in T_5 (N.P.K100:40:40) 9 ^{0}Brix.

Jakob *et al.,* (2007) reported that the amount of anthocyanin determined by HPLC method Range from 202 to 287 mg-I in strawberry.

Kahu *et al.*, (2015) the objective of this study was to assess the strawberry cultivars in organic and conventional growing with regard to their yield and berry quality. No significant differences in commercial and defective yield per plant between two growing variants were observed in 2004, but the commercial yields were significantly higher in the conventional variant in 2005 and 2006. It was noted that organically grown strawberries had a higher content of soluble solids, but a lower content of ascorbic acid comparing with conventionally grown strawberries. Due to its good productivity and high content of soluble solids and ascorbic acid, 'Bounty' was the most profitable cultivar in this study, and appeared highly suitable for organic cultivation.

Kopanski and Kawecki (1994) showed that N application of 90 kg N per ha increased the vitamin C content of 'Dukat' and 'Senga Sengana' cultivars of strawberry.

Kirad *et al*., (2009) reported that the quality parameters of strawberry were increased with decreasing level of chemical fertilizers. Maximum acidity was recorded with the application of recommended fertilizers rate along with 25 % Vermicompost.

Kumar *et al*., (2015) applied combined application of Vermicompost (250 g) per plant and *Azotobacter* (2 g) per plant in strawberry cv. Chandler and observed total soluble solid (9.85 ^{O}Brix), titratable acidity (0.95%), ascorbic acid (53.75 mg/100g), reducing sugar (4.60 %) and total sugars (5.91%).

Kumar *et al*., (2015) the experiment was laid out In Randomized Block Design with 12 treatments in thrice replications on different levels of nitrogen, phosphorus, potassium and farmyard manure. The results revealed that the Maximum T.S.S (9.91 0Brix), Specific gravity (1.71), Ascorbic Acid (54.39 mg/100g of pulp) and the minimum Acidity (0.51%) and pH (3.50) were recorded in T_7 (150:75:60 (N: P: K) Kg/ha. + 20 tones/ha FYM) followed by T_{10}. The least values were recorded in the control.

Kumar *et al*., (2015) the present study was conducted to find out the effect of Vermicompost and *Azotobacter* on quality parameters of strawberry (*Fragaria* ×

ananassa Duch.) cv. Sweet Charlie during 2014-2015. Vermicompost and *Azotobacter* were applied separately and in combination at 100 q/ha and 30 ml/litre water, respectively. Different treatment combination revealed significant positive effect on most of the parameters studied under the experiment. Maximum total soluble solid (10.73 ^{0}Brix), titratable acidity (0.74 %), reducing sugar (4.49 %), total sugars (6.39 %), vitamin-C (69.33 mg/100g) and vitamin-A (60.00 IU/100 g) were recorded in T_4. whereas; maximum TSS: acid ratio (17.05) and sugars: acid ratio (10.15) was recorded in T_5. Higher contest of pectin (0.57 %) and anthocyanin (58.55 IU/100 g) were observed in treatments 4 and 5, respectively. Conclusively, T_4 (Vermicompost 75 % + *Azotobacter* 25%) was found most effective to improve chemical parameters of strawberry cv. Sweet Charlie.

Lacertosa *et al.,* (1999) assured that ascorbic acid and sugar concentrations were inversely correlated with the content of nitrogen in the fruits, indicating that proper N fertilizer application could be effective in improving fruit quality of strawberry.

Leskinen *et al.* (2002) recorded that organic grown strawberry had more sugar than conventional grown.

Lingua *et al.,* (2013) it is known that Arbascullar Mycorrhizae (AM) fungi can influence the plant secondary metabolic pathways such as the synthesis of essential oils in aromatic plants, of secondary metabolites in roots, and increase flavonoids concentration. Plant Growth-Promoting Bacteria (PGPB) is able to increase plant growth, improving plant nutrition and supporting plant development under natural or stressed conditions.

Macit *et al.,* (2007) observed that quality parameters of strawberry significantly affected by organic and conventionally method of cultivation.

Mahadeen *et al.,* (2009) evaluated that vitamin- C content of strawberry fruit showed a significant increased with application of organic fertilizer when compared with untreated plots with organic fertilizer. Application of 40 tons of organic fertilizer per ha with or without chemical fertilize resulted in increased vitamin C content of strawberry fruit about two times when compared with untreated plots with organic fertilizer.

Makkun *et al.,* (2001) showed that N rate of 225 kg/ha improved fruit firmness during 21 days of storage, compared to lower N rates, such as 150 kg/ha. Higher N rates increased fruit acidity and reduced sugar content.

Martinsson *et al.,* (2006) treatments with several N rates were applied to determine the optimal N rate for fertigation systems. Fertigation with a complete nutrient package lead to a 47% yield increase and enhanced N use efficiency. Fertigation with 60 kg N/ha was sufficient for high yield and good fruit quality. A field trial on light soil with broadcast solid fertilizers showed that a change from one application to 3 or 4 split applications, enhanced yield by 3-5%. In a pot trial, calcium nitrate in combination with potassium nitrate was better than an ammonium based fertilizer package without extra calcium in terms of yield (+13%), berry size (25%) and root growth (6%).

Miner *et al.,* (2016) market yield maximized with total N at ≈120 $kg \cdot ha^{-1}$ with one-half banded in the fall and the remainder drip-applied in the spring. Fruit firmness decreased with increasing N rate. Fruit pH and concentrations of total acids and soluble solids were not affected by N treatments, but soluble solids increased as the harvest season progressed. Plant crown number was not affected by N treatment but crown yield increased with N rate similar to market yield. There was no response to drip-applied K for any variable in either year. Based on soil test, fall-applied K (broadcast-soil incorporated) met the K requirements both years.

Misrha and Tripathi (2011) Azotobacter and PSB (each at 6 Kg/ha) also produced berries with maximum length (4.63 cm), width (2.64 cm), weight (8.48 g),volume (6.14 cc), TSS (10.30 ^{0}Brix), total sugars (9.54%), ascorbic acid (57.55 mg/100g edible material) with minimum titratable acidity (0.548 %) contents in comparison to untreated plants under plains of Central Uttar Pradesh (India).

Moor *et al.,* (2009) experiments were carried out with 'Polka' frigo plants in South Estonia in 2005 and 2006. The number of leaves per plant, total and marketable yields, fruit size, fruit ascorbic acid content (AAC), soluble solids content (SSC), titratable acidity (TA), anthocyanins (ACY) and total antioxidant activity (TAA) were recorded. The results indicate that Phi fertilization does not affect plant growth. Phi fertilization had no advantages in terms of yield increase, compared to traditional Pi fertilization. Fruit acidity increased and TSS decreased due to foliar fertilization with Phi in 2006. Soaking plants in Phi fertilizer solution prior planting was effective in activating plant defence mechanisms, since fruit ascorbic acid and anthocyanin content increased.

Nakata and Ohme-Tagaki (2014) anthocyanin are a class of flavonoids and important plant pigments. They attract insects to pollinate flowers, protect plants from UV irradiation, and act as antimicrobial agents against herbivores and pathogens. Biosynthesis of anthocyanin is stimulated by diverse developmental signals and environmental stresses including drought, wounding, pathogen infection and insect attack. Plant hormones such as jasmonates, a stress-related plant hormone, also induce accumulation of anthocyanin. Sensitivity of plants to these stress stimuli can be measured by accumulation of anthocyanin. Here we describe a simple method for measurement of anthocyanin in *Arabidopsis thaliana* seedlings. Amount of anthocyanin are calculated only from absorbance at 530 and 657 nm of crude extract.

Nestby *et al.,* (2005) the intention here is to narrow the information to results that suggest a direct connection between nutrient uptake and fruit quality.

Pandit *et al.,* (2015) conducted application of *Azotobacter* 5 kg per ha in strawberry cv. Chandler resulted that total soluble solids (9.65 ^{0}Brix) and acidity content of fruits (0.70%) obtained from *Azotobacter* treated plants.

Pandit *et al.,* (2015) found that application of *Azotobacter* 7 kg per ha in strawberry cv. Chandler resulted total sugars (4.70 %), reducing sugar (3.30 %), non-reducing sugar (1.33%) and vitamin-C (46.11 mg/100 g) was recorded in the fruits obtained from *Azotobacter* treated plants.

Panova *et al.,* (1976) carried out an experiment on strawberry cv. Festival Naya and Kamsomolka with the application of NPK at 100:60:80 kg per ha along with Vermicompost at 5 tonnes per ha. The addition of N increased fruit sugar constant but decreased total acidity. Different type of nitrogenous fertilizers did not differ in their effect on fruit chemical composition.

Rana and Chandel (2003) ascertained that inoculation of *Azotobacter* with 80 kg N/ha in strawberry cv. Chandler resulted in maximum T.S.S. content (8.78 ^{O}Brix), whereas maximum total sugar (7.65%) was recorded in the fruits obtained from *Azotobacter* inoculated plants.

Sahoo and Singh (2005) observed that soil application of different levels of bio-fertilizers (*Azotobacter, Azospirillum*) on strawberry cv. Sweet Charlie, have significantly effect on quality attributes of strawberry fruits. T.S.S (8.6 ^{0}Brix) were enhanced with the application of 6 kg Azotobacter per ha.

Shehata *et al.,* (2011) revealed that by using compost the amounts of total soluble salt and anthocyanin levels in strawberry fruit have increased in greater extent with respect to chemical fertilizer.

Singh *et al.,* (2012) confirmed that T.S.S. (9.75 ^{0}Brix), titratable acidity (0.534%), total sugars (7.06%) and ascorbic acid (49.59%) by using Vermicompost (5 tonnes per ha) in strawberry cv. Senga Sengana. Whereas, combined application of Vermicompost (5 tonnes per ha) and *Azotobacter* (20 g per plant) resulted T.S.S. (9.86 ^{0}Brix), titratable acidity (0.523 %), total sugars (7.37 %) and ascorbic acid (49.96 %).

Singh *et al.,* (2010) the maximum T.S.S. (8.81°B), TSS/acidity ratio (12.77), total sugars (7.40%) and ascorbic acid (50.69 mg/100 g) were recorded under co-inoculation with *Azotobacter* + *Azospirillum* + *Pseudomonas striate* being at par with *Azotobacter* + *Azospirillum* + *Arbascullar Mycorrhizae* fungi but significantly higher over application of recommended dose of fertilizers. However, maximum titratable acidity was recorded with control (0.82%) which was significantly higher over all the treatments.

Singh and Singh (2009) the maximum growth in terms of plant height, number of leaves, leaf area, crowns/plant and total biomass were observed in the treatment consisting of *Azotobacter* + *Azospirillum* + 60 kg N ha^{-1} + 100 ppm GA_3 .

This treatment also contains highest chlorophyll content in leaves. Highest fruit set, yield and optimum fruit quality was recorded in plants inoculated with *Azotobacter* and *Azospirillum* along with 60 kg N ha^{-1} (50% N of the standard dose) and 100 ppm GA_3. The plant nutrient status was much influenced by combined use of bio-fertilizer and bio-regulators. Dual inoculation with *Azotobacter* and *Azospirillum* along with 60 kg N ha^{-1} and 100 ppm GA_3 application resulted in maximum N and Mg content in plant while the maximum Zn content was obtained in dual inoculation along with 90 kg N ha^{-1} and 100 ppm GA_3. However, maximum K content was recorded with 100 ppm BA treatment alone.

Tripathi *et al.,* (2011) observed that maximum duration of harvesting (70.90 days) and minimum number of days taken to produce first flower(56.69 days) and fruit set (6.12 days) with significantly more yield (322.17 g/plant) were also observed in *Azotobacter* and PSB (each at 6 Kg/ha) fertilized plants. So far as the quality characters of berries are concerned, plants fertilized with *Azotobacter* and PSB (each at 6 Kg/ha) also produced berries with maximum length (4.63 cm), width (2.64 cm), weight (8.48 g),volume (6.14 cc), TSS (10.30 ^{0}Brix), total sugars (9.54%), ascorbic acid (57.55 mg/100g edible material) with minimum titratable acidity (0.548 %) contents in comparison to untreated plants under plains of Central Uttar Pradesh (India).

Tonutare *et al.,* (2014) the aim of the research was to analyse the weaknesses of the pH differential method for strawberry anthocyanin determination. The work is based on practical experiments with 12 strawberry cultivars and on analysis of published papers. We used following molar absorption coefficients (values): 26900 and 29600 M-1 cm-1 for cyaniding 3glycoside (C3g) and 15600, 22400, 27300 and 36000 M-1 cm-1 for pelargonidin 3 glycoside (P3g). In order to show how the calculated value of total anthocyanin depends on the predominant anthocyanin used for the calculations, we compared the results of spectroscopic and chromatographic analysis. Present research demonstrated that different values may influence the results of total anthocyanin even more than cultivar properties. The most frequently used values 26900 M-1 cm-1 and 29600 M-1 cm-1 gave underestimated values. C3g was present in minor amounts in all cultivars. Conclusively, P3g with the = 15600 M-1 cm-1 should be used for ensuring most precise estimation of total anthocyanin content in strawberries.

Umar *et al.,* (2010) summarized that application of 25% nitrogen through subabul + 75% nitrogen in the form of urea augmented with bio-fertilizer resulted in maximum total soluble solid (6.836 ^{0}Brix), total sugars (4.85%) in strawberry cv. Chandler.

Yadav *et al.,* (2010) observed that the maximum amount of ascorbic acid (57.55 mg/100g edible material) content was recorded in berries produced from the plants fertilized with *Azotobacter* + PSB (each at 6 kg/ha), closely followed by *Azotobacter* 6 kg/ha+ PSB 5 kg/ha (56.47 mg/100g edible material), whereas, the minimum amount of ascorbic acid content (47.64 mg/100g edible material) was recorded in fruits produced from untreated plants in strawberry.

Yoshida *et al.,* (2002) assessed that anthocyanin synthesis in strawberry fruits may be reduced by N deficiency.

Z.A. Baba *et al.,* (2010) study the combined effect of nitrogen (0, 75, 150 Kg ha^{-1}), phosphorus (0, 50, 100 kg ha^{-1}) and bio-fertilizers (No inoculants, *Azotobacter* sp., *Bacillus* sp., *Pseudomonas* sp., *Glomus* sp.) on soil Physico-chemical properties and micro nutrient availability in strawberry growing soils.

Benefit Cost Ratio

Gupta, Pratima and Kumar, Vidhur (2015) the experiment consisting 12 treatments with 3 replication was conducted in field plot with Randomized Block Design. The growth parameter viz., Plant height, plant spread, number of leaf/plant and petiole length. Different organic manures and bio-fertilizer viz., FYM poultry manure, Sheep manure, Azotobacter, phosphobacter, Vermicompost are taken for the better growth and yield of strawberry. It was calculate that T_2 Azotobacter 5 kg ha^{-1} + Phosphobacter 5 kg ha^{-1} + FYM 25 t ha^{-1} is the best for plant height, plant spread, no. of leaf/plant and petiole length etc. and for maximum yield and more profit.

Singh *et al.,* (2018) On the basis of results obtained, It is concluded that the treatment T_5 (75% RDF + 25% Vermicompost + Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha) was found beneficial in terms of maximum yield (24.87 t/ha) and quality of strawberry with net return of 19, 86, 880 Rs/ha. = 19.86 Lakh/ha and maximum benefit cost ratio (1: 4.97).

MATERIALS AND METHODS

Chapter III

MATERIALS AND METHODS

The present investigation entitled **"Effect of Inorganic and Bio-fertilizers on Growth, Yield and Physico – chemical characters of Strawberry (*Fragaria* x *ananassa* L. Duch.) cv. Chandler in Central Uttar Pradesh"** was carried out at the Horticulture Research Farm of the Department of Applied Plant Science (Horticulture) Babasaheb Bhimrao Ambedkar University, Vidya Vihar, and Rae Bareli Road, Lucknow 226025 during the winter season of 2014-15 and 2015-2016 year. The details of methodology adapted in this experiment have been presented under.

LOCATION AND SITE OF EXPERIMENT:

The experiment was conducted at the Horticultural Research Farm-I, of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow. The experimental plot located approximately 10 km from Lucknow on the Rae Bareli Road towards the south city of the Lucknow. The farm is situated at an elevation of 129 meters above the mean sea level. Lucknow is geographically situated in the subtropical tract of central U.P. at 26^o 46' North latitude and 80^o 55' East longitudes.

TOPOGRAPHY, CLIMATE AND WEATHER CONDITIONS:

The climate of the region is subtropical with maximum temperature ranging from 29.3 ^oC to 46 ^OC in the summer season and minimum temperature ranging from 3.5 ^OC to 12 ^OC in winter. The relative humidity (RH) is 50 -77 % in different seasons of the year with hot or summer and cold winter. The average rainfall is 700 mm, most of which is received from July to September distributed over a period of about 100 days, with the peak period between July to August. Scattered showers also occur during the winter months. In general, the temperature ranges from 5 ^OC to 42 ^OC. The coldest month of the year is January, while the maximum temperature is recorded during the months of May and June, respectively. The soil of experimental farm was saline with soil pH less than 8.2, Electrical conductivity more than 4.0 and sodium exchangeable percentage less than 15.0. During the period of experiment, meteorological observations were recorded from Indian Institute of Sugarcane Research, Lucknow and presented in Table 3.1.

EXPERIMENTAL MATERIAL:

The runners of Chandler variety of strawberry were brought from the Dr Yashwant Singh Parmar University of Horticulture & Forestry, Nauni, Solan (H. P.) in both years. The runners were kept for two days in shade for hardening before transplanting in well- prepared beds under open field condition plots which were distributed randomly in three replications with thirteen treatments. Standard cultural practices were followed during the period of the experiment for maintaining the runners quality and yield also.

Table-3.1: Weekly Meteorological observations recorded during the Experimental period of the crop (2014-15, 2015- 16)

2014-15

Period		**Mean Temp.(ºC)**		**Relative humidity (%)**		**Wind Velocity (Km/hr)**	**Total Rainfall (mm)**
Month	**Date**	**Maximum**	**Minimum**	**Maximum**	**Minimum**		
Sep. 2014	01-07	32.31	21.53	92.29	74.00	02.80	02.76
	08-14	33.93	20.36	91.00	71.29	01.30	06.54
	15-21	29.91	21.59	91.14	62.29	01.40	02.90
	21-30	31.48	20.29	72.67	41.89	03.10	00.10
Oct. 2014	01-07	30.93	19.50	91.02	55.57	00.95	05.01
	08-14	30.21	15.25	92.11	60.50	01.82	05.55
	15-21	27.22	11.34	91.86	53.00	04.26	02.60
	21-31	28.49	11.70	95.00	55.60	00.75	00.00
Nov. 2014	01-07	26.40	09.61	91.71	47.00	01.59	00.00
	08-14	25.91	09.53	88.29	40.09	01.70	00.00
	15-21	26.21	09.25	90.86	41.57	01.20	00.00

	21-30	26.50	09.31	94.11	41.11	01.10	00.00
Dec. 2014	01-07	23.54	09.54	88.20	45.29	01.52	00.00
	08-14	20.40	08.84	92.56	54.71	01.33	01.77
	15-21	18.64	08.96	96.14	68.00	01.44	00.00
	21-31	14.59	05.17	95.20	68.30	00.72	00.00
Jan. 2015	01-07	19.10	10.04	92.01	71.00	02.30	00.00
	08-14	15.01	06.50	96.30	72.02	00.56	00.00
	15-21	14.30	06.30	95.00	72.00	01.22	00.00
	22-28	23.00	09.30	92.00	60.00	01.88	00.00
Feb. 2015	01-04	21.60	08.22	93.00	48.21	02.70	00.00
	05-11	22.20	09.20	91.02	49.20	03.02	00.00
	12-18	25.30	11.03	92.06	42.02	02.10	00.00
	19-25	29.70	15.20	92.02	43.00	02.20	00.00
	26-28	26.20	16.30	90.02	41.02	02.60	00.00
Mar. 2015	01-04	25.30	15.50	90.21	60.00	02.60	00.00
	05-11	26.10	12.60	88.30	38.05	04.62	00.00
	12-18	25.55	14.80	85.01	48.20	04.60	00.00
	19-25	30.20	15.80	85.30	40.02	04.02	00.00
	26-30	34.02	18.70	91.20	42.01	02.30	00.00

2015-16

Period		**Mean Temp.(ºC)**		**Relative humidity (%)**		**Wind Velocity (Km/hr)**	**Total Rainfall (mm)**
Month	**Date**	**Maximum**	**Minimum**	**Maximum**	**Minimum**		
Sep. 2015	01-07	33.31	22.53	91.29	72.00	02.70	02.86
	08-14	31.93	22.36	93.00	73.29	01.34	06.74
	15-21	32.91	22.59	94.14	66.29	01.49	02.97
	21-30	34.48	21.29	77.67	47.89	03.17	00.00
Oct. 2015	01-07	32.93	20.07	93.86	59.57	01.00	00.69
	08-14	32.91	16.69	93.29	61.57	01.81	05.77
	15-21	28.19	13.19	94.86	54.57	04.56	03.60
	21-31	30.59	12.70	96.00	59.60	00.83	00.00

Nov.2015	01-07	29.40	09.61	93.71	47.43	01.69	00.00
	08-14	29.51	09.93	90.29	40.29	01.70	00.00
	15-21	27.21	09.71	92.86	43.57	01.49	00.00
	21-30	27.00	09.43	95.11	43.33	01.19	00.00
Dec.2015	01-07	25.37	09.57	89.57	46.29	01.87	00.00
	08-14	22.70	08.84	94.86	54.71	01.33	01.77
	15-21	19.64	08.96	96.14	69.00	01.54	00.00
	21-31	15.95	05.17	96.20	70.30	0.72	00.00
Jan. 2016	01-07	20.10	11.40	94.00	72.00	02.40	00.00
	08-14	16.40	06.50	97.00	74.00	01.00	00.00
	15-21	15.70	06.70	95.00	70.00	01.40	00.00
	22-28	20.00	10.50	96.00	61.00	01.80	00.00
Feb. 2016	01-04	21.80	08.20	92.00	49.00	02.90	00.00
	05-11	22.90	10.40	92.00	51.00	03.30	00.00
	12-18	26.30	11.60	93.00	43.00	02.30	00.00
	19-28	29.70	15.20	95.00	45.00	02.40	00.00
Mar. 2016	01-04	26.20	16.20	91.00	60.00	02.70	00.00
	05-11	27.60	13.90	88.00	39.00	05.30	00.00
	12-18	28.40	15.80	89.00	50.00	4.70	00.00
	19-25	31.30	16.80	85.00	41.00	05.00	00.00
	26-30	34.00	19.70	92.00	43.00	02.30	00.00

[Source – Indian Institute of Sugarcane Research (IISR) Lucknow]

Soil status of experimental area:

The soil of experimental field is sandy loam and slightly alkaline in nature with the soil pH 8.2. The physical and chemical properties of soli have been presented in below Table.

