Effect of Organic, Inorganic and Biofertilizers on growth, yield and quality traits of okra [*Abelmoschus esculentus* (L.)Moench.]

THESIS

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Organic, Inorganic and Biofertilizers on growth, yield and quality traits of okra [*Abelmoschus esculentus* (L.) Moench.]"** submitted by Ms. **Smriti Singh**, Enrollment No. 555/13 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.

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DECLARATION

I, **Smriti Singh, Enrollment No. 555/13,** hereby declare that I am a candidate for the degree of **Doctor of Philosophy in Horticulture**, Department of Applied Plant science (Horticulture),School for Biosciences and Biotechnology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar, Rae Bareli Road, Lucknow-226025 (U.P.), India and have carried out my research work entitled **"Effect of Organic, Inorganic and Biofertilizers on growth, yield and quality traits of okra [*Abelmoschus esculentus* (L.) Moench.]"** The Thesis has been submitted for the award of the degree of Doctor of Philosophy in Horticulture is my