Physical and chemical properties of soil

A	Physical Property of soil		
S. No.	**Soil Particle**	**Percentage**	
1	Sand	34.50	Hydrometer meter method (Block, 1965)
2	Silt	50.20	
3	Clay	15.30	
4	Texture class	Sandy loam	Triangular method (Sigmoid, 1928)
B	**Chemical property 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, 1983)
3	Available K_2O (Kg/ha)	190.40	Flame photometer (Jackson, 1983)
4	Organic carbon (%)	0.12	Rapid titration method (Jackson, 1983)
5	Ph	8.2	Glass electrode, pH meter (Jackson, 1983)
6	E.C (1:1)	0.26	Conductivity meter (Jackson, 1983)
7	E.S.P.	14.80	Conductivity meter (Jackson, 1983)

Test crop- Strawberry (*Fragaria* × *ananassa.* Duch)

Preparation of experimental field

The experimental field was ploughed to the depth of 30 cm with the help of tractor. The field was kept open to sun for at least 10 days for killing the weeds and eggs of insects by repeated plough followed by planking to obtain fine tilth. Required area was marked and prepared according to the lay out plan. A total 48 plots were made with a size 2.1 x 1.2 m^2 of each plot. 0.5 m wide drainage channel were made between the two replications. Each plot contains 6 rows (rows were raised by 15 cm from main field) and runners were planted at distance of 30 x 15 cm (6 plants in each row), accommodated 36 plants in each plot. The strawberry runners were planted on 29th October (date matched by planting material brought) in the evening 2013-14 and 2014-15, respectively. The details of experimental layout are presented in Table 3.3 and Figure 3.2.

Lay out of field fig.3.2.

Path	canal	Treatment	Treatment	canal	Treatment	canal	Path
		T_1	T_7		T_{13}		
		T_2	T_8		T_{12}		
		T_3	T_9		T_{11}		
		T_4	T_{10}		T_{10}		
		T_5	T_{11}		T_9		
		T_6	T_{12}		T_8		
		T_7	T_{13}		T_7		
		T_8	T_6		T_6		
		T_9	T_5		T_5		
		T_{10}	T_4		T_4		
		T_{11}	T_3		T_3		
		T_{12}	T_2		T_2		
		T_{13}	T_1		T_1		

Planting:

The planting was done in single row system, healthy runners was transplanted on 10th October 2015 and October 2016 during evening hours. Runners were planted in four rows in each plot at a distance of 30 cm row to row and 15 cm plant to plant

Irrigation:

The first irrigation was applied immediately after planting and the subsequent irrigation 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. Weeding and hoeing were done manually with the help of hand hoe and khurpi. Generally four to five weeding and hoeing were done during the crop period.

LAY OUT OF EXPERIMENT:

An area of 17.60 m x 7.60 m size was divided into 39 plots having the size of 1.2 m x 1.2 m and arranged in the three replications of 13 plots. The experiment was laid out in R. B. D under 13 treatments as depicted in Fig-2.

Length=17.60 meter

Path= 1 meter

Main Irrigation Channel= 1 meter

Back Border= 1.0 meter

Bed – 13 x 1.2 meter = 15.6 meter

Width= 7.60 meter

2 Path = 1.0m + 1.0 m = 2.0 meter

Sub Irrigation Channel= 1.0 + 1.0 = 2.0 meter

Bed Width= 3 x 1.2 m =3.6 meter

Plate 1: General View of Field

Plate 2: Weighing of Fertilizers

Plate 3: Treatment Combinations

T_1 Control (No Inorganic and no Bio-fertilizers)

T_2 (100 Kg N ha^{-1}+ *Azotobacter*)

T_3 = (100 Kg N ha-1 + PSB)

T_4 = (75 Kg N ha-1 + *Azotobacter*)

T_5 = (75 Kg N ha-1+ PSB)

T_6 = (60 Kg P ha-1 + *Azotobacter*)

T_7 = (60 Kg P ha-1+ PSB)

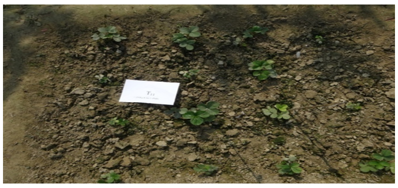
T_8 = (45 Kg P ha-1 + *Azotobacter*)

Plate 4: Treatment Combinations

T_9 = (45 Kg P ha-1 + PSB)

T_{10} = (60 Kg K ha-1 + *Azotobacter*)

T_{11} = (60 Kg K ha-1 + PSB)



T_{12} = (45 Kg K ha-1 + *Azotobacter*)

T_{13} = (45 Kg K ha-1 + PSB)

Plate 5: General View

A general view of fruiting stage

A general view of field

A general view of mulched field

PROGRAMME OF WORK:

The details of materials to be used and procedures to be followed during the course of investigation are mentioned below:

Location:

Horticultural Research Farm of the Department of Applied Plant Science (Horticulture), School of Bio-Science & Bio-Technology, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.)

Variety is to be used: Chandler

Source of N, P and K (Urea, SSP and M.O.P)

Level of N

100 % of RDF

75 % of RDF

Level of P

100 % of RDF

75 % of RDF

Level of K

100 % of RDF

75 % of RDF

Level of bio-fertilizers

Azotobacter 100 %

PSB 100 %

Treatments Detail:

T_1= Control (No Inorganic and no Bio-fertilizers)

T_2 = (100 Kg N ha^{-1}+ *Azotobacter*)

T_3 = (100 Kg N ha^{-1} + PSB)

T_4 = (75 Kg N ha^{-1} + *Azotobacter*)

T_5= (75 Kg N ha^{-1} + PSB)

T_6 = (60 Kg P ha^{-1} + *Azotobacter*)

T_7 = (60 Kg P ha^{-1} + PSB)

T_8 = (45 Kg P ha^{-1} + *Azotobacter*)

T_9 = (45 Kg P ha^{-1} + PSB)

T_{10} = (60 Kg K ha^{-1} + *Azotobacter*)

T_{11} = (60 Kg K ha^{-1} + PSB)

T_{12} = (45 Kg K ha^{-1} + *Azotobacter*)

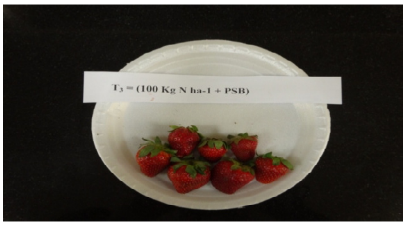
T_{13} = (45 Kg K ha^{-1} + PSB)

Plate 6: Treatment Viz Fruits

Fruits of treatment first

Fruits of treatment second

Fruits of treatment third



Fruits of treatment fourth

Fruits of treatment five

Fruits of treatment six

Fruits of treatment seven

Fruits of treatment eight

Plate 7: Treatment Viz Fruits

Fruits of treatment nine

Fruits of treatment ten

Fruits of treatment eleven

Fruits of treatment twelve

Fruits of treatment thirteen

DETAILS OF EXPERIMENTAL LAYOUT:

Number of Treatment combination	=	13
Replication	=	3
Number of plots	=	39
Net plot size	=	1.20 x 0.90 m
Row to row distance	=	30 cm
Plant to plant distance	=	15cm
Number of runners per Plot	=	24
Total number of runners to be required	=	936
Design	=	Randomized Block Design

OBSERVATIONS RECORDED

(A) Growth Parameters:

(1) Height of plant (cm):

The average height of the plants was measured from ground level of terminal end of leaf with the help of measuring scale at 15 days interval (30, 45, 60, 75, 90) from planting till harvest and data were express in centimetre.

(2) Spread of the plant (cm):

The spreading of plant was observed in both North – South, East – West direction with the help of measuring scale which denotes in centimetre.

(3) Number of leaves:

The number of leaves was recorded at 15 days interval by counting them from planting till harvest and data were express as an average number of leaves per plant.

(4) Leaf length (cm):

The leaf length was also observed with the help of measuring scale in North – South direction and expressed in centimetre.

(5) Leaf width (cm):

The leaf width was measured with the help of measuring scale in East – West direction and expressed in centimetre.

(6) Number of runners:

The average numbers of runners in all plant were recorded in each treatment after last flush of fruit harvest in the end of March.

(B) Yield Parameters:

1. Number of fruits per plant:

The total number of fruits was recorded at 15 days interval by counting total fruit set and harvested fruit from same plant.

Total number of fruits = fruit set + fruit harvest

% fruit set = No. of fruits /No. of flower X 100

2. Fruit length (cm):

The fruit length also measured by digital vernier callipers and reading denotes by centimetre.

3. Fruit width (cm):

The fruit width measured by digital vernier callipers and reading denotes by centimetre.

4. Fruit weight (g):

The determination of berry weight selected ten berries was weighted and the average weight of berry was calculated and expressed in grams (g).

5. Fruit yield per plant (g):

The fruit yield per plant was recorded from each bed at the time of harvesting and average weight of fruit per plant was calculated and expressed in gram.

5. Fruit yield per plot (Kg):

The fruit yield per plot was recorded from multiplication of fruit yield per plant (g) and the total number of plant in each treatment (24), which expressed in Kg.

6. Fruit yield per hectare (t):

(C) Physico- Chemical Parameters:

1. Total soluble solids (T.S.S.)

The total soluble solids were determined by using a Digital hand refractrometer. The refractrometer was set at zero with distilled water. A small amount of fruit was taken in muslin cloth and crushed. The refractrometer was wiped clear with a moist muslin cloth. A drop of juice of crushed pulp was taken on refractrometer and the value was read against light. Values thus, obtained were expressed in percentage (Saini *et al.,* 2001).

2. Titrable Acidity:

One hundred gram (100g) fruit was crushed in a blender and the juice obtained was filtered and volume made up to 100 ml. Ten ml aliquot of sample was titrated against 0.1N NaOH using few drop of Phenolphthalein as indicator. The result was calculated as percent anhydrous Mallic acid according to following formula (Saini *et al.,* 2001).

$$\textbf{Titrable Acidity} = \frac{\text{Titer x normality of alkali x vol. made up x Equivalent weight of acid}}{\text{Volume of sample taken for estimation X weight or volume of sample taken}} \text{X } 100$$

3. Ascorbic acid (vitamin C):

10 ml of fruit juice was made up to 100 ml with 3% HPO_3 and filtered. 10 ml aliquot was titrated against standard dye (2, 4- Dichlorophenol indophenols) to obtain a pink colour which persisted for at least 15 seconds. Ascorbic acid content was calculated by using following formula (V.R. Sagar, D.V.K Samuel, 2008).

$$\textbf{Mg of ascorbic/100g} = \frac{\text{Titer X dye factor X volume made up}}{\text{Volume of extract X weight or volume of sample taken for estimation}} \text{X 100}$$

4. Pigment Anthocyanin (mg/ 100 g)

The Anthocyanin was determined by the method as suggested by Rangana (1997). Dilute 10 ml of juice to 50 ml, with 0.1NHCL and allow equilibrating in the dark for one hour. Record the absorbance (O.D.) at 510 nm.

5. Total sugars:

Twenty gram of fresh berry pulp was thoroughly homogenized with distilled water in warring blender and volume was made to 250ml. To this solution, 5 ml of 10 percent sodium oxalate was added to precipitate the excess of lead acetate and filtered, 50 ml of the filtrate was taken and hydrolyzed by adding concentrated hydrochloric acid (HCL) and it was allowed to stand overnight. The excess of HCL was neutralized with saturated NaOH solutions.

The hydrolyzed aliquot was taken in a burette and titrated against boiling solution containing 5 ml each of Fehling 'A' and Fehling 'B' using methyl blue as an indicator (A.O.A.C., 1980). The end point was indicated by the appearance of brick red colour and the total sugars (glucose equivalent) were worked out as grams of fresh weight of berry pulp.

6. Reducing sugar (%)

To determine the reducing sugar, 10 g pulp was crushed with distilled water. Filtered with muslin cloth and volume was maintained up to 100 ml. Five ml aliquot was taken with 5 ml Fehling solution 'A' and 'B' in 100 ml conical flask and was titrated against 1 per cent glucose solution , while boiling by using methyl blue as indicator. The end point was marked by the appearance of brick red colour.

7. Non – reducing sugar (%)

Non-reducing sugar was estimated by deducting the quantity of reducing sugar from total invert sugar and multiplied by factor 0.95.The results were expressed as per cent for non-reducing sugar.

Non-reducing sugar (%) = Total sugars (%) – reducing sugar (%) x 0.95

3.12. Statistical Analysis

The data recorded for various vegetative, flowering, fruiting, yield and quality characters during the year 2015-16 of experiment were statistically analyzed as per method described by S.R.S. Chandel (1984). The significance of difference tested through variance ratio and the significance of difference between any two means was judged with the critical difference (C. D.) at 5% level of significance which was worked out according to following formula:

The standard error (S.E.M$\pm$) for the difference of treatment mean was computed as follow:

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

Where,

MSE =Mean sum of squares 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 per cent level of significance

EXPERIMENTAL FINDINGS

Chapter IV

EXPERIMENTAL FINDINGS

The present experiment entitled **"Effect of Inorganic and Bio-fertilizers on Growth, Yield and Physico – chemical characters of Strawberry (*Fragaria* x *annanasa* L. Duch.) cv. Chandler in Central Uttar Pradesh"** was carried out at the Horticulture Research Farm-I, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow (U.P.) during 2014-2015 and 2015-2016. In this chapter, the observations recorded during the period of experimentation 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

(C) Physico – Chemical Parameters

4.1 Plant Growth Characters:

4.1.1 Plant height (cm):

The data with respect to plant height were recorded at 15 days interval from 30 days to 90 days of planting. The data illustrated in Table 4.1 and Fig no. 4.1.1 clearly indicated significant differences among the various treatments combination with respect to height of plants in strawberry cv. Chandler during 2014-15 and 2015-16. During the period 2014-15 height of plant varies from 4.05cm to 18.67cm at 90 days after planting whereas, the highest plant height observed at 30 days after planting find under the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) which followed by the treatment T_4 (75 Kg N ha^{-1} + *Azotobacter*) and at 90 days after planting the maximum plant height (18.67cm) was assess in treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*).

Among the plant height of rest of the treatments, the shortest plants (14.18cm) were noticed in the T_1 (control).

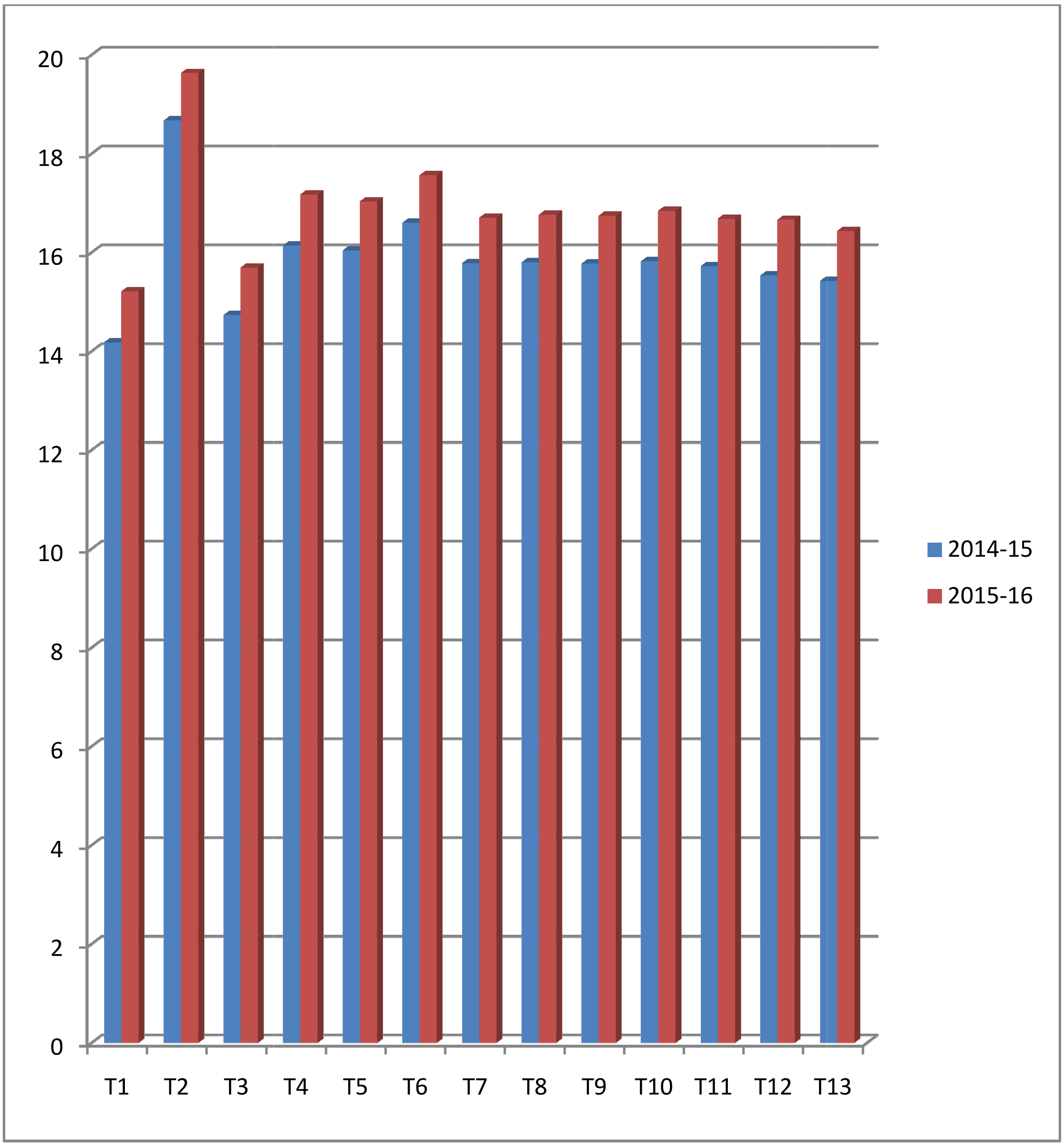
Height of the plants ranged from 5.07cm to 19.63cm during the period 2015-16. The maximum plant height at 30 days after planning (6.32cm) observed in the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by treatment T_4 (75 Kg N ha^{-1} + *Azotobacter*). The maximum plant height (19.63cm) observed in the plots which were treated with T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_6 (60 Kg P ha^{-1} + *Azotobacter*). From the observations made during both the years it was noted that treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) produced tallest plant.

In the pooled data showed at 30days after planting that the maximum value of plant height was observed in treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by treatment T_4 (75 Kg N ha^{-1} + *Azotobacter*) and minimum value in treatment T_1 Control(without fertilizers). However, at 90 days after planting the maximum plant height (19.15cm) observed in treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_6 (60 Kg P ha^{-1} + *Azotobacter*) 17.08cm and minimum value also find out in treatment T_1 Control (with out fertilizers).

Table-4.1: Effect of Inorganic and Bio-fertilizers on plant height (cm) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	14.18	15.21	14.69
T_2(100 Kg N ha-1+ *Azotobacter*)	18.67	19.63	19.15
T_3(100 Kg N ha-1 + PSB)	14.73	15.69	15.21
T_4(75 Kg N ha-1 + *Azotobacter*)	16.14	17.17	16.65
T_5(75 Kg N ha-1+ PSB)	16.04	17.03	16.53
T_6(60 Kg P ha-1 + *Azotobacter*)	16.60	17.56	17.08
T_7(60 Kg P ha-1+ PSB)	15.78	16.70	16.24
T_8(45 Kg P ha-1 + *Azotobacter*)	15.80	16.76	16.28
T_9(45 Kg P ha-1 + PSB)	15.77	16.74	16.25
T_{10}(60 Kg K ha-1 + *Azotobacter*)	15.82	16.84	16.33
T_{11}(60 Kg K ha-1 + PSB)	15.72	16.68	16.20
T_{12}(60 Kg K ha-1 + PSB)	15.53	16.66	16.09
T_{13}(45 Kg Kha-1 + PSB)	15.42	16.43	15.92
CD at 5%	0.178	0.150	0.164

Fig no.4.1.1 Effect of Inorganic and Bio-fertilizers on plant height (cm) at 90DAP



4.1.2 Plant spread (cm)

The data with respect to plant spread were observed at 15 days interval from 30 days to 90 days of planting in Table no. 4.2, 4.3 with Fig no. 4.2.1, 4.3.1. Representing the effect of N, P, K and with combination of *Azotobacter,* PSB, influenced the spread of plants significantly in strawberry cv. Chandler during two consecutive years of experimentation (2014-15 and 2015-16). During 2014-15, it varied from 3.33cm to 26.73cm being the highest under treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) at 30 days after planting followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*) in N-S direction. The maximum value find out at 90 days after planting (26.73cm) in the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) which statistically at par with the treatment T_4 (75 Kg N ha^{-1} + *Azotobacter*).

In the year 2015-16 the minimum observation finds in the N-S direction 30 days in (3.61cm) the treatment T_1 Control (without fertilizers) and the maximum value (7.88cm) observed in the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*). At 90 days after planting the higher value ascertain in the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) and the minimum value noted in the treatment T_1 Control (without fertilizers).

In pooled data, the highest value (26.89cm) assess in the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) and the lowest data observed in the treatment T_1 Control (without fertilizers).

In E-W direction the result find out at 30 days after planting in 2014-15 minimum spreading observed (2.71cm) in treatment T_1 (control) (No Inorganic and no Bio-fertilizers) and the maximum value (4.72cm) in treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*). The maximum spreading assess in the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*), minimum plant spreading (14.83cm) was noticed in the control at 90 days after planting.

Spread of the plants ranged from 2.83cm to 14.94cm during 2015-16. The plants having maximum spread (14.94cm) were grown in the plots which were treated (100 Kg N ha^{-1} + *Azotobacter*) T_2 followed by (75 Kg N ha^{-1} + *Azotobacter*) T_4 (14.82cm).

The mean value of both years clearly revealed that the maximum plant spread was found in treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*) whereas, the minimum plant spread was resulted in T_1 (control) (No Inorganic and no Bio-fertilizers).

Table-4.2: Effect of Inorganic and Bio-fertilizers on spread of plant N-S (cm) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	15.63	15.96	15.79
T_2(100 Kg N ha-1+ *Azotobacter*)	26.73	27.06	26.89
T_3(100 Kg N ha-1 + PSB)	20.33	20.71	20.52
T_4(75 Kg N ha-1 + *Azotobacter*)	21.78	21.11	21.44
T_5(75 Kg N ha-1+ PSB)	19.77	20.10	19.93
T_6(60 Kg P ha-1 + *Azotobacter*)	20.73	21.06	20.89
T_7(60 Kg P ha-1+ PSB)	19.78	20.11	19.94
T_8(45 Kg P ha-1 + *Azotobacter*)	18.83	19.16	18.99
T_9(45 Kg P ha-1 + PSB)	18.78	19.11	18.94
T_{10}(60 Kg K ha-1 + *Azotobacter*)	19.73	20.06	19.89
T_{11}(60 Kg K ha-1 + PSB)	19.63	19.96	19.79
T_{12}(60 Kg K ha-1 + PSB)	18.76	19.10	18.93
T_{13}(45 Kg Kha-1 + PSB)	18.37	18.70	18.53
CD at 5%	0.082	1.021	0.551

Table-4.3: Effect of Inorganic and Bio-fertilizers on Spread of plant E-W (cm) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	12.27	12.60	12.43
T_2(100 Kg N ha-1+ *Azotobacter*)	14.83	14.94	14.88
T_3(100 Kg N ha-1 + PSB)	13.83	14.16	13.99
T_4(75 Kg N ha-1 + *Azotobacter*)	14.77	14.82	14.79
T_5(75 Kg N ha-1+ PSB)	13.75	14.05	13.90
T_6(60 Kg P ha-1 + *Azotobacter*)	13.78	13.85	13.81
T_7(60 Kg P ha-1+ PSB)	13.73	13.80	13.76
T_8(45 Kg P ha-1 + *Azotobacter*)	12.73	12.76	12.74
T_9(45 Kg P ha-1 + PSB)	12.67	12.60	12.63
T_{10}(60 Kg K ha-1 + *Azotobacter*)	13.77	13.81	13.79
T_{11}(60 Kg K ha-1 + PSB)	12.85	12.88	12.86
T_{12}(60 Kg K ha-1 + PSB)	12.72	12.74	12.73
T_{13}(45 Kg Kha-1 + PSB)	12.53	12.63	12.58
CD at 5%	0.122	0.469	0.295

Fig. No. -4.2.1: Effect of Inorganic and Bio-fertilizers on Spread of plant N-S (cm) at 90DAP

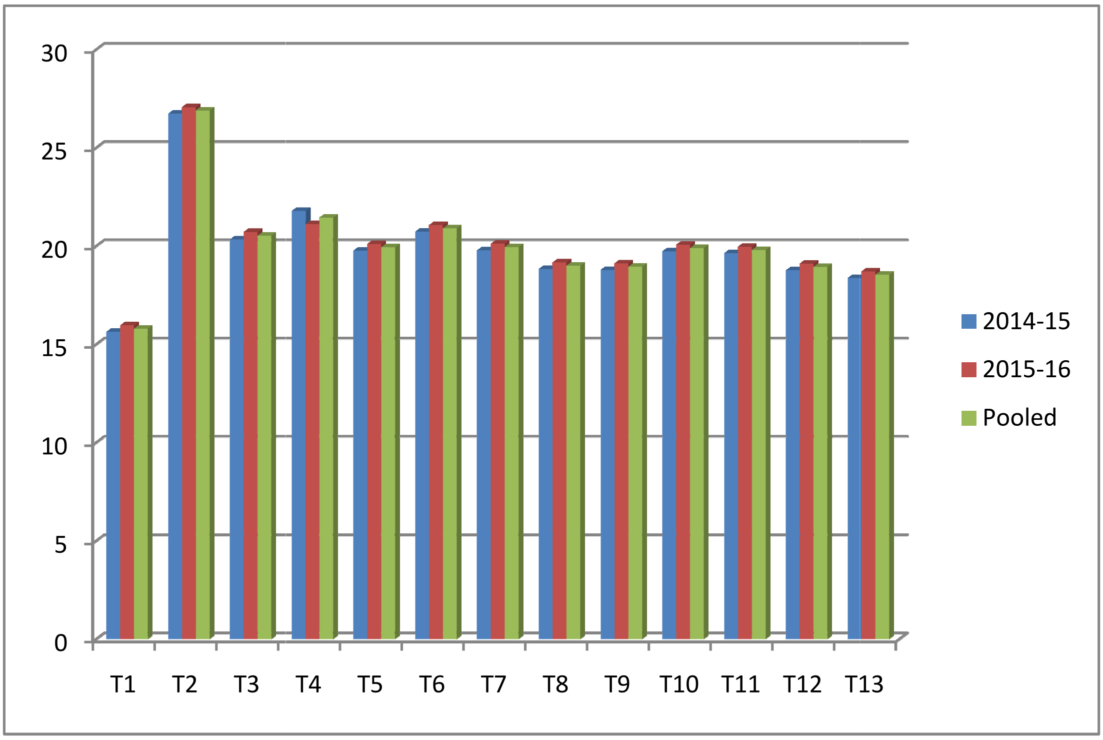
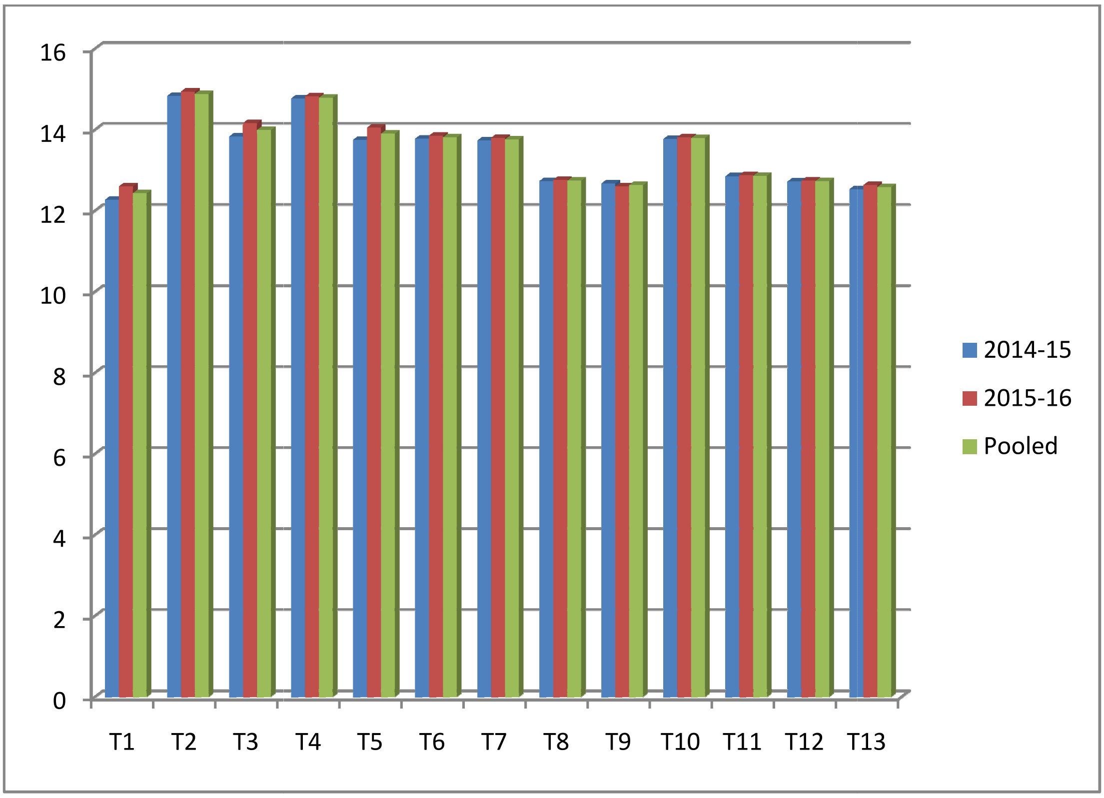


Fig. no. -4.3.1: Effect of Inorganic and Bio-fertilizers on Spread of plant E-W (cm) at 90DAP



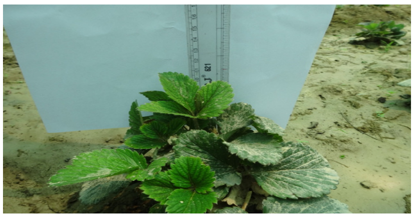
4.1.3 Number of leaves per plant:

The number of leaves observed at 15 days interval from 30 days to 90 days of planting. Numbers of leaves per plant varied from 2.67 to 18.67 during 2014-15 and 3.33 to 19.63 during 2015-16 as elaborated in Table- 4.4 and Fig 4.4.1. The treatment combination T_2 (100 Kg N ha^{-1} + *Azotobacter*) produced the maximum number of leaves per plant followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*) in 2014-15. However, the minimum numbers of leaves per plant 14.33 were recorded under the treatment T_1 (control).

During the period of 2015-16, maximum numbers of leaves per plant (19.33) were recorded in the plants treated with T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*) and minimum number of leaves ascertain in the treatment T_1 control (No Inorganic and no Bio-fertilizers).

Plate 8: Observations to be Recorded

Plant height



Leaf length

Leaf width

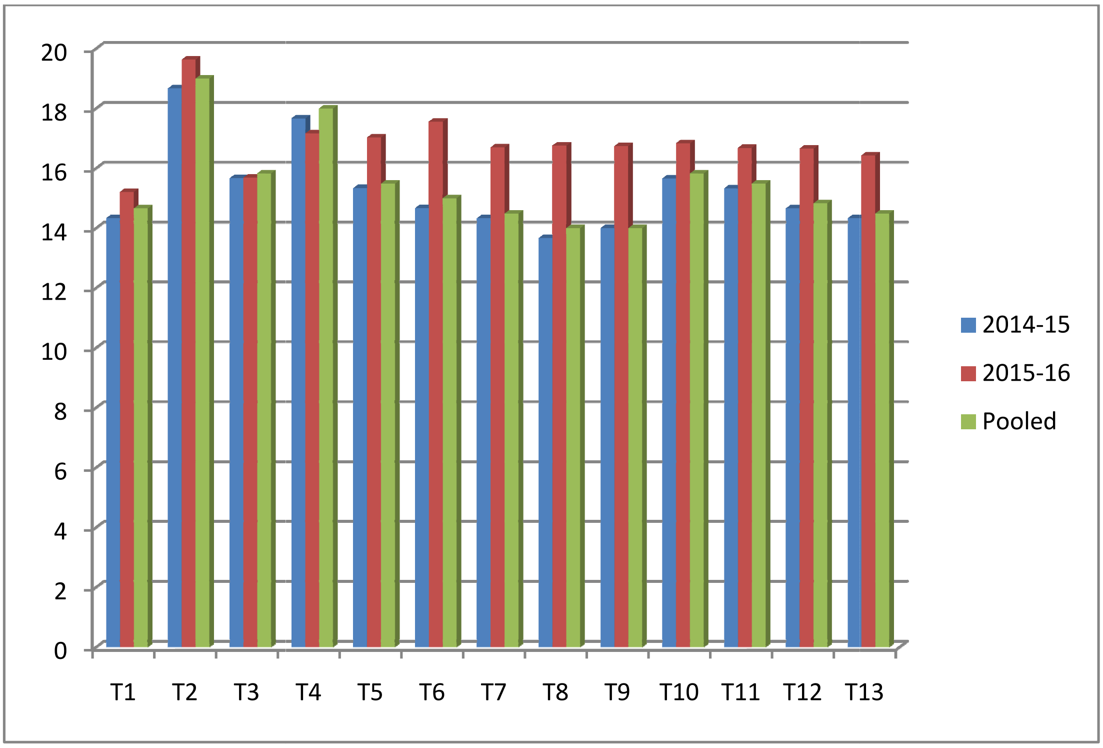
Sample for analysis purpose

The mean value of both years clearly revealed that the maximum numbers of leaves (19.00) were observed in treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_4 (18.00) while, the lowest numbers (14.66) of leaves were found in (T_1) control (No Inorganic and no Bio-fertilizers).

Table-4.4: Effect of Inorganic and Bio-fertilizers on number of leaves at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	14.33	15.21	14.66
T_2(100 Kg N ha-1+ *Azotobacter*)	18.67	19.63	19.00
T_3(100 Kg N ha-1 + PSB)	15.67	15.69	15.83
T_4(75 Kg N ha-1 + *Azotobacter*)	17.67	17.17	18.00
T_5(75 Kg N ha-1+ PSB)	15.34	17.03	15.49
T_6(60 Kg P ha-1 + *Azotobacter*)	14.67	17.56	15.00
T_7(60 Kg P ha-1+ PSB)	14.33	16.70	14.49
T_8(45 Kg P ha-1 + *Azotobacter*)	13.67	16.76	14.00
T_9(45 Kg P ha-1 + PSB)	14.00	16.74	14.00
T_{10}(60 Kg K ha-1 + *Azotobacter*)	15.66	16.84	15.83
T_{11}(60 Kg K ha-1 + PSB)	15.33	16.68	15.49
T_{12}(60 Kg K ha-1 + PSB)	14.66	16.66	14.83
T_{13}(45 Kg Kha-1 + PSB)	14.33	16.43	14.49
CD at 5%	0.957	1.704	1.330

Fig. no.-4.4.1: Effect of Inorganic and Bio-fertilizers on number of leaves at 90DAP



4.1.5 Leaf length (cm)

The data analysis of leaf length done at 15 days interval at 30 to 90 days of planting and find out the relevant data which shows below. The data pertaining to leaf length clearly showed that in Table- 4.5 with Fig no. 4.5.1 the significant difference among the various treatments During the years 2014-15 Table- 4.3 leaf length varied from 3.53cm to 9.94 cm being the highest under treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100kg N+P.S.B). In year 2015-16 the leaf length varies between 3.86cm to 10.28cm. The lowest leaf length (7.21cm) was asses at 90 days after planting in treatment T_1 Control (without fertilizers).

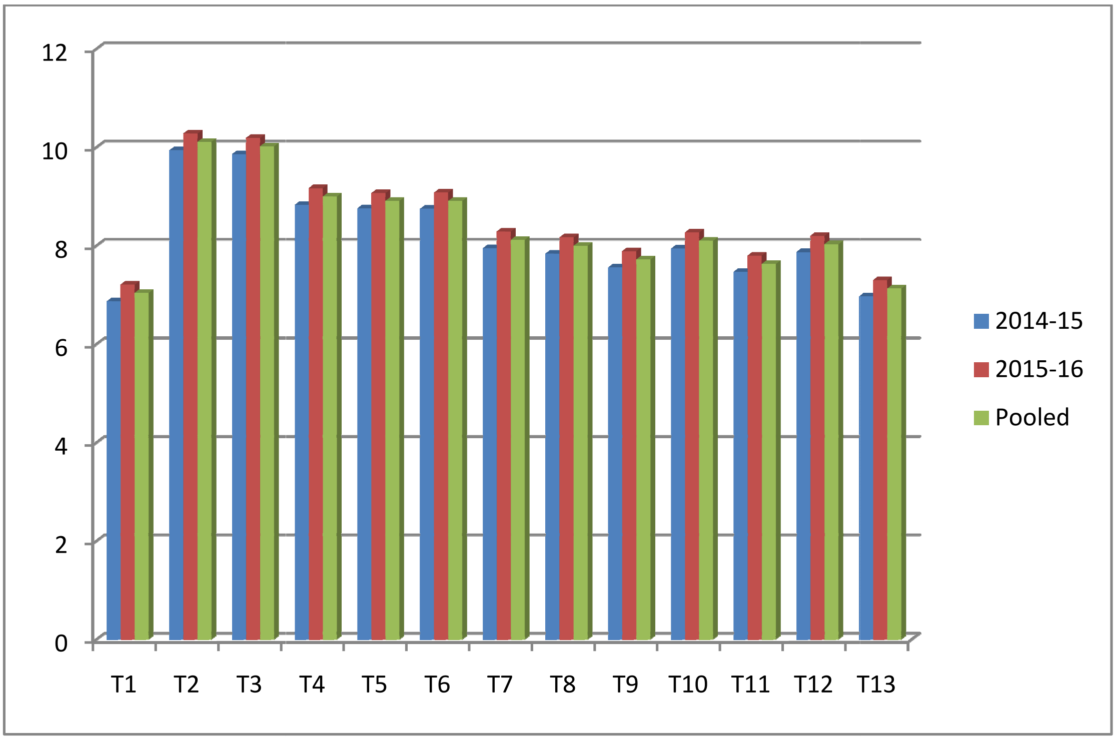
The plants having maximum leaf length (10.28cm) were grown in the plots which were treated with T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha^{-1} + PSB) (10.19cm) at 90 days after planting in the year 2015-16. The minimum leaf length (7.21cm) was noted under the control.

The mean value of both years clearly revealed that the maximum leaf length was found in treatment T_2 followed by T_3 (100 Kg N ha^{-1} + PSB) and T_4 (75 Kg N ha^{-1} + *Azotobacter*) while, the minimum leaf length was observed under the control (No Inorganic and no Bio-fertilizers) treatment.

Table-4.5: Effect of Inorganic and Bio-fertilizers on Leaf length (cm) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	6.87	7.21	7.04
T_2(100 Kg N ha-1+ *Azotobacter*)	9.94	10.28	10.11
T_3(100 Kg N ha-1 + PSB)	9.86	10.19	10.02
T_4(75 Kg N ha-1 + *Azotobacter*)	8.83	9.17	9.00
T_5(75 Kg N ha-1+ PSB)	8.76	9.07	8.91
T_6(60 Kg P ha-1 + *Azotobacter*)	8.75	9.08	8.91
T_7(60 Kg P ha-1+ PSB)	7.95	8.29	8.12
T_8(45 Kg P ha-1 + *Azotobacter*)	7.84	8.17	8.00
T_9(45 Kg P ha-1 + PSB)	7.56	7.89	7.72
T_{10}(60 Kg K ha-1 + *Azotobacter*)	7.94	8.27	8.10
T_{11}(60 Kg K ha-1 + PSB)	7.47	7.80	7.63
T_{12}(60 Kg K ha-1 + PSB)	7.87	8.20	8.03
T_{13}(45 Kg Kha-1 + PSB)	6.97	7.30	7.13
CD at 5%	0.024	1.025	0.524

Fig. no.-4.5.1: Effect of Inorganic and Bio-fertilizers on Leaf length (cm) at 90DAP



4.1.6 Leaf width (cm)

The assessment of leaf width done at 15 days interval at 30days to 90 days of planting find out the effective data which influence on plant growth. The data incorporated in Table -4.6 with Fig. No.- 4.6.1 showed the significant differences among the NPK and *Azotobacter*, PSB alone and in combination with treatments in respect to leaf width during the period 2014-15 and 2015-16.

During the period of 2014-15, leaf width varied from 3.41cm to 10.14cm at 30 days to 90 days of planting. The maximum value (5.82cm) find out under the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (5.71cm) while the minimum leaf width (3.41cm) was noticed in the plots treated under control at 30 days of planting. The highest value noted under the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (10.06 cm) while the minimum leaf width (7.02cm) was noticed in the plots treated under control.

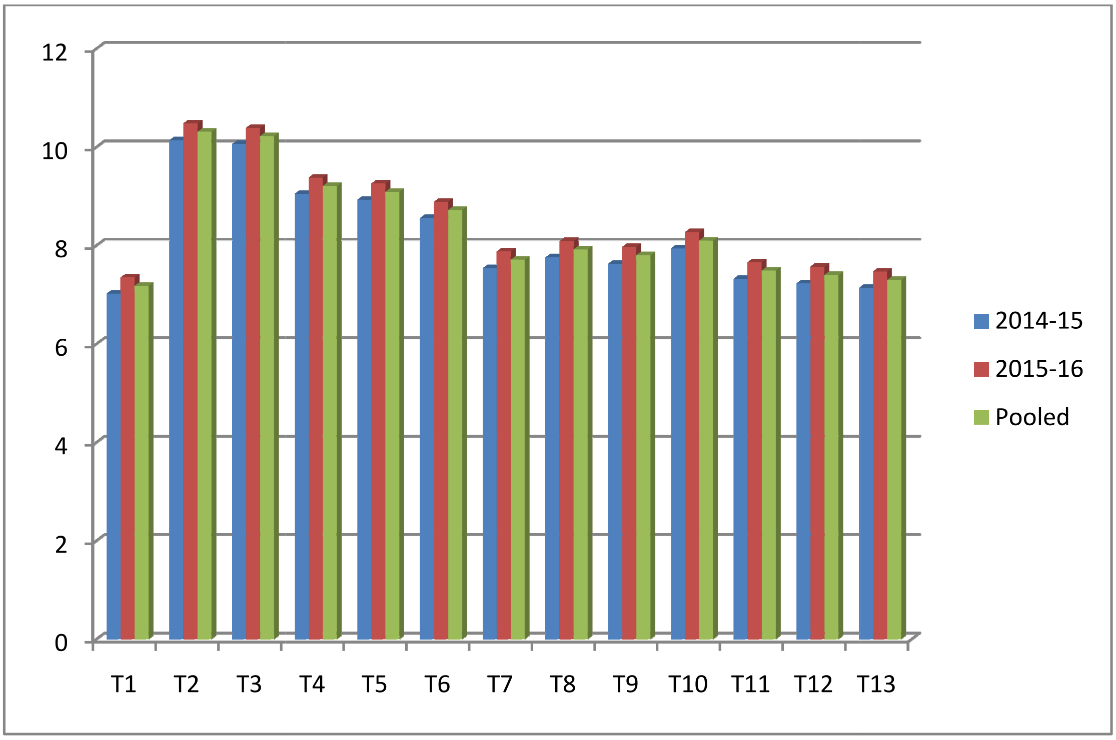
Leaf width ranged from 3.74cm to 10.48cm during 2015-16. The plants having maximum leaf width (10.48cm) were grown in the plots which were treated with T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha^{-1} + PSB) (10.39cm) and T_4 (9.38cm) at 90 days of planting. The minimum leaf length was observed (7.35cm) under the control.

The average value of both years clearly revealed the significant differences among the various treatments with maximum leaf width in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha^{-1} + PSB) and T_4 (75Kg N ha^{-1} + *Azotobacter*). The pooled data pertaining to leaf width shows the minimum leaf width was observed in control (No Inorganic and no Bio-fertilizers).

Table-6: Effect of Inorganic and Bio-fertilizers on Leaf width (cm) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	7.02	7.35	7.18
T_2(100 Kg N ha-1+ *Azotobacter*)	10.14	10.48	10.31
T_3(100 Kg N ha-1 + PSB)	10.06	10.39	10.22
T_4(75 Kg N ha-1 + *Azotobacter*)	9.05	9.38	9.21
T_5(75 Kg N ha-1+ PSB)	8.93	9.26	9.09
T_6(60 Kg P ha-1 + *Azotobacter*)	8.56	8.89	8.72
T_7(60 Kg P ha-1+ PSB)	7.54	7.88	7.71
T_8(45 Kg P ha-1 + *Azotobacter*)	7.76	8.09	7.92
T_9(45 Kg P ha-1 + PSB)	7.63	7.97	7.80
T_{10}(60 Kg K ha-1 + *Azotobacter*)	7.94	8.27	8.10
T_{11}(60 Kg K ha-1 + PSB)	7.32	7.66	7.49
T_{12}(60 Kg K ha-1 + PSB)	7.23	7.57	7.40
T_{13}(45 Kg Kha-1 + PSB)	7.14	7.47	7.30
CD at 5%	0.033	0.940	0.486

Fig. no-6.1: Effect of Inorganic and Bio-fertilizers on Leaf width (cm) at 90DAP



4.1.7 Number of runners per plant

It is obvious from the data given in Table- 4.7 with Fig no. 4.7.1 that various treatments showed significant differences during 2014-15 and 2015-16 at 90 days of planting.

During the first year 2014-15 the maximum number of runners per plant (6.66) were counted in the plants treated with treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by treatment (6.33) T_3 (100kg N ha^{-1} + P.S.B) and T_4 (75Kg N ha^{-1} + *Azotobacter*) (6.33). The minimum number of runners (3.33) was observed in treatment T_1 (control).

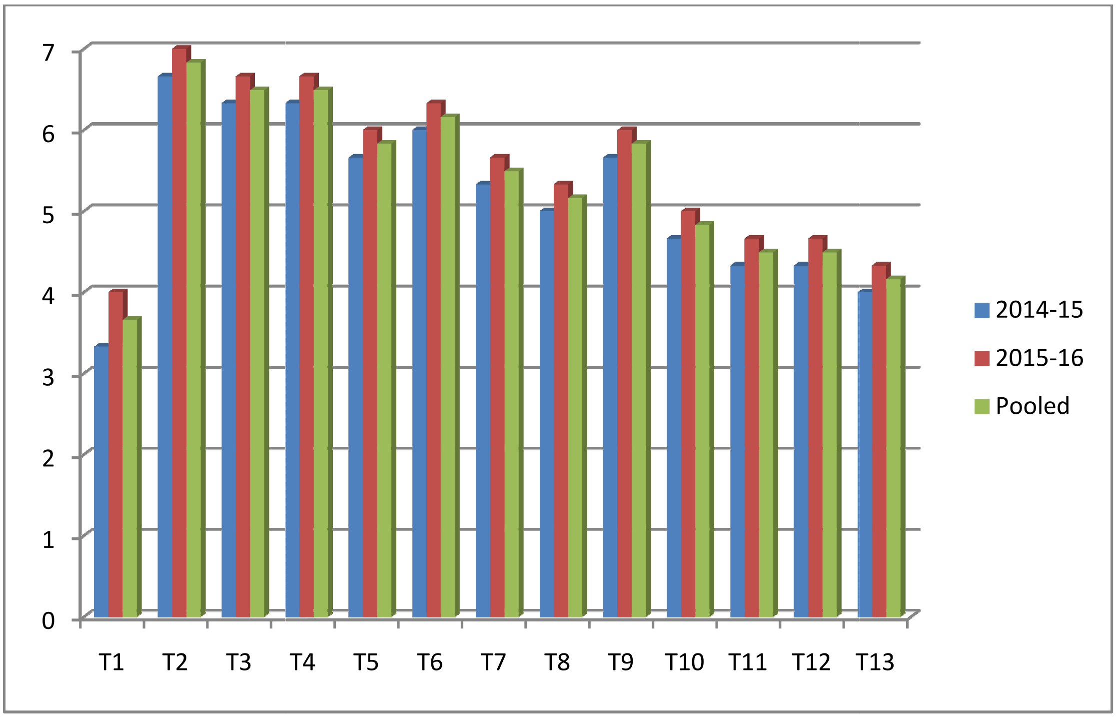
Number of runners varied from 4.00 to 7.00 in the year 2015-16. Maximum number of runners was found in the plots treated with treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by treatment T_3 (100kg N ha^{-1} + P.S.B) and T_4 (75Kg N ha^{-1} + *Azotobacter*).

The pooled data clearly shows that the maximum number of runners (6.83) were found in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha^{-1} + PSB), whereas the lowest number (3.66) of runners were produced under the control plots.

Table-4.7: Effect of Inorganic and Bio-fertilizers on Number of runners at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	3.33	4.00	3.66
T_2(100 Kg N ha-1+ *Azotobacter*)	6.66	7.00	6.83
T_3(100 Kg N ha-1 + PSB)	6.33	6.66	6.49
T_4(75 Kg N ha-1 + *Azotobacter*)	6.33	6.66	6.49
T_5(75 Kg N ha-1+ PSB)	5.66	6.00	5.83
T_6(60 Kg P ha-1 + *Azotobacter*)	6.00	6.33	6.16
T_7(60 Kg P ha-1+ PSB)	5.33	5.66	5.49
T_8(45 Kg P ha-1 + *Azotobacter*)	5.00	5.33	5.16
T_9(45 Kg P ha-1 + PSB)	5.66	6.00	5.83
T_{10}(60 Kg K ha-1 + *Azotobacter*)	4.66	5.00	4.83
T_{11}(60 Kg K ha-1 + PSB)	4.33	4.66	4.49
T_{12}(60 Kg K ha-1 + PSB)	4.33	4.66	4.49
T_{13}(45 Kg Kha-1 + PSB)	4.00	4.33	4.16
CD at 5%	1.160	0.840	1.000

Fig. no.-4.7.1: Effect of Inorganic and Bio-fertilizers on Number of runners at 90DAP



4.1.8 Number of fruits per plant

The number of fruits observed at 7 days interval with 67 days to 81 days of planting. The data with respect to number of fruits per plant illustrated in Table-4.8 with Fig no. 4.8.1 revealed the significant differences among the various treatments during 2014-15; it varied from 1.33 to 10.66 at 67 days to 81 days of planting. Maximum number of fruits per plant (10.66) was counted in the plants treated with T_{12} (45 Kg K ha^{-1} + *Azotobacter*) and followed (10.33) by T_{11} (60 Kg K ha^{-1} + P.S.B), T_{13} (45 Kg K ha^{-1} + P.S.B). The minimum number of fruits per plant (6.33) was observed under the control at 81 days of planting.

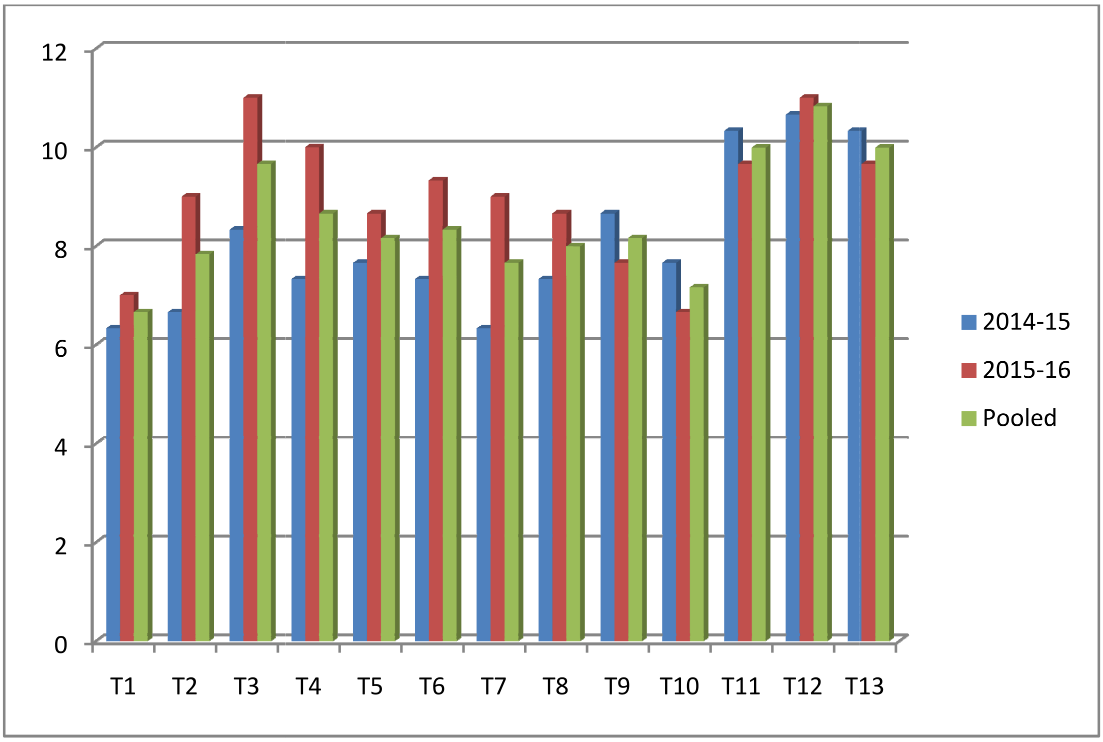
During the period of 2015-16 it ranged from 1.33 to 11.00 with 7 days of interval at 67 days to 81 days of planting. The maximum number of fruits per plant (11.00) was observed in plants treated with T_{12} (45 Kg K ha^{-1} + *Azotobacter*), T_3 (100 Kg N ha^{-1} + PSB) followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*). The minimum number of fruits per plant (6.66) observed under T_{10} (60 Kg K ha^{-1} + *Azotobacter*).

The average value of both years clearly revealed that the maximum number of fruits was found in treatment T_{12} (45 Kg K ha^{-1} + *Azotobacter*) (10.83) followed by T_{11} (60 Kg K ha^{-1} + P.S.B) (9.99) and T_{13} (45 Kg K ha^{-1} + P.S.B) (9.99), whereas, the minimum was observed in T_1 (6.66) (No Inorganic and no Bio-fertilizers).

Table-4.8: Effect of Inorganic and Bio-fertilizers on Number of fruits at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	6.33	7.00	6.66
T_2(100 Kg N ha-1+ *Azotobacter*)	6.66	9.00	7.83
T_3(100 Kg N ha-1 + PSB)	8.33	11.00	9.66
T_4(75 Kg N ha-1 + *Azotobacter*)	7.33	10.00	8.66
T_5(75 Kg N ha-1+ PSB)	7.66	8.66	8.16
T_6(60 Kg P ha-1 + *Azotobacter*)	7.33	9.33	8.33
T_7(60 Kg P ha-1+ PSB)	6.33	9.00	7.66
T_8(45 Kg P ha-1 + *Azotobacter*)	7.33	8.66	7.99
T_9(45 Kg P ha-1 + PSB)	8.66	7.66	8.16
T_{10}(60 Kg K ha-1 + *Azotobacter*)	7.66	6.66	7.16
T_{11}(60 Kg K ha-1 + PSB)	10.33	9.66	9.99
T_{12}(60 Kg K ha-1 + PSB)	10.66	11.00	10.83
T_{13}(45 Kg Kha-1 + PSB)	10.33	9.66	9.99
CD at 5%	1.178	1.183	1.180

Fig. no.-4.8.1: Effect of Inorganic and Bio-fertilizers on Number of fruits at 90DAP



4.1.9 Length of fruits

Data regarding the fruit length in strawberry cv. Chandler as presented in Table- 4.9 with Fig no. 4.9.1 revealed the significant differences among the various treatments during 2014-15 and 2015-16. During the period of 2014-15, it ranged from 3.95cm to 5.51 cm while, 4.29cm to 5.85cm during 2015-16.

The maximum fruit length was measured in the plants treated with treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) during both consecutive cropping years (2014-15 and 2015-16). During 2014-15 maximum fruit length was observed in T_2 (100 Kg N ha^{-1} + *Azotobacter*) (5.51cm) statistically at par with treatment T_4 (75 Kg N ha^{-1} + *Azotobacter*), T_3 (100Kg N ha^{-1} + P.S.B).

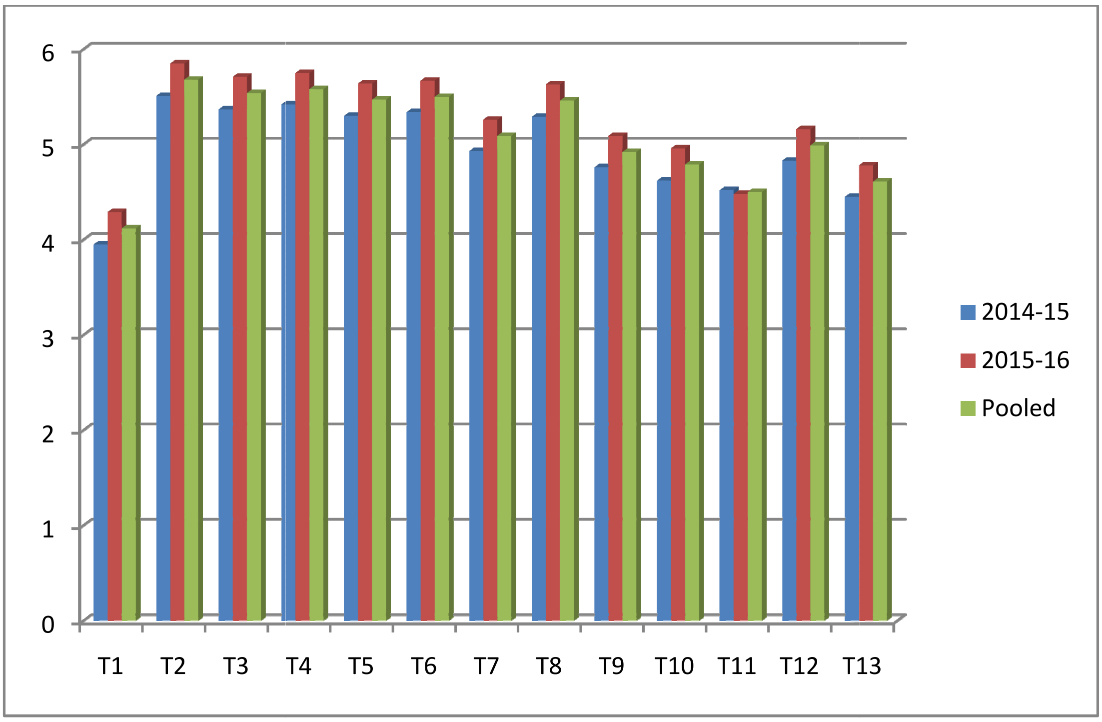
During the second year (2015-16), the longest fruit (5.85cm) was observed in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*), and T_3 (100Kg N ha^{-1} + P.S.B).

The pooled data as presented in Table 4.6 clearly revealed the significant differences among the treatments. The longest fruits were observed in T_2 (100 Kg N ha^{-1} + *Azotobacter*) (5.68cm) which were significantly higher to other treatments, whereas the shortest fruit was recorded in control (No Inorganic and no Bio-fertilizers).

Table-4.9: Effect of Inorganic and Bio-fertilizers on Length of fruits (cm) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	3.95	4.29	4.12
T_2(100 Kg N ha-1+ *Azotobacter*)	5.51	5.85	5.68
T_3(100 Kg N ha-1 + PSB)	5.37	5.71	5.54
T_4(75 Kg N ha-1 + *Azotobacter*)	5.42	5.75	5.58
T_5(75 Kg N ha-1+ PSB)	5.30	5.64	5.47
T_6(60 Kg P ha-1 + *Azotobacter*)	5.34	5.67	5.50
T_7(60 Kg P ha-1+ PSB)	4.93	5.26	5.09
T_8(45 Kg P ha-1 + *Azotobacter*)	5.29	5.63	5.46
T_9(45 Kg P ha-1 + PSB)	4.76	5.09	4.92
T_{10}(60 Kg K ha-1 + *Azotobacter*)	4.62	4.96	4.79
T_{11}(60 Kg K ha-1 + PSB)	4.52	4.48	4.50
T_{12}(60 Kg K ha-1 + PSB)	4.83	5.16	4.99
T_{13}(45 Kg Kha-1 + PSB)	4.45	4.78	4.61
CD at 5%	0.038	0.038	0.038

Fig. no.-4.9: Effect of Inorganic and Bio-fertilizers on Length of fruits (cm) at 90DAP



4.1.10 Fruit width (cm)

During the period of 2014-15 fruit width was range between 3.60cm to 4.47cm with Table -4.10, Fig No. 4.10.1 the maximum fruit width (4.47cm) was observed in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*) (4.42cm), T_3 (100Kg N ha^{-1} + P.S.B) (4.37cm).

However, the minimum fruit width was observed in control (3.60cm). During the second year 2015-16, the fruit width varied from 3.93cm to 4.80cm.

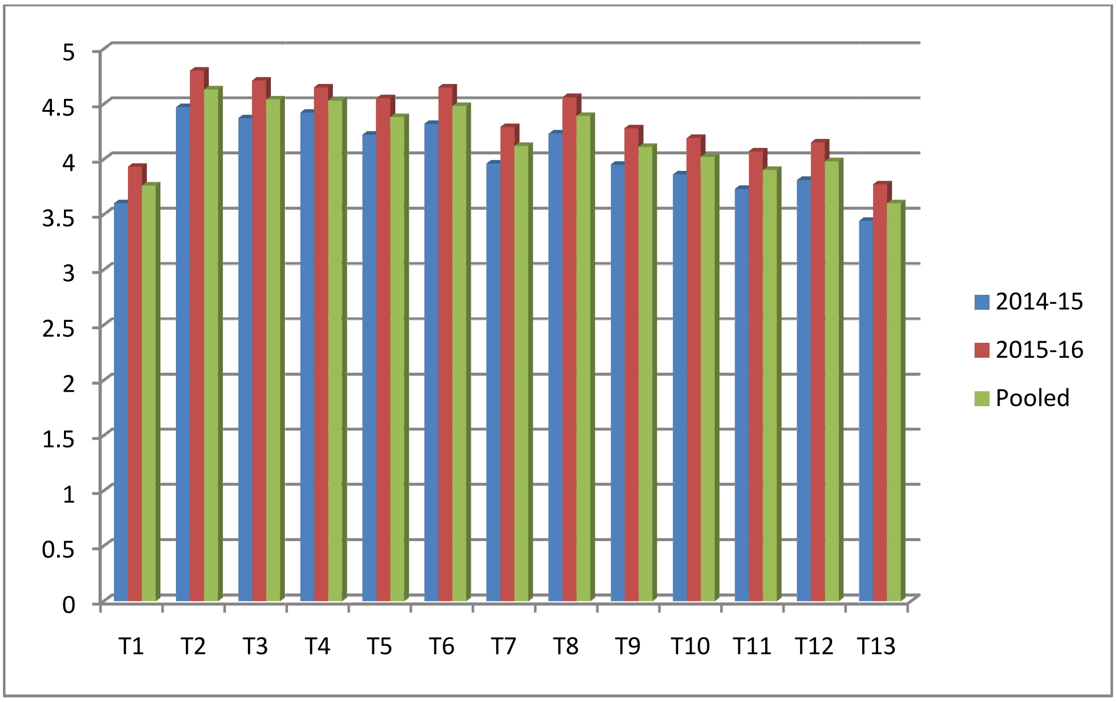
The maximum fruit width (4.80cm) was recorded in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha^{-1} + PSB) (4.71cm) and T_4 (75 Kg N ha^{-1} + *Azotobacter*) (4.65cm), whereas minimum (3.93cm) fruit width was observed in control.

In the pooled data clearly shows that maximum fruit width in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha^{-1} + PSB) (4.54cm), T_4 (75 Kg N ha^{-1} + *Azotobacter*) (4.53cm) and minimum under control (No Inorganic and no Bio-fertilizers).

Table-4.10: Effect of Inorganic and Bio-fertilizers on Width of fruits (cm) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	3.60	3.93	3.76
T_2(100 Kg N ha-1+ *Azotobacter*)	4.47	4.80	4.63
T_3(100 Kg N ha-1 + PSB)	4.37	4.71	4.54
T_4(75 Kg N ha-1 + *Azotobacter*)	4.42	4.65	4.53
T_5(75 Kg N ha-1+ PSB)	4.22	4.55	4.38
T_6(60 Kg P ha-1 + *Azotobacter*)	4.32	4.65	4.48
T_7(60 Kg P ha-1+ PSB)	3.96	4.29	4.12
T_8(45 Kg P ha-1 + *Azotobacter*)	4.23	4.56	4.39
T_9(45 Kg P ha-1 + PSB)	3.95	4.28	4.11
T_{10}(60 Kg K ha-1 + *Azotobacter*)	3.86	4.19	4.02
T_{11}(60 Kg K ha-1 + PSB)	3.73	4.07	3.90
T_{12}(60 Kg K ha-1 + PSB)	3.81	4.15	3.98
T_{13}(45 Kg Kha-1 + PSB)	3.44	3.77	3.60
CD at 5%	0.060	0.076	0.068

Fig. no.-4.10.1: Effect of Inorganic and Bio-fertilizers on Width of fruits (cm) at 90DAP



4.1.11 Fruit weight (g)

It is observed from data given in Table- 4.11 with Fig. No. 4.11.1 that fruit weight varied significantly during experimentation years i.e. 2014-15 and 2015-16. In the first year the value of fruit weight ranges between 9.38g to 26.04g. The highest fruit weight of berries was obtained in T_2 (100 Kg N ha^{-1} + *Azotobacter*) (26.04g) followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*) (22.11g). However, the lowest fruit weight (09.38g) was recorded in T_{11} (60 Kg K ha^{-1} + PSB) during 2014-15.

During the period of 2015-16 the fruit weight ascertain 10.04g to 20.33g. The maximum fruit (20.33g) weight was observed in plants treated with T_2 (100 Kg N ha^{-1} + Azotobacter) followed by T_5 (75 Kg N ha^{-1} + P.S.B) (17.56g), T_8 (45 Kg P ha^{-1} + *Azotobacter*) (16.57g), while the minimum fruit weight was observed in T_{13} (45 Kg K ha^{-1} + P.S.B) (10.04g).

The mean value of both years revealed that the maximum fruit weight was observed in T_2 (100 Kg N ha^{-1} + Azotobacter) followed by T_5 (75 Kg N ha^{-1} + P.S.B) and T_4 (75 Kg N ha^{-1} + *Azotobacter*), respectively but minimum value asses in control (No Inorganic and no Bio-fertilizers).

Table-4.11: Effect of Inorganic and Bio-fertilizers on Weight of fruits (g) per plant at90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	12.08	11.53	11.80
T_2(100 Kg N ha-1+ *Azotobacter*)	26.04	20.33	23.18
T_3(100 Kg N ha-1 + PSB)	19.11	16.00	17.55
T_4(75 Kg N ha-1 + *Azotobacter*)	22.11	16.00	19.05
T_5(75 Kg N ha-1+ PSB)	21.10	17.56	19.33
T_6(60 Kg P ha-1 + *Azotobacter*)	19.02	14.67	16.84
T_7(60 Kg P ha-1+ PSB)	19.65	13.95	16.80
T_8(45 Kg P ha-1 + *Azotobacter*)	20.00	16.57	18.28
T_9(45 Kg P ha-1 + PSB)	13.05	14.90	13.97
T_{10}(60 Kg K ha-1 + *Azotobacter*)	14.28	15.30	14.79
T_{11}(60 Kg K ha-1 + PSB)	09.38	10.10	09.74
T_{12}(60 Kg K ha-1 + PSB)	11.01	11.00	11.00
T_{13}(45 Kg Kha-1 + PSB)	09.80	10.04	09.92
CD at 5%	1.787	1.701	1.744

Fig. no.-4.11.1: Effect of Inorganic and Bio-fertilizers on Weight of fruits (g) per plant at90DAP

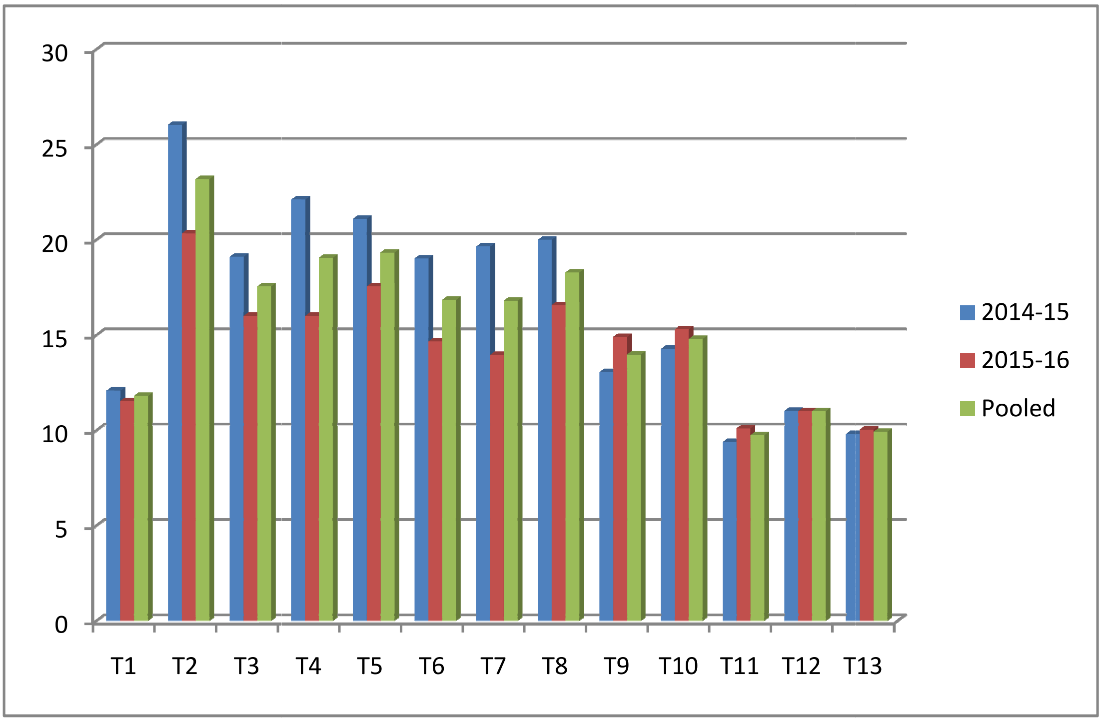


Plate 9: Weighing of Fruits

4.1.12 Fruit yield per plant (g)

The data observed at first picking to last picking of fruits i.e. 67 days to 81 days of planting. The fruit yield per plant varied significantly as per data given in Table- 4.12 with Fig. No. 4.12.1 during 2014-15, it ranged from 076.46g to 173.42g per plant being maximum in treatment combination of T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*) (162.02g), T_3 (100 Kg N ha^{-1} + PSB) (161.62g). Minimum fruit yield per plant (076.42g) was observed in T_1 (control).

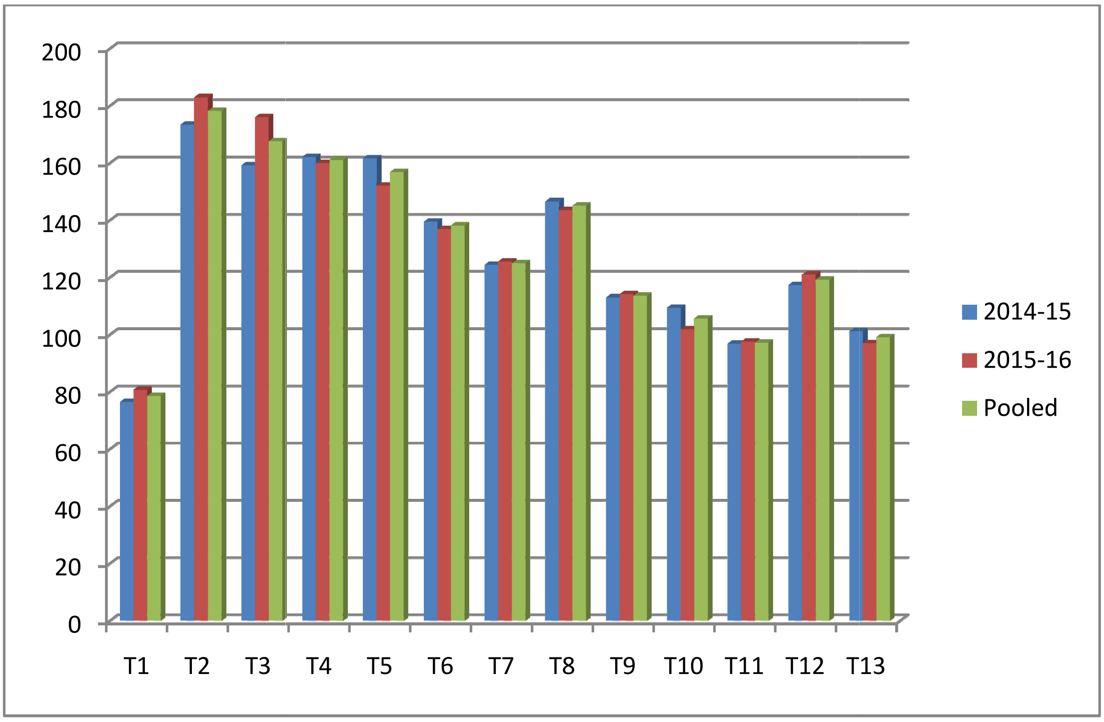
During the second year 2015-16, fruit yield per plant varied from 080.71g to 182.97g. The maximum fruit yield per plant recorded in (182.97g) in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha-1 + PSB) and T_4 (75 Kg N ha^{-1} + *Azotobacter*). The minimum fruit yield per plant was observed in control.

The mean value of both years revealed that the maximum fruit yield per plant recorded in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha-1 + PSB) and T_4 (75 Kg N ha^{-1} + *Azotobacter*). Whereas, the minimum yield per plant was observed under control (No Inorganic and no Bio-fertilizers).

Table-4.12: Effect of Inorganic and Bio-fertilizers on Fruit yield per plant (g) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	076.46	080.71	078.58
T_2(100 Kg N ha-1+ *Azotobacter*)	173.42	182.97	178.19
T_3(100 Kg N ha-1 + PSB)	159.18	176.00	167.59
T_4(75 Kg N ha-1 + *Azotobacter*)	162.06	160.00	161.03
T_5(75 Kg N ha-1+ PSB)	161.62	152.06	156.84
T_6(60 Kg P ha-1 + *Azotobacter*)	139.41	136.87	138.14
T_7(60 Kg P ha-1+ PSB)	124.38	125.55	124.96
T_8(45 Kg P ha-1 + *Azotobacter*)	146.60	143.49	145.05
T_9(45 Kg P ha-1 + PSB)	113.01	114.13	113.57
T_{10}(60 Kg K ha-1 + *Azotobacter*)	109.38	101.89	105.63
T_{11}(60 Kg K ha-1 + PSB)	096.89	097.56	097.22
T_{12}(60 Kg K ha-1 + PSB)	117.36	121.00	119.18
T_{13}(45 Kg Kha-1 + PSB)	101.23	096.98	099.10
CD at 5%	1.691	14.105	7.898

Fig. no.-4.12.1: Effect of Inorganic and Bio-fertilizers on Fruit yield per plant (g) at 90DAP



4.1.13 Fruit yield per plot (Kg)

Data observed for the fruit yield per plot in strawberry cv. Chandler at the first to last picking as presented in Table- 4.13 with Fig. No. 4.13.1 revealed the significant differences, among the various treatments during 2014-15 and 2015-16.

During the first year 2014-15, it ranged from 1.83Kg to 4.16Kg. The maximum fruit yield per plot was measured in the plants treated with T_2 (100 Kg N ha^{-1} + *Azotobacter*) (4.16Kg) followed by T_4 (75 Kg N ha^{-1} + *Azotobacter*) (3.89Kg) and T_5 (75 Kg N ha^{-1} + PSB) (3.87Kg) per plot and the minimum yield per plot (1.86Kg) was observed in T_1 (control).

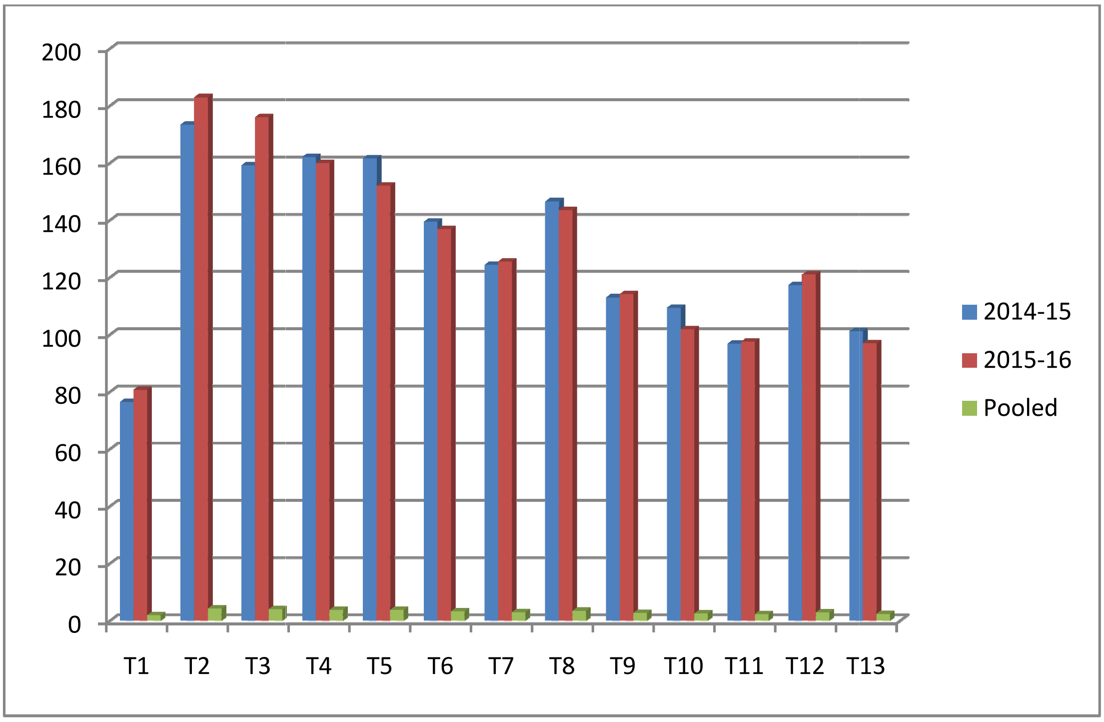
During the period 2015-16 it, varied from 1.93 Kg to 4.39Kg. The maximum fruit yield per plot (4.39Kg) observed in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha-1 + PSB) (4.22Kg) and T_4 (75 Kg N ha^{-1} + *Azotobacter*) (3.80Kg). The minimum yield per plot (1.93Kg) was observed in T_1 (control).

The average data of both years depicted that the maximum fruit yield per plot observed in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha-1 + PSB) and T_4 (75 Kg N ha^{-1} + *Azotobacter*), the minimum yield per was recorded in T_1 (control) (No Inorganic and no Bio-fertilizers).

Table-4.13: Effect of Inorganic and Bio-fertilizers on Fruit Yield per plot (kg) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	1.83	1.93	1.88
T_2(100 Kg N ha-1+ *Azotobacter*)	4.16	4.39	4.27
T_3(100 Kg N ha-1 + PSB)	3.82	4.22	4.02
T_4(75 Kg N ha-1 + *Azotobacter*)	3.89	3.80	3.84
T_5(75 Kg N ha-1+ PSB)	3.87	3.64	3.75
T_6(60 Kg P ha-1 + *Azotobacter*)	3.34	3.28	3.31
T_7(60 Kg P ha-1+ PSB)	2.98	3.01	2.99
T_8(45 Kg P ha-1 + *Azotobacter*)	3.51	3.44	3.47
T_9(45 Kg P ha-1 + PSB)	2.71	2.73	2.72
T_{10}(60 Kg K ha-1 + *Azotobacter*)	2.62	2.44	2.53
T_{11}(60 Kg K ha-1 + PSB)	2.32	2.34	2.33
T_{12}(60 Kg K ha-1 + PSB)	2.82	2.90	2.86
T_{13}(45 Kg Kha-1 + PSB)	2.42	2.32	2.37
CD at 5%	0.208	0.016	0.112

Fig. no.-4.13.1: Effect of Inorganic and Bio-fertilizers on Fruit Yield per plot (kg) at 90DAP



4.1.14 Fruit yield per hectare (t)

Data calculated for the period 2014-15, 2015-16 which was significantly affected by each treatment shows Table-4.14 with Fig No.- 4.14.1. In the period of 2014-15 the fruit yield varies between 16.92t to 38.51t. The maximum yield was given by the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) (38.51t) followed by treatment T_4 (75 Kg N ha^{-1} + *Azotobacter*) (36.01t), whereas the minimum yield per was recorded in T_1 (control).

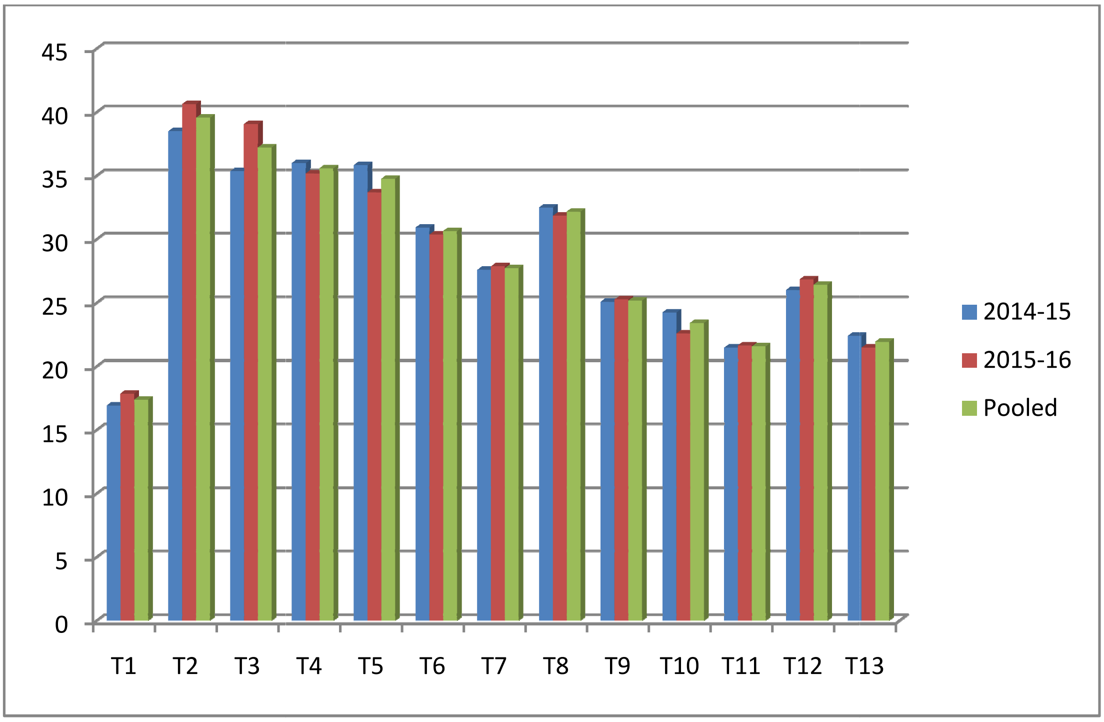
During second year 2015-16 the maximum yield was given by the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) (40.64t) followed by treatment T_3 (100 Kg N ha-1 + PSB) (39.07t), whereas the minimum yield per was recorded in T_1 (control) (17.87t).

Although, the pooled value shows the maximum yield was in the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) (39.57t) followed by T_3 (100 Kg N ha-1 + PSB) (37.22t) and also found in T_1 (control) (17.39t).

Table-4.14: Effect of Inorganic and Bio-fertilizers on Fruit Yield per hac (t) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	16.92	17.87	17.39
T_2(100 Kg N ha-1+ *Azotobacter*)	38.51	40.64	39.57
T_3(100 Kg N ha-1 + PSB)	35.37	39.07	37.22
T_4(75 Kg N ha-1 + *Azotobacter*)	36.01	35.18	35.59
T_5(75 Kg N ha-1+ PSB)	35.83	33.70	34.76
T_6(60 Kg P ha-1 + *Azotobacter*)	30.92	30.37	30.64
T_7(60 Kg P ha-1+ PSB)	27.59	27.87	27.73
T_8(45 Kg P ha-1 + *Azotobacter*)	32.50	31.85	32.17
T_9(45 Kg P ha-1 + PSB)	25.09	25.27	25.18
T_{10}(60 Kg K ha-1 + *Azotobacter*)	24.25	22.59	23.42
T_{11}(60 Kg K ha-1 + PSB)	21.48	21.66	21.57
T_{12}(60 Kg K ha-1 + PSB)	26.01	26.85	26.43
T_{13}(45 Kg Kha-1 + PSB)	22.40	21.48	21.94
CD at 5%	0.826	1.743	1.284

Fig. no. -4.14.1: Effect of Inorganic and Bio-fertilizers on Fruit Yield per hac (t) at 90DAP



4.1.15 Total Soluble Solids (°Brix)

It is evident from the data presented in Table- 4.15 with Fig. No.- 4.15.1 that the significant variation were noticed in total soluble solids in strawberry during 2014-15 and 2015-16 due to different treatment combinations.

During the first year 2014-15 it varied from 7.85 °Brix to 9.50 °Brix. The maximum soluble solids (9.50°Brix) was observed in fruits produced from T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by T_7 (60 Kg P ha^{-1} + P.S.B) (9.35°Brix) and T_2 (100 Kg N ha^{-1} + *Azotobacter*) (8.90°Brix). The fruits of minimum soluble solids (7.85°Brix) were found in T_1 (control).

During the period 2015-16, it ranged from 8.18 °Brix to 9.83 °Brix. The fruits with maximum soluble solids (9.83°Brix) was observed in T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by T_7 (60 Kg P ha^{-1} + P.S.B) (9.80°Brix) and T_2 (100 Kg N ha^{-1} + *Azotobacter*) (9.23°Brix). The fruits with minimum soluble solids were found (8.18°Brix) in T_1 (control).

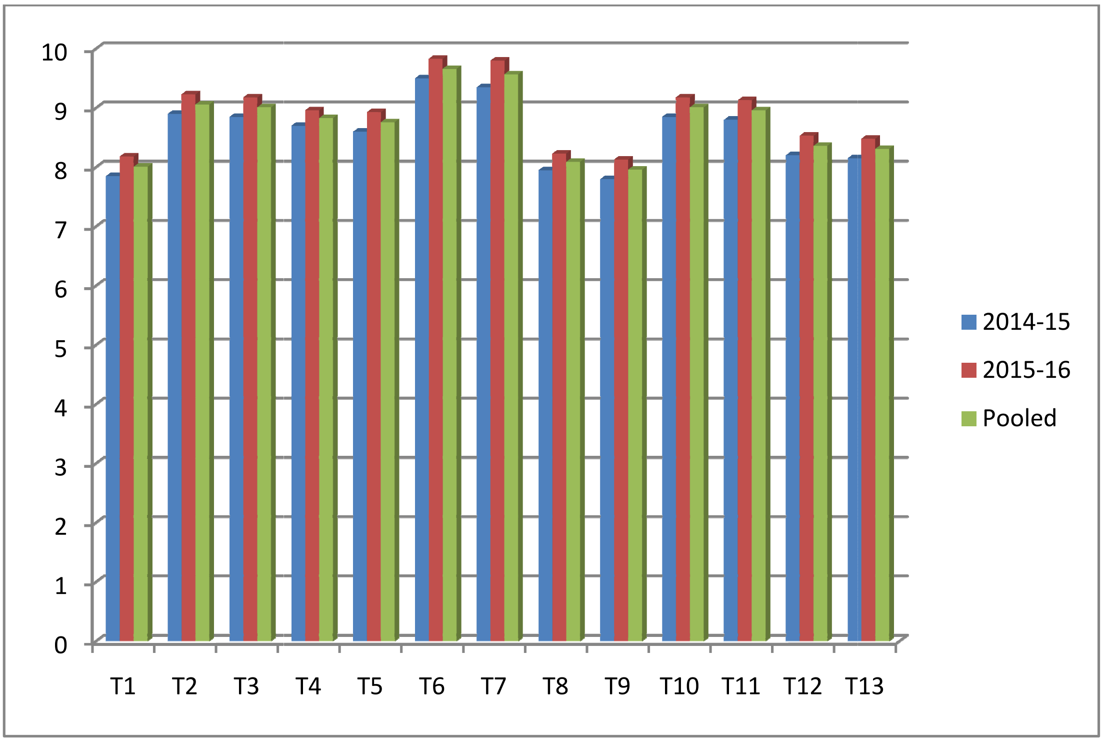
The pooled data clearly shows that maximum soluble solids observed in T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by T_7 (60 Kg P ha^{-1} + PSB) and T_2 (100 Kg N ha^{-1} + *Azotobacter*), minimum under T_1 (control) (No Inorganic and no Bio-fertilizers).

Table-4.15: Effect of Inorganic and Bio-fertilizers on T.S.S. (°Brix) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	7.85	8.18	8.01
T_2(100 Kg N ha-1+ *Azotobacter*)	8.90	9.23	9.06
T_3(100 Kg N ha-1 + PSB)	8.85	9.18	9.01
T_4(75 Kg N ha-1 + *Azotobacter*)	8.70	8.96	8.83
T_5(75 Kg N ha-1+ PSB)	8.60	8.93	8.76
T_6(60 Kg P ha-1 + *Azotobacter*)	9.50	9.83	9.66
T_7(60 Kg P ha-1+ PSB)	9.35	9.80	9.57
T_8(45 Kg P ha-1 + *Azotobacter*)	7.95	8.23	8.09
T_9(45 Kg P ha-1 + PSB)	7.80	8.13	7.96
T_{10}(60 Kg K ha-1 + *Azotobacter*)	8.85	9.18	9.01
T_{11}(60 Kg K ha-1 + PSB)	8.80	9.13	8.96
T_{12}(60 Kg K ha-1 + PSB)	8.20	8.53	8.36
T_{13}(45 Kg Kha-1 + PSB)	8.15	8.48	8.31
CD at 5%	0.163	0.890	0.526

Fig. no.-4.15.1: Effect of Inorganic and Bio-fertilizers on T.S.S. (°Brix) at 90DAP

T.S.S. (°Brix)



4.1.16 Titratable acidity (%)

The observations recorded for titratable acidity of strawberry cv. Chandler juice as formulated in Table- 4.16 with Fig. No. - 4.16.1 revealed the significant variation from 0.50 to 0.76 percent during 2014-15. The plant which nourished with treatment T_6 (60 Kg P ha^{-1} + *Azotobacter*) produced the berries containing minimum acid content followed by T_7 (60 Kg P ha^{-1} + PSB). The fruit with maximum acid content was recorded in T_1 (control).

During the year 2015-16, it ranged from 0.47 to 0.70 percent. The maximum acid (0.70%) in berries was observed in plant treated with T_1 (No Inorganic and no Bio-fertilizers) followed by T_{13} (45 Kg K ha^{-1} + P.S.B).

The mean value of both years revealed that the maximum acid content was observed in T_1 (No Inorganic and no Bio-fertilizers) followed by T_8 (45 Kg P ha^{-1} + *Azotobacter*) and T_{12} (45 Kg K ha^{-1} + *Azotobacter*).

Table-4.16: Effect of Inorganic and Bio-fertilizers on Acidity (%) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	0.76	0.70	0.73
T_2(100 Kg N ha-1+ *Azotobacter*)	0.54	0.51	0.52
T_3(100 Kg N ha-1 + PSB)	0.56	0.53	0.54
T_4(75 Kg N ha-1 + *Azotobacter*)	0.59	0.56	0.57
T_5(75 Kg N ha-1+ PSB)	0.62	0.58	0.60
T_6(60 Kg P ha-1 + *Azotobacter*)	0.50	0.47	0.48
T_7(60 Kg P ha-1+ PSB)	0.52	0.49	0.50
T_8(45 Kg P ha-1 + *Azotobacter*)	0.66	0.63	0.64
T_9(45 Kg P ha-1 + PSB)	0.64	0.60	0.62
T_{10}(60 Kg K ha-1 + *Azotobacter*)	0.57	0.54	0.55
T_{11}(60 Kg K ha-1 + PSB)	0.58	0.55	0.56
T_{12}(60 Kg K ha-1 + PSB)	0.65	0.62	0.63
T_{13}(45 Kg Kha-1 + PSB)	0.68	0.65	0.66
CD at 5%	0.049	0.057	0.053

Fig. no. -4.16.1: Effect of Inorganic and Bio-fertilizers on Acidity (%) at 90DAP

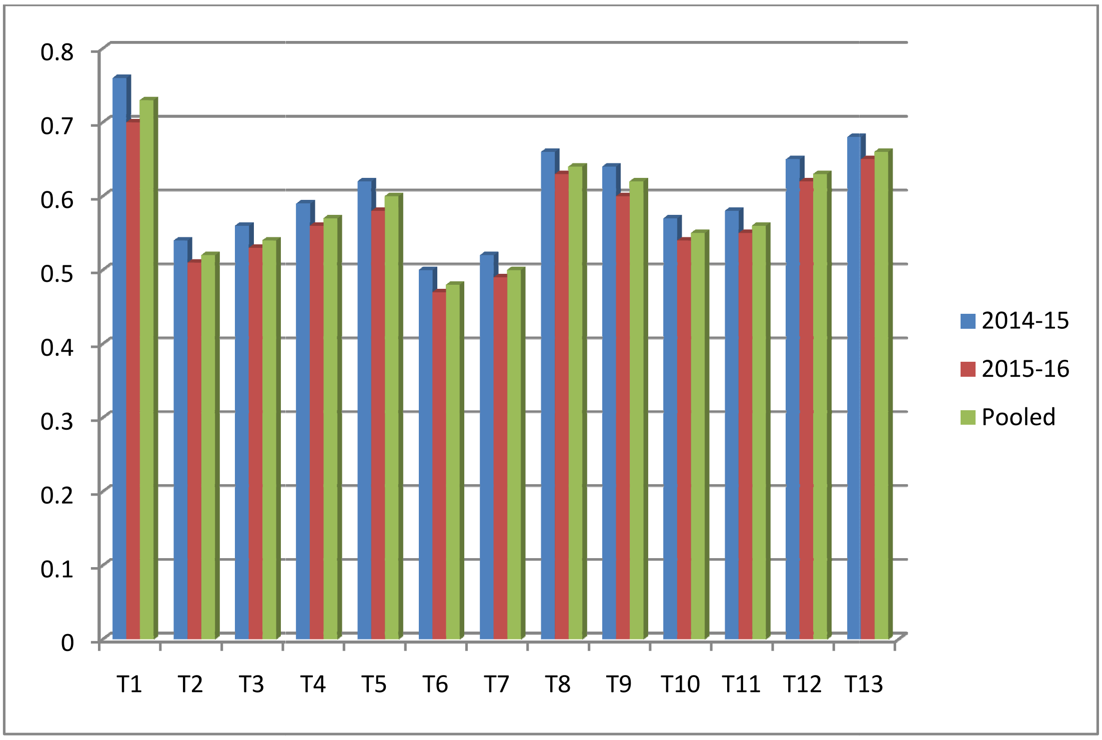
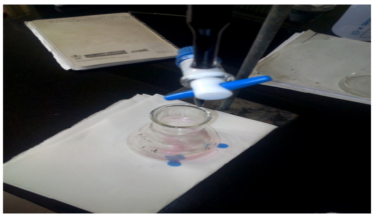


Plate 10: Lab Work Analysis

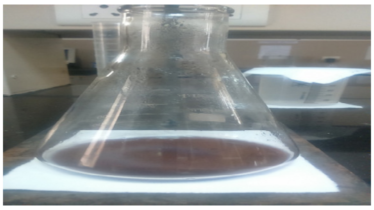
Analysis of T.S.S.

Analysis for ascorbic acid



Analysis of acidity

Analysis of total sugars



4.1.17 Ascorbic acid (mg /100g)

The observations recorded for ascorbic acid content of strawberry juice as formulated in Table- 4.17 with Fig. No. – 4.17.1 revealed the significant variation from 55.10 mg/100g to 62.23 mg/100g during 2014-15 and 58.44 mg/100g to 65.56 mg/100g during 2015-16, representing the plants nourished with T_6 (60 Kg P ha^{-1} + *Azotobacter*) produced the berries containing maximum ascorbic acid content during both the years.

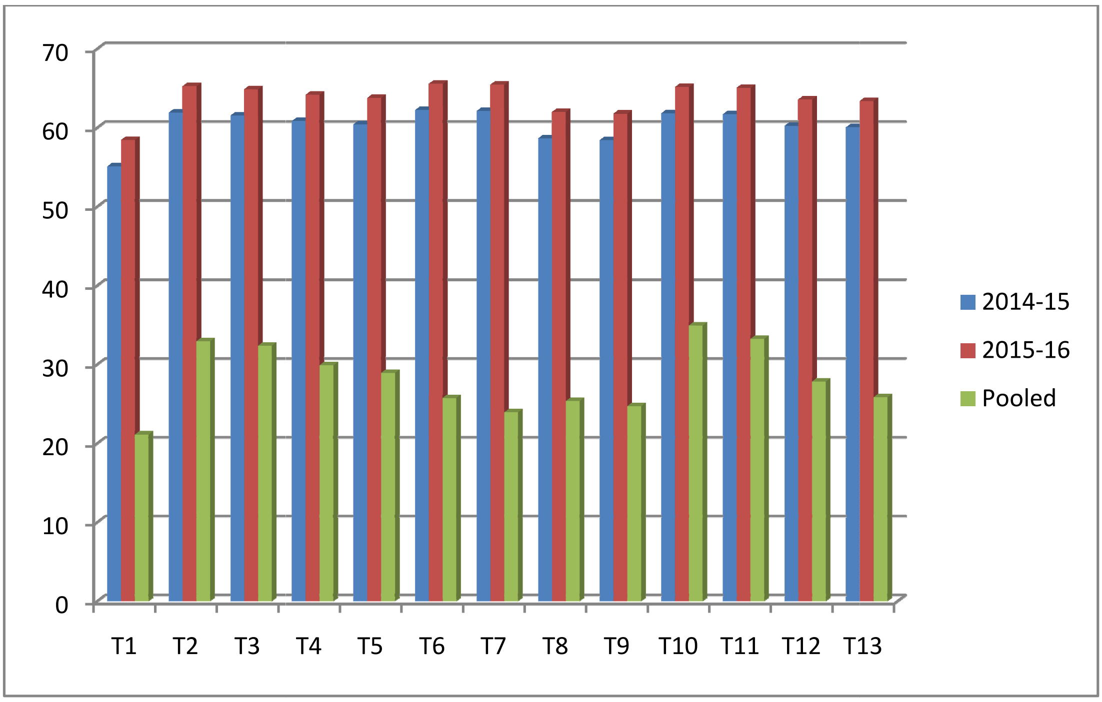
However, the berries harvested from T_1 (control) No Inorganic and no Bio-fertilizers revealed the minimum ascorbic acid content of 55.10 mg /100g during 2014-15 and 58.44 mg /100g during 2015-16.

The pooled data clearly shows that maximum ascorbic acid in with T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by T_7 (60 Kg P ha^{-1} + PSB).

Table-4.17: Effect of Inorganic and Bio-fertilizers on Ascorbic acid (mg/ 100g) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	55.10	58.44	21.11
T_2(100 Kg N ha-1+ *Azotobacter*)	61.92	65.25	32.93
T_3(100 Kg N ha-1 + PSB)	61.52	64.86	32.37
T_4(75 Kg N ha-1 + *Azotobacter*)	60.85	64.18	29.90
T_5(75 Kg N ha-1+ PSB)	60.43	63.77	28.93
T_6(60 Kg P ha-1 + *Azotobacter*)	62.23	65.56	25.75
T_7(60 Kg P ha-1+ PSB)	62.11	65.45	23.93
T_8(45 Kg P ha-1 + *Azotobacter*)	58.64	61.98	25.36
T_9(45 Kg P ha-1 + PSB)	58.43	61.77	24.72
T_{10}(60 Kg K ha-1 + *Azotobacter*)	61.82	65.15	34.92
T_{11}(60 Kg K ha-1 + PSB)	61.71	65.05	33.23
T_{12}(60 Kg K ha-1 + PSB)	60.23	63.57	27.82
T_{13}(45 Kg Kha-1 + PSB)	60.05	63.38	25.85
CD at 5%	0.063	7.550	3.806

Fig. no-4.17.1: Effect of Inorganic and Bio-fertilizers on Ascorbic acid (mg/ 100g) at 90DAP



4.1.18 Anthocyanin (mg /100g)

The observations recorded for anthocyanin content of strawberry juice as formulated in Table- 4.18 with Fig. No. - 4.18.1 revealed the significant variations from 20.66mg to 34.66 mg /100g during 2014-15 and 21.56 to 35.18 mg /100g during 2015-16.

During the period 2014-15, the maximum anthocyanin content of fruit recorded under the T_{10} (60 Kg K ha^{-1} + *Azotobacter*) (34.66 mg /100 g) followed by T_{11} (33.00 mg/100g) (60 Kg K ha^{-1} + PSB). The minimum anthocyanin (20.66 mg/100 g) content in strawberry was obtained from T_1 (control) No Inorganic and no Bio-fertilizers.

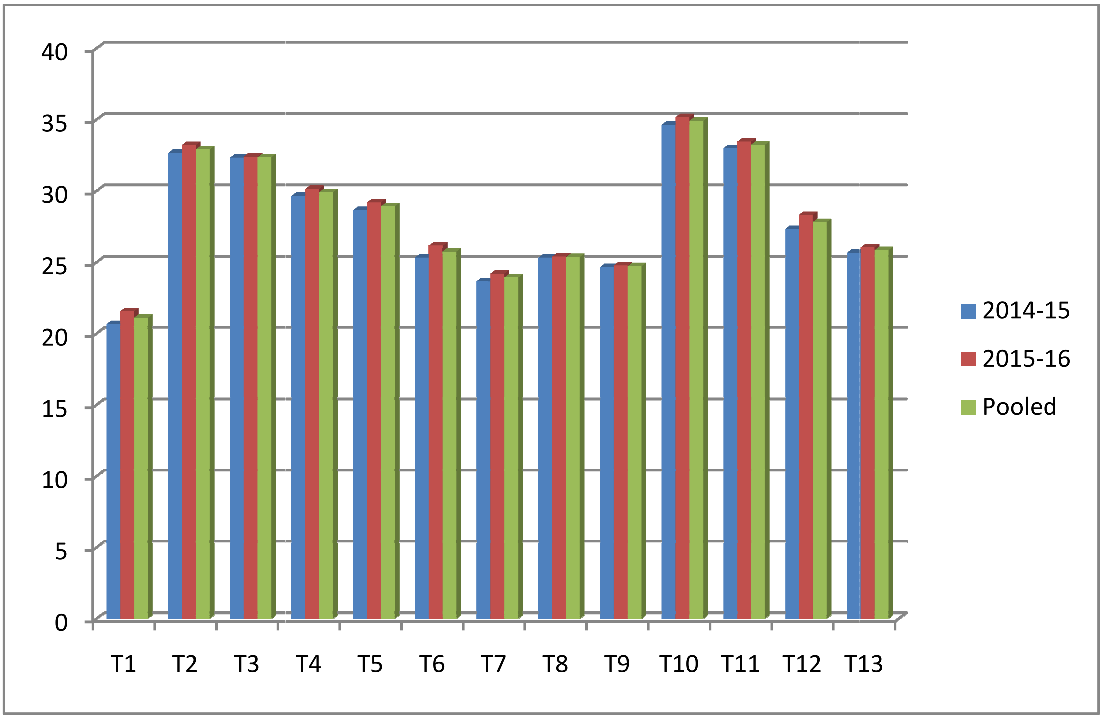
During the second year 2015-16, the maximum anthocyanin was recorded from the fruits produced under T_{10} (35.18 mg /100 g) (60 Kg K ha^{-1} + *Azotobacter*) followed by T_{11} (33.46 mg/100g) (60 Kg K ha^{-1} + PSB). The minimum anthocyanin (21.56 mg/100 g) content in strawberry was obtained from T_1 (control) (No Inorganic and no Bio-fertilizers).

The average mean value of both years revealed that the fruits with maximum anthocyanin under T_{10} (60 Kg K ha^{-1} + *Azotobacter*), T_{11} (60 Kg K ha^{-1} + PSB) and T_2 (100 Kg N ha^{-1}+ *Azotobacter*) respectively.

Table-4.18: Effect of Inorganic and Bio-fertilizers on Anthocyanin (mg/ 100g) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	20.66	21.56	21.11
T_2(100 Kg N ha-1+ *Azotobacter*)	32.66	33.21	32.93
T_3(100 Kg N ha-1 + PSB)	32.33	32.41	32.37
T_4(75 Kg N ha-1 + *Azotobacter*)	29.66	30.15	29.90
T_5(75 Kg N ha-1+ PSB)	28.66	29.20	28.93
T_6(60 Kg P ha-1 + *Azotobacter*)	25.33	26.17	25.75
T_7(60 Kg P ha-1+ PSB)	23.66	24.20	23.93
T_8(45 Kg P ha-1 + *Azotobacter*)	25.33	25.40	25.36
T_9(45 Kg P ha-1 + PSB)	24.66	24.78	24.72
T_{10}(60 Kg K ha-1 + *Azotobacter*)	34.66	35.18	34.92
T_{11}(60 Kg K ha-1 + PSB)	33.00	33.46	33.23
T_{12}(60 Kg K ha-1 + PSB)	27.33	28.32	27.82
T_{13}(45 Kg Kha-1 + PSB)	25.66	26.04	25.85
CD at 5%	1.509	0.359	0.934

Fig. no.-4.18.1: Effect of Inorganic and Bio-fertilizers on Anthocyanin (mg/ 100g) at 90DAP



4.1.19 Total sugars (%)

Total sugars content varied significantly as per data projected in Table- 4.19 with Fig. No.- 4.19.1. During the period 2014-15, it ranged from 5.65 percent to 7.81 percent being maximum in treatment combination of T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by T_7 (7.62 percent) (60 Kg P ha^{-1} + PSB) and treatment T_1 (control) (No Inorganic and no Bio-fertilizers) revealed the lowest total sugars content (5.65 percent) as compared to other treatment combinations.

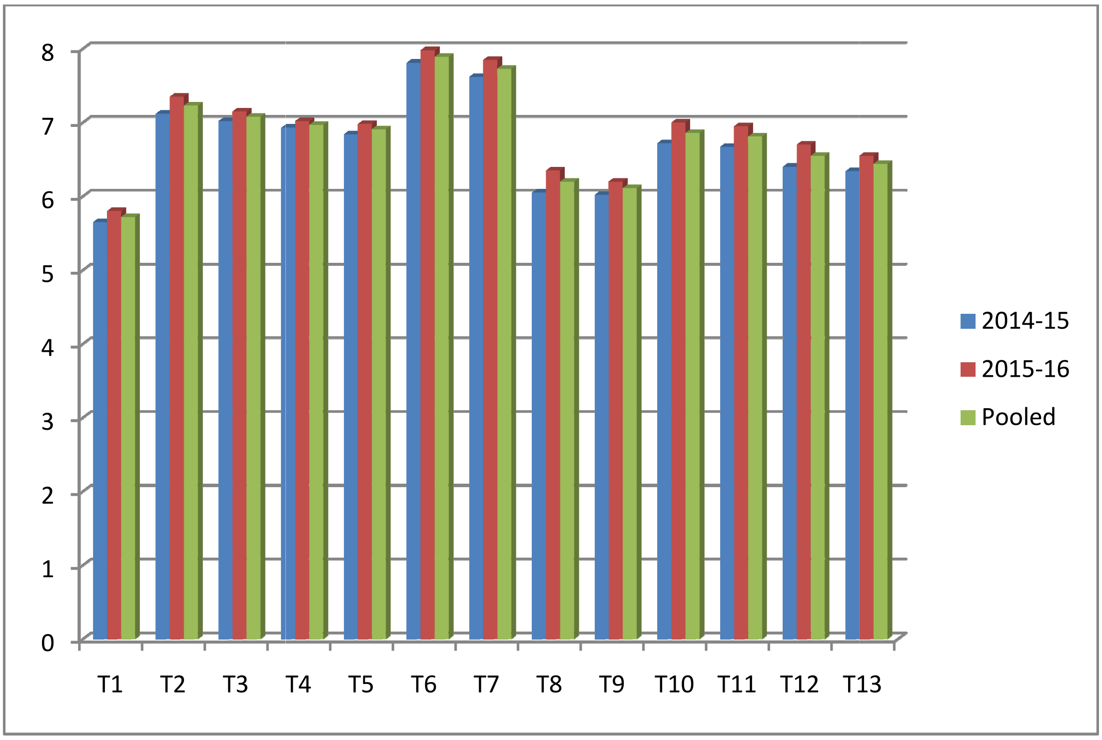
During the year 2015-16, it varied from 5.80 percent to 7.98 percent. The maximum total sugars was recorded in T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by T_7 (7.85 percent) and minimum total sugars was obtained in T_1 (control).

The data varies between 5.72 percent to 7.89 percent. The pooled data clearly shows that maximum total sugars was recorded in berries under T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by T_7 (60 Kg P ha^{-1} + PSB) and the minimum value asses (5.72%) in the treatment T_1 (control).

Table-4.19: Effect of Inorganic and Bio-fertilizers on Total sugars (%) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	5.65	5.80	5.72
T_2(100 Kg N ha-1+ *Azotobacter*)	7.12	7.35	7.23
T_3(100 Kg N ha-1 + PSB)	7.02	7.15	7.08
T_4(75 Kg N ha-1 + *Azotobacter*)	6.93	7.02	6.97
T_5(75 Kg N ha-1+ PSB)	6.84	6.98	6.91
T_6(60 Kg P ha-1 + *Azotobacter*)	7.81	7.98	7.89
T_7(60 Kg P ha-1+ PSB)	7.62	7.85	7.73
T_8(45 Kg P ha-1 + *Azotobacter*)	6.05	6.35	6.20
T_9(45 Kg P ha-1 + PSB)	6.02	6.20	6.11
T_{10}(60 Kg K ha-1 + *Azotobacter*)	6.72	7.00	6.86
T_{11}(60 Kg K ha-1 + PSB)	6.67	6.95	6.81
T_{12}(60 Kg K ha-1 + PSB)	6.40	6.70	6.55
T_{13}(45 Kg Kha-1 + PSB)	6.34	6.55	6.44
CD at 5%	0.084	0.508	0.296

Fig. no.-4.19.1: Effect of Inorganic and Bio-fertilizers on Total sugars (%) at 90DAP



4.1.20 Reducing sugar (%)

Data furnished in Table- 4.20 with Fig. No. 4.20.1 clearly indicated the variation from 4.28 to 5.58 percent reducing sugar of strawberry during 2014-15. The maximum reducing sugar of berries was recorded (5.58 percent) in T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by (5.49 percent) T_7 (60 Kg P ha^{-1} + PSB). The minimum reducing sugar (4.28 percent) content in strawberry was obtained from T_1 (control) (No Inorganic and no Bio-fertilizers).

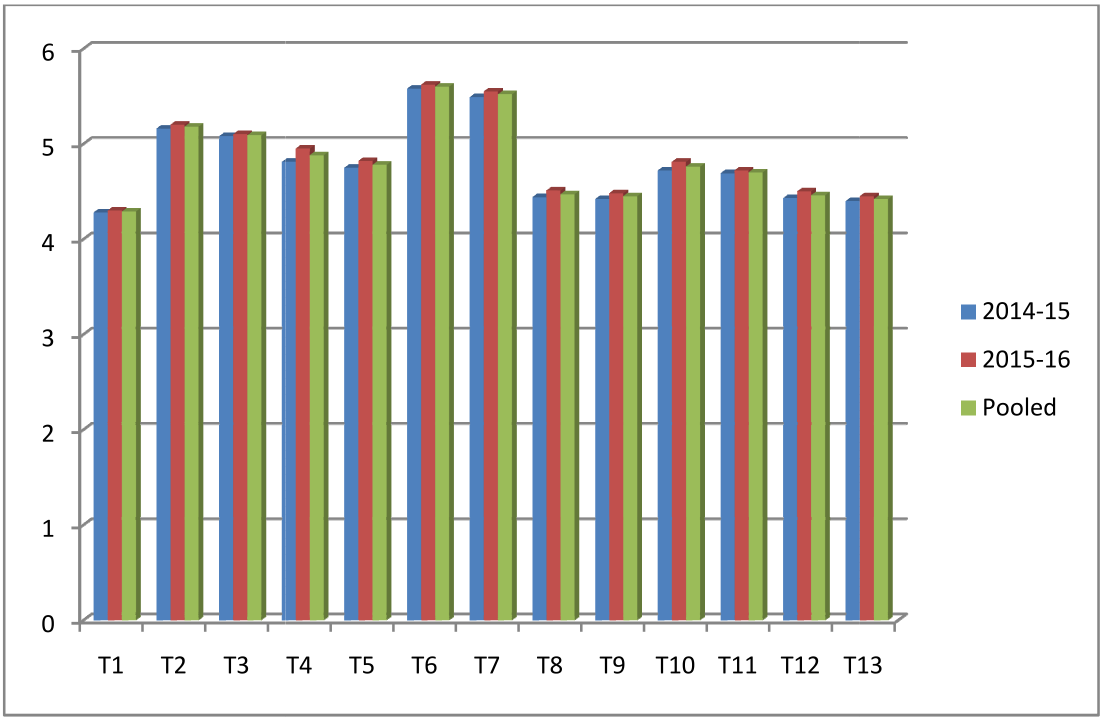
During the period 2015-16, it ranged from 4.30 to 5.62 percent. The maximum reducing sugar was recorded (5.62 percent) in fruits produced T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by (5.55 percent) in T_7 (60 Kg P ha^{-1} + PSB). The minimum reducing sugar (4.30 percent) content in strawberry fruits were obtained from T_1 (No Inorganic and no Bio-fertilizers).

The average data of both years depicted that the maximum reducing sugar was recorded in fruits produced T_6 (60 Kg P ha^{-1} + *Azotobacter*) and the minimum value ascertain T_1 (No Inorganic and no Bio-fertilizers).

Table-4.20: Effect of Inorganic and Bio-fertilizers on reducing sugars (%) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	4.28	4.30	4.29
T_2(100 Kg N ha-1+ *Azotobacter*)	5.16	5.20	5.18
T_3(100 Kg N ha-1 + PSB)	5.08	5.10	5.09
T_4(75 Kg N ha-1 + *Azotobacter*)	4.81	4.95	4.88
T_5(75 Kg N ha-1+ PSB)	4.75	4.82	4.78
T_6(60 Kg P ha-1 + *Azotobacter*)	5.58	5.62	5.60
T_7(60 Kg P ha-1+ PSB)	5.49	5.55	5.52
T_8(45 Kg P ha-1 + *Azotobacter*)	4.44	4.51	4.47
T_9(45 Kg P ha-1 + PSB)	4.42	4.48	4.45
T_{10}(60 Kg K ha-1 + *Azotobacter*)	4.72	4.81	4.76
T_{11}(60 Kg K ha-1 + PSB)	4.69	4.72	4.70
T_{12}(60 Kg K ha-1 + PSB)	4.43	4.50	4.46
T_{13}(45 Kg Kha-1 + PSB)	4.40	4.45	4.42
CD at 5%	0.162	0.170	0.166

Fig. no.-4.20.1: Effect of Inorganic and Bio-fertilizers on reducing sugars (%) at 90DAP



4.1.21 Non- reducing sugar (%)

The estimation made for non-reducing sugar content of strawberry juice as presented in Table- 4.21 with Fig. No. – 4.21.1. During 2014-15, it varied from 1.37 percent to 2.23 percent and during 2015-16 it ranged from 1.50 percent to 2.36 percent. The maximum non-reducing sugar was obtained under T_6 (60 Kg P ha^{-1} + *Azotobacter*) (2.23 percent) followed by T_7 (2.13 per cent), minimum non-reducing sugar was obtained in T_1 (control) during 2014-15.

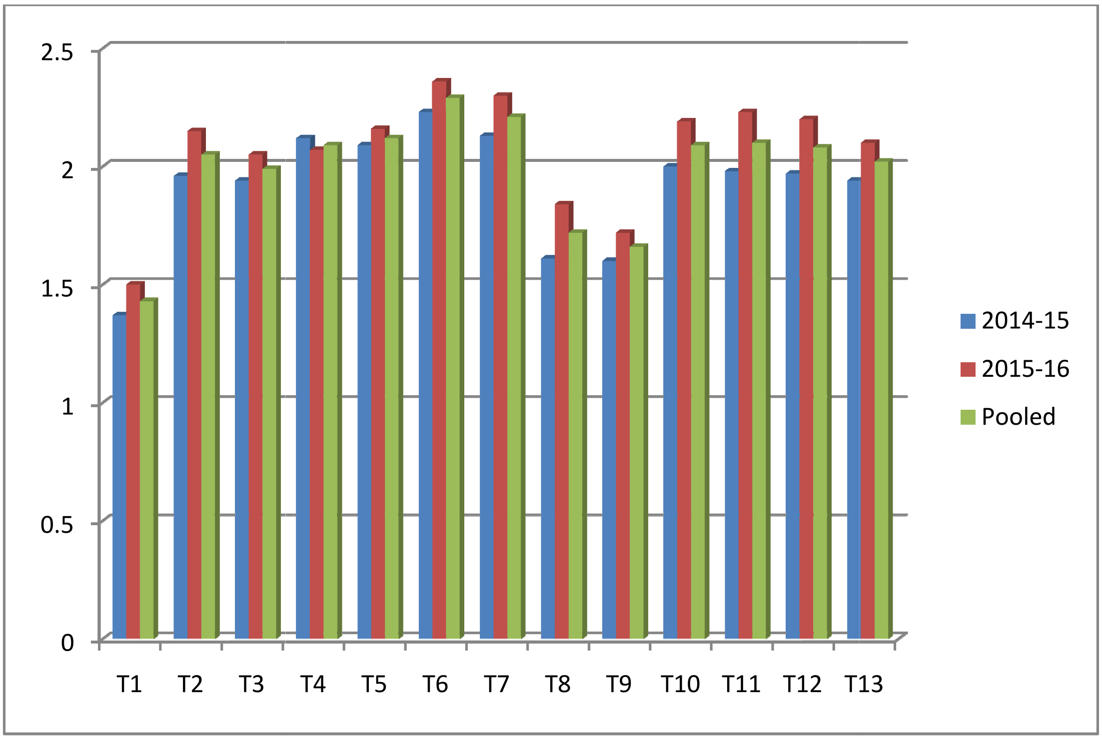
The Maximum non-reducing sugar was obtained under T_6 (60 Kg P ha^{-1} + *Azotobacter*) (2.36 percent) followed by T_7 (60 Kg ha^{-1} P +P.S.B) (2.30 per cent), minimum non-reducing sugar was obtained in T_1 (control) during 2015-16.

The mean value of both years revealed that the maximum non sugar was recorded in fruits in T_6 (60 Kg P ha^{-1} + *Azotobacter*) followed by T_7 (60 Kg P ha^{-1} + PSB) and the minimum value find out in T_1 (control).

Table-4.21: Effect of Inorganic and Bio-fertilizers on Non-reducing sugars (%) at 90DAP.

Treatment Combinations	2014-15	2015-16	Pooled
T_1 Control (No Inorganic and no Bio-fertilizers)	1.37	1.50	1.43
T_2(100 Kg N ha-1+ *Azotobacter*)	1.96	2.15	2.05
T_3(100 Kg N ha-1 + PSB)	1.94	2.05	1.99
T_4(75 Kg N ha-1 + *Azotobacter*)	2.12	2.07	2.09
T_5(75 Kg N ha-1+ PSB)	2.09	2.16	2.12
T_6(60 Kg P ha-1 + *Azotobacter*)	2.23	2.36	2.29
T_7(60 Kg P ha-1+ PSB)	2.13	2.30	2.21
T_8(45 Kg P ha-1 + *Azotobacter*)	1.61	1.84	1.72
T_9(45 Kg P ha-1 + PSB)	1.60	1.72	1.66
T_{10}(60 Kg K ha-1 + *Azotobacter*)	2.00	2.19	2.09
T_{11}(60 Kg K ha-1 + PSB)	1.98	2.23	2.10
T_{12}(60 Kg K ha-1 + PSB)	1.97	2.20	2.08
T_{13}(45 Kg Kha-1 + PSB)	1.94	2.10	2.02
CD at 5%	0.062	0.170	0.116

Fig. no. -4.21.1: Effect of Inorganic and Bio-fertilizers on Non-reducing sugars (%) at 90DAP



DISCUSSION

Chapter V

DISCUSSION

The present research work entitle **"Effect of Inorganic and Bio-fertilizers on growth, Yield and Physico – chemical Characters of Strawberry (*Fragaria* x *annanasa* L. Duch.) cv. Chandler in Central Uttar Pradesh"** was carried out at the Horticulture Research Farm-I, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow (U.P.) during 2014-2015 and 2015-2016. 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.

5.1. Effect of Inorganic and Bio-fertilizers on growth parameters:

The vegetative growth characters of strawberry cv. Chandler in terms of plant height, plant spread, number of leaves per plant, leaf length, leaf width and number of runners per plant, are presented in Table 4.1 and 4.2 for two consecutive years (2014-15 and 20158-16) of experimentation.

From the observations made during both years, it was finding that the combination of 100 Kg N ha^{-1}+ *Azotobacter* was able to produce the tallest plants. This might be due to the higher dose of Nitrogen along with the *Azotobacter*. It has been reported that such enhancement of plant growth may be attributed to the existence of biologically plant growth promoting mechanisms. Nitrogen is responsible for increased plant growth, essential components of proteins, protoplasm and chlorophyll. Similar findings are also reported by **Ahlawat *et al.*, (1988), Andersson *et al.*, (2012), Tripathi *et al.*, (2010)** in strawberry, whereas production of growth regulators by the *Azotobacter* in the root zone which gets absorbed by the plant roots has been reported by **Rana and Chandel (2003)** in strawberry. The use of bio-fertilizer is increasing day by day due to increase in the price of chemical fertilizers, its beneficial effect on soil health and increase in production of crop **Hazarika and Ansari (2007)**. Organic products are being famous for all people around the world.

Due to the great global market demand, production of organic foods has rapidly increased in the past decades. On this basis organic agriculture has become a great choice as means of organic product producing. Organic cultured strawberries produced higher vegetative growth in compare to conventionally cultured strawberries produced **Abu-Zahra and Tahboub (2008).**

The maximum plant height was recorded in both years with treatment T_2 due to the application of full dose Nitrogen with combination of Azotobacter i.e. 100 Kg N ha^{-1}+ *Azotobacter,* because nitrogen play a vital role for plant vegetative growth and the nitrogen availability also enhances by the use of Azotobacter which accumulate the environmental nitrogen easily to the plant. Nitrogen also helps to constitution of cell wall, impart green colour to plant, encourage vegetative growth, essential constitution of protein, play important role of synthesis of auxin. The application of Vermicompost + Azotobacter + PSB + AM produced maximum plant height (20.26 cm) **Anil *et al.* (2015).** Among the fertilizers, the single effect of N (115 kg ha^{-1}), P (40 kg ha^{-1}), K (110 kg ha^{-1}) and S (25 kg ha^{-1}) gave maximum growth and yield of strawberry. The highest concentration of N, P, K and S were found in shoot and fruit of strawberry when N, P, K and S fertilizers were used 140, 60, 135 and 35 kg ha^{-1}, respectively. The highest values of plant height (25.60 cm) **Afroz *et al.* (2016). Gupta and Tripathi (2012)** examined that the combined application of *Azotobacter* 6 kg per ha and Vermicompost 30 tonnes per ha significantly increased the height of plant (19.45 cm).

In both years the spreading of plant was observed highest in T_2 100 Kg N ha^{-1}+ *Azotobacter* followed by treatment T_4 75 Kg N ha^{-1} + *Azotobacter*, it may be due to the Azotobacter which enhance the growth of nitrogen fixing and phosphate solublizing micro-organisms enhance the phosphorus activity in plants. It may enhance the growth as well as the nutrient in the plant. The micro-organisms Azotobacter and Phosphate Solublizing Bacteria helps to increase the N and P availability by making available biologically fixed N and biologically solubilize P was attributed to the intimate mixing of ingested particles within soil. Similar results also find by **Anil *et al.* (2015)** application of Vermicompost + Azotobacter + PSB + AM produced maximum plant height (20.26 cm), plant spread (25.64 cm), number of leaves (54.30) and leaf area (97.87 cm^2) $plant^{-1}$, whereas all the growth characters were found minimum in control. **Dar *et al.* (2013)** the application of 100 kg N + 80 kg K/ha resulted in maximum growth and yield improvement in strawberry followed by 100 kg N treatment and 80 kg P + 80 kg K/ha treatment. The study revealed that strawberry crop requires optimum NPK to harness maximum yield.

The mean value shows the maximum leaf under the application of T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_4 while, the lowest numbers of leaves were found in (T_1) control (No Inorganic and no Bio-fertilizers). The application of Azotobacter, urea with addition to the higher concentration of *Azotobacter* might have helped in N-fixation and its quick release for plants absorption. Increase in the number of leaves might be due to the production of more chlorophyll content with inoculation of nitrogen fixers. The other reason for increased vegetative growth may be due to the production of plant growth regulators by *Azotobacter* in the rhizosphere which are absorbed by the roots. Better development of root system and the possibly synthesis of plant growth hormones like IAA, GA3 and cytokinin and direct influence of *Azotobacter* might have caused increased number of leaves per plant. These results are suggested by **Jeeva *et al.* (1988)** reported that the application of *Azospirillum* inoculation in banana with graded levels of N fertilizers (100, 75, 50 Kg) of the standard rates was investigated. Inoculation + highest dose of N (100%) enhanced the height and girth of pseudostem, number of leaf and leaf area. **Kumar *et al.* (2014)** claimed the maximum plant height, maximum number of leaves, spread of plant, number of flowers, length diameter ratio of fruits and average number of fruit per plant in strawberry was recorded with the application of 100 kg N/ ha. **Rana and Chandel (2003)** used bio-fertilizers and nitrogen to strawberry cv. Chandler and found that *Azotobacter* inoculated plants attained maximum plant height (24.92 cm), number of leaves (26.29), leaf area (96.12 cm^2), and number of runners (18.70) per plant as compared to other treatments. They further observed that the application of *Azotobacter* in combination with 60 kg N per ha produced maximum leaf area (102.50 cm^2) over all other treatments.

The maximum leaf length in both experimental years was found in treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha^{-1} + PSB) and T_4 (75 Kg N ha^{-1} + *Azotobacter*) while, the minimum leaf length was observed under the control (No Inorganic and no Bio-fertilizers) treatment. The observation of leaf length similar by **Jeeva *et al.* (1988)** reported that the application of *Azospirillum* inoculation in banana with graded levels of N fertilizers (100, 75, 50 Kg) of the standard rates was investigated. Inoculation + highest dose of N (100%) enhanced the height and girth of pseudostem, number of leaf and leaf area. **Rube *et al.* (2013)** observed that the maximum height of the plant, number of leaves per plant, length of leaves and width of leaves were recorded in the treatment T_{12} - *Azotobacter* (50%) + *Azospirillum* (50%) + NPK (50%) + FYM.

The minimum mean leaf length was examined in treatment T_1 i.e. control which shows the value width due to without application of any fertilizer dose. The maximum value also find out by the treatment T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha^{-1} + PSB) and T_4 (75 Kg N ha^{-1} + *Azotobacter*). The same result also reported by **Kumar *et al.* (2014)** claimed the maximum plant height, maximum number of leaves, spread of plant, number of flowers, length diameter ratio of fruits and average number of fruit per plant in strawberry was recorded with the application of 100 kg N/ ha. **Umar *et al.* (2009)** determined the positive effect of organics, FYM, in integration with urea and *Azotobacter* on strawberry cv. Chandler. They reported that maximum height of plant (21.24 cm), plant spread (28.16 cm), leaf area (74.9 cm^2) was in 100% N (Urea) + *Azotobacter* treated plants.

The pooled data clearly shows that the maximum number of runners were found in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (100 Kg N ha^{-1} + PSB), whereas the lowest number of runners were produced under the control plots. The increased runner production under higher concentration of *Azotobacter* treated plots might be due to secretion of growth promoting substances, especially cytokinin by *Azotobacter* which increases the runner production in strawberry. Similar findings were also reported by **Rana and Chandel (2003), Sahoo and Singh (2005); Nazir *et al.* (2006)** in strawberry. Increased number of runners per plant might be due to the increased growth of plant in the form of height, number of leaves and leaf area, which accumulated more photosynthates and thereby increased runners per plant. The results are in conformity with the findings of **Lata *et al.* (2013), Sharma *et al.* (2004)** and **Umar *et al.* (2009)** in strawberry, where they observed that the integrated nutrient management was better than the single application of nutrients for runner production in strawberry.

5.2. Effect of Inorganic and Bio-fertilizers on Yield parameters:

The yield parameters also influenced by the application of organic and inorganic fertilizers with different level of doses in both experimental periods.

The average value of both years clearly showed that the maximum number of fruits was found in treatment T_{12} (10.83.) followed by T_{11} (9.99), T_{13} (9.99) whereas, the minimum was observed in T_1, Similar finding was also observed by **Gaur and Deepak (2003)** carried out that application of 200 kg N/ha resulted in the maximum plant height (19.90 cm), maximum number of leaves per plant (23.15), maximum average number of flowers per plant (3.95), fruit set (68.35%), fruit length (2.56 cm), fruit width (2.04 cm), number of fruits per plant (16.7) and average fruit weight (7.90 g). *Azotobacter* is expected to hasten plant development; hence an increase in fruit set in the present studies is due to the cumulative effect of *Azotobacter* and fertilizer application. This increase in number of fruits per plant possibly due to the fact that *Azotobacter* and N, P, K application accelerated the development of inflorescence, leaf number in autumn, which are positively correlated with the number of fruits in the following spring. Increased number of fruit might have also resulted because of increase in number of crowns per plant. Similar observations were also reported by **Kumar *et al.* (2014)** claimed the maximum plant height, maximum number of leaves, spread of plant, number of flowers, length diameter ratio of fruits and average number of fruit per plant in strawberry was recorded with the application of 100 kg N/ ha **Pandit *et al.* (2015), Tripathi *et al.* (2010)** in strawberry.

The pooled data as presented clearly revealed the significant differences among the treatments. The longest fruits were observed in T_2 5.68cm (100 Kg N ha^{-1} + *Azotobacter*) which were significantly higher to other treatments, whereas the shortest fruit was recorded in control (No Inorganic and no Bio-fertilizers). The same result was also assed by **Afroz *et al.* (2016)** the highest values of plant height (25.60 cm), number of leaves (21.66), flowers (125.33), fruits (12.35),destroyed fruits (11), fruit weight (215.10 g) plant^{-1} and fruit length (4.16 cm). **Gaur and Deepak (2003)** carried out that application of 200 kg N/ha resulted in the maximum plant height (19.90 cm), maximum number of leaves per plant (23.15), maximum average number of flowers per plant (3.95), fruit set (68.35%), fruit length (2.56 cm). **Kumar *et al.* (2014)** claimed the maximum plant height, maximum number of leaves, spread of plant, number of flowers, length diameter ratio of fruits and average number of fruit per plant in strawberry was recorded with the application of 100 kg N/ ha.

During 2014-15 fruit width was ranged from 3.60cm to 4.47cm. With maximum fruit width was observed in T_2 (4.47cm) 100 Kg N ha^{-1} + *Azotobacter* followed by T_4 (4.42cm), T_3 (4.37cm). Minimum fruit width was observed in control (3.60cm). During 2015-16, fruit width varied from 3.93cm to 4.80cm. Maximum fruit width (4.80cm) was recorded in T_2 (100 Kg N ha^{-1} + *Azotobacter*) followed by T_3 (4.71cm), whereas minimum fruit width was observed in control (3.93cm). The similar findings also suggested by **Rayees *et al.* (2015)** the data regarding the different growth parameters observed at 30, 45, 60, 90, 105, 120 days after planting, yield parameters at 45, 60, 90, 120, 135, 150 days after planting and their quality parameters clearly indicate that the application of integrated sources of nutrients significantly affect the vegetative, reproductive and yield characteristics of the strawberry plant. **Sara *et al.* (2015)** in this regard, studies were conducted using six different organic amendments on strawberry (*Fragaria ananassa* Duch.) cv. Chandler which included T_1 = planting media (soil + silt + farm yard manure); T_2 = planting media + 400 mgl^{-1} humic acid; T_3 = planting media + 200 g kg^{-1} leaf manure; T_4 = planting media + 200 4g kg^{-1} Vermicompost; T_5 = planting media + 200 g kg^{-1} plant fertilizer and T_6 = planting media + 200 g kg-1 bio-compost during 2011-12 at PMAS-Arid Agriculture University, Rawalpindi. Treatment T_1 (soil + silt + FYM) induced positive influence on plant height (15.21 cm), canopy spread (20.37 cm),crown diameter (1.47 cm), fresh weight of plant (10.71 g), number of runners per plant (2), total number of flowers (58), total number of fruits (42), fruit size (3.04 cm).

The mean value of both years revealed that the maximum fruit weight was observed in T_2 followed by T_5 and $T_{4,}$ respectively but minimum value asses in control (No Inorganic and no Bio-fertilizers). The values also examined by **Tripathi *et al.* (2015)** study the influence of *Azotobacter*, Vermicompost on growth, flowering, yield and quality of strawberry cv. Chandler. There were nine treatments comprising two levels each of *Azotobacter* (6 and 7 kg/ha) and Vermicompost (20 and 30 t/ ha) and their combinations along with one control, replicated thrice in randomized block design. Five kg of FYM was applied as a basal dose in all the treatments including control. Plants fertilized with *Azotobacter* at 6 kg/ha + Vermicompost at 30 t/ha also produced the berries with maximum length (4.76 cm), width (2.49 cm), weight (8.75 g). **Umar *et al.* (2010)** have reported that application of 25% nitrogen through subabul + 75% nitrogen in the form of urea augmented with bio fertilizer resulted in maximum plant height (20.9 cm), plant spread (27.8 cm) leaf area (70 cm^2), fruit size(38.4 x 28.9mm), T.S.S (6.836 ^{0}Brix), Total sugar(4.85%), fruit weight(16.9 g).

Fruit yield per plant varied significantly affected by the various doses of fertilizer and Bio-fertilizers. The mean values of both years showed the maximum value of fruit yield per plant in treatment T_2 followed by T_3 and $T_{4,}$ whereas the minimum yield per plant was observed under control (No Inorganic and no Bio-fertilizers). The result also observed by **El – Hamid *et al.* (2006)** observed that application of P.S.B. (5 Kg/ha) in strawberry resulted increased size, firmness and yield (252 g/plant). **Gupta and Tripathi (2012)** examined that the combined application of *Azotobacter* 6 kg per ha and Vermicompost 30 tonnes per ha significantly increased the yield (324.38 g/plant).

SUMMARY AND CONCLUSION

Chapter VI

SUMMARY AND CONCLUSION

The present investigation entitled "**Effect of Inorganic and Bio-fertilizers on Growth, Yield and Physico-chemical Characters of Strawberry [*Fragaria* x *ananassa* L. Duch.] cv. Chandler in Central Uttar Pradesh**" was carried out at Horticulture Research Farm, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow, U.P. during the winter season of 2014-15 and 2015-16. The experimental material consisted of 13 treatments with 3 replication of variety Chandler in Randomized Block Design. The salient features of the experiment are summarized below:-

1. The maximum plant height was noticed by the application of 100 Kg N ha^{-1} + Azotobacter i.e. T_2 which was at par with T_6 i.e. 60 Kg P ha-^{1} + Azotobacter. The minimum plant height was observed in control T_1 Control i.e. No Inorganic and no Bio-fertilizers.

2. The maximum number of leaves was studied in the application of 100 Kg N ha^{-1} + Azotobacter i.e. T_2 which was at par with T_4 i.e. 75 Kg N ha^{-1} + Azotobacter. The minimum number of leaves was assessed in control T_1 Control i.e. No Inorganic and no Bio-fertilizers.

3. In North-south direction the maximum spreading was observed in treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter at par with treatment T_4 i. e. 75 Kg N ha^{-1} + Azotobacter, minimum spreading in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

4. In case of East-west direction the highest spreading of plant examined in treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter at par with treatment T_4 i. e. 75 Kg N ha^{-1} + Azotobacter and minimum spreading in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

5. The superior leaf length was observed in the treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter at par with treatment T_3 i.e. 100 Kg N ha^{-1} + PSB whereas, minimum leaf length in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

6. The maximum leaf width was recorded the treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter at par with treatment T_3 i.e. 100 Kg N ha^{-1} + PSB , minimum in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

7. Number of fruit was maximum in T_{12} i.e. 45 Kg K ha^{-1} + Azotobacter at par with T_{13} i.e. 45 Kg Kha^{-1} + PSB and minimum was observed in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

8. The runner production was superior find out in treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter at par with treatment T_3 i.e. 100 Kg N ha^{-1} + PSB, T_4 i. e. 75 Kg N ha^{-1} + Azotobacter. Minimum runner was observed in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

9. The highest length of fruits was assess in the treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter followed by treatment T_4 i. e. 75 Kg N ha^{-1} + Azotobacter. Minimum length of fruit was observed in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

10. The minimum width was recorded in the in T_1 Control i.e. No Inorganic and no Bio-fertilizers, maximum in treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter at par with treatment T_3 i.e. 100 Kg N ha^{-1} + PSB.

11. In view of fruit weight was superior in the treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter followed by treatment T_3 i.e. 100 Kg N ha^{-1} + PSB. Minimum weight of fruit was assessing in treatment T_1 Control i.e. No Inorganic and no Bio-fertilizers.

12. In terms of fruit yield per plant, fruit yield per plot was highest in treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter at par with treatment T_3 i.e. 100 Kg N ha^{-1} + PSB but poorest observations found in treatment T_1 Control i.e. No Inorganic and no Bio-fertilizers.

13. Yield per hectare was superior in the application of 100 Kg N ha^{-1} + Azotobacter i.e. T_2 which was at par with T_3 i.e. 100 Kg N ha^{-1} + PSB and the minimum per hectare yield was observed in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

14. The highest T.S.S. reading was observed in treatment T_6 i.e. 60 Kg P ha-^{1} + Azotobacter followed by treatment T_7 i.e. 60 Kg P ha^{-1}+ PSB. In view of minimum T_1 Control i.e. No Inorganic and no Bio-fertilizers.

15. The acidity was recorded minimum in treatment T_6 i.e. 60 Kg P ha-^{1} + Azotobacter, maximum acidity was find out in treatment T_1 Control i.e. No Inorganic and no Bio-fertilizers.

16. The maximum value of ascorbic acid was observed in treatment T_6 i.e. 60 Kg P ha-^{1} + Azotobacter followed by treatment T_7 i.e. 60 Kg P ha^{-1}+ PSB. In view of minimum value of ascorbic acid was noticed in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

17. In case of pigment anthocyanin maximum value was assess in treatment T_{10} i.e. 60 Kg K ha^{-1} + Azotobacter followed by treatment T_{11} i.e. 60 Kg K ha^{-1} + PSB and minimum value of anthocyanin find out in treatment T_1 Control i.e. No Inorganic and no Bio-fertilizers.

18. Total, Reducing and Non-reducing sugar was maximum in treatment T_6 i.e. 60 Kg P ha-^{1} + Azotobacter followed by treatment T_7 i.e. 60 Kg P ha^{-1}+ PSB. In view of minimum values of sugar was noticed in T_1 Control i.e. No Inorganic and no Bio-fertilizers.

19. The highest benefit cost ratio was recorded in treatment T_2 i.e. 100 Kg N ha^{-1} + Azotobacter at par with treatment T_3 i.e. 100 Kg N ha^{-1} + PSB but poorest observation was found in treatment T_1 Control i.e. No Inorganic and no Bio-fertilizers.

CONCLUSION

On the basis of above result obtained in the present investigation, it was concluded that the plant height (cm), number of leaves, spreading of plant (cm), leaf length (cm), leaf width (cm), runner production, yield (t/ha) and benefit cost ratio was highest in treatment T_2 i.e.100 Kg N ha^{-1} + Azotobacter followed by T_3 i. e. 100 Kg N ha^{-1} + PSB. Whereas, minimum benefit cost ratio was found in treatment T_1 i.e. No

Inorganic and no Bio-fertilizers but for qualitative parameters was observed in treatment T_6 i.e. 60 Kg P ha-^{1} + Azotobacter followed by treatment T_7 i.e. 60 Kg P ha^{-1} + PSB.

Therefore, it may be recommend that the treatment T_2 i.e.100 Kg N ha^{-1} + Azotobacter for higher yield and as well as higher return under Lucknow condition.

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APPENDICES

APPENDICES

Appendix-1

Analysis of variance of plant height (cm) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.095			
Treatment	12	38.887	39.246	294.525	0.00000
Error	24	0.264	0.011		
Total	38	39.246			

Appendix-2

Analysis of variance of plant height (cm) at 90 days after panting 2015-16

Source of Variation	**Dm**	**Sum of Squares**	**Mean Squares**	**F-Calculated**	**Significance**
Replication	2	0.033			
Treatment	12	38.052	3.171	402.381	-0.00000
Error	24	0.189	0.008		
Total	38	38.274			

Appendix-3

Analysis of variance of plant spread N-S (cm) at 90 days after panting 2014-15

Source of Variation	**Dm**	**Sum of Squares**	**Mean Squares**	**F-Calculated**	**Significance**
Replication	2	0.006			
Treatment	12	226.563	18.880	8,072.615	0.00000
Error	24	0.056	0.002		
Total	38	226.625			

Appendix-4

Analysis of variance of plant spread N-S (cm) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.652			
Treatment	12	226.563	18.880	52.024	0.00000
Error	24	8.710	0.363		
Total	38	235.925			

Appendix-5

Analysis of variance of plant spread E-W (cm) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.024			
Treatment	12	25.705	2.142	413.002	0.00000
Error	24	0.124	0.005		
Total	38	25.853			

Appendix-6

Analysis of variance of plant spread E-W (cm) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.149			
Treatment	12	26.341	2.195	28.674	0.00000
Error	24	1.837	0.077		
Total	38	28.327			

Appendix-7

Analysis of variance of Number of leaves at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.359			
Treatment	12	75.436	6.286	19.745	0.00000
Error	24	7.641	0.318		
Total	38	83.436			

Appendix-8

Analysis of variance of Number of leaves at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	1.077			
Treatment	12	84.974	7.081	7.006	0.00003
Error	24	24.256	1.011		
Total	38	24.256			

Appendix-9

Analysis of variance of Leaf length (cm) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.011			
Treatment	12	34.173	2.848	13,905.072	0.00000
Error	24	0.005	0.000		
Total	38	34.189			

Appendix-10

Analysis of variance of Leaf length (cm) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.100			
Treatment	12	34.118	2.843	7.774	0.00001
Error	24	8.778	0.366		
Total	38	42.996			

Appendix-11

Analysis of variance of Leaf width (cm) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.027			
Treatment	12	41.486	3.457	9,043.716	-0.00000
Error	24	0.009	0.000		
Total	38	41.521			

Appendix-12

Analysis of variance of Leaf width (cm) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	1.838			
Treatment	12	41.486	3.457	11.236	0.00000
Error	24	7.385	0.308		
Total	38	50.708			

Appendix-13

Analysis of variance of Number of runners per plant at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	3.436			
Treatment	12	37.692	3.141	6.712	0.00004
Error	24	11.231	0.468		
Total	38	52.359			

Appendix-14

Analysis of variance of Number of runners per plant at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	3.436			
Treatment	12	34.256	2.855	11.617	0.00000
Error	24	5.897	0.246		
Total	38	43.590			

Appendix-15

Analysis of variance of Number of fruits per plant at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	1.077			
Treatment	12	82.103	6.842	14.168	0.00000
Error	24	11.590	0.483		
Total	38	94.769			

Appendix-16

Analysis of variance of Number of fruits per plant at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	4.974			
Treatment	12	64.308	5.359	11.000	0.00000
Error	24	11.692	0.487		
Total	38	80.974			

Appendix-17

Analysis of variance of Fruit length (cm) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.007			
Treatment	12	8.089	0.674	1,361.348	-0.00000
Error	24	0.012	0.000		
Total	38	8.108			

Appendix-18

Analysis of variance of Fruit length (cm) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	8.794			
Treatment	12	8.089	0.674	1,361.348	-0.00000
Error	24	0.012	0.000		
Total	38	16.895			

Appendix-19

Analysis of variance of Fruit width (cm) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.009			
Treatment	12	4.006	0.334	269.859	-0.00000
Error	24	0.030	0.001		
Total	38	4.045			

Appendix-20

Analysis of variance of Fruit width (cm) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	3.642			
Treatment	12	3.788	0.316	1.693	0.13146
Error	24	4.473	0.186		
Total	38	11.904			

Appendix-21

Analysis of variance of Fruit weight (g) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	7.538			
Treatment	12	1,059.692	88.308	114.800	0.00000
Error	24	18.462	0.769		
Total	38	1,085.692			

Appendix-22

Analysis of variance of Fruit weight (g) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	1.847			
Treatment	12	340.705	28.392	28.212	0.00000
Error	24	24.153	1.006		
Total	38	366.705			

Appendix-23

Analysis of variance of Fruit yield per plant (g) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	11.231			
Treatment	12	29,417.436	2,451.453	2,926.735	-0.00000
Error	24	20.103	0.838		
Total	38	29,448.769			

Appendix-24

Analysis of variance of Fruit yield per plant (g) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	938.335			
Treatment	12	36,757.727	3,063.144	44.242	0.00000
Error	24	1,661.653	69.236		
Total	38	39,357.715			

Appendix-25

Analysis of variance of Fruit yield per plot (Kg) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.003			
Treatment	12	17.250	1.438	352.321	0.00000
Error	24	0.098	0.004		
Total	38	17.352			

Appendix-26

Analysis of variance of Fruit yield per plot (Kg) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.000			
Treatment	12	21.082	1.757	18,632.244	0.00000
Error	24	0.002	0.000		
Total	38	21.084			

Appendix-27

Analysis of variance of Fruit yield per hac (t) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.790			
Treatment	12	1,436.499	119.708	876.626	0.00000
Error	24	3.277	0.137		
Total	38	1,440.567			

Appendix-28

Analysis of variance of Fruit yield per hac (t) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.621			
Treatment	12	1,805.582	150.465	142.286	0.00000
Error	24	25.380	1.057		
Total	38	1,831.582			

Appendix-29

Analysis of variance of T.S.S. (^{O}Brix) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.039			
Treatment	12	10.855	0.905	98.122	0.00000
Error	24	0.221	0.009		
Total	38	11.115			

Appendix-30

Analysis of variance of T.S.S. (^{O}Brix) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	2.225			
Treatment	12	10.817	0.901	3.267	0.00654
Error	24	6.622	0.276		
Total	38	19.664			

Appendix-31

Analysis of variance of Acidity (%) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.004			
Treatment	12	0.188	0.016	18.982	0.00000
Error	24	0.020	0.001		
Total	38	0.211			

Appendix-32

Analysis of variance of Acidity (%) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.072			
Treatment	12	0.158	0.013	11.858	0.00000
Error	24	0.027	0.001		
Total	38	0.257			

Appendix-33

Analysis of variance of Ascorbic acid (mg/100g) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	-0.002			
Treatment	12	146.867	12.239	8,747.029	0.00000
Error	24	0.034	0.001		
Total	38	146.898			

Appendix-34

Analysis of variance of Ascorbic acid (mg/100g) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	314.602			
Treatment	12	146.867	12.239	0.529	0.87437
Error	24	554.897	23.121		
Total	38	1,016.365			

Appendix-35

Analysis of variance of Anthocyanin (mg/100g) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.974			
Treatment	12	650.974	54.248	68.431	0.00000
Error	24	19.026	0.793		
Total	38	670.974			

Appendix-36

Analysis of variance of Anthocyanin (mg/100g) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.105			
Treatment	12	634.739	52.895	1,177.356	0.00000
Error	24	1.078	0.045		
Total	38	635.922			

Appendix-37

Analysis of variance of Total Sugars (%) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.003			
Treatment	12	13.871	1.156	469.553	-0.00000
Error	24	0.059	0.002		
Total	38	13.933			

Appendix-38

Analysis of variance of Total Sugars (%) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.069			
Treatment	12	13.591	1.133	12.624	0.00000
Error	24	2.153	0.090		
Total	38	15.813			

Appendix-39

Analysis of variance of Reducing Sugars (%) at 90 days after panting 2014-15

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.037			
Treatment	12	6.487	0.541	58.891	0.00000
Error	24	0.220	0.009		
Total	38	6.744			

Appendix-40

Analysis of variance of Reducing Sugars (%) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.020			
Treatment	12	6.404	0.534	53.304	0.00000
Error	24	0.240	0.010		
Total	38	6.664			

Appendix-41

Analysis of variance of Non-Reducing Sugars (%) at 90 days after panting 2014-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.010			
Treatment	12	2.191	0.183	136.086	0.00000
Error	24	0.032	0.001		
Total	38	2.232			

Appendix-42

Analysis of variance of Non-Reducing Sugars (%) at 90 days after panting 2015-16

Source of Variation	Dm	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.018			
Treatment	12	2.130	0.177	17.634	0.00000
Error	24	0.242	0.010		
Total	38	2.390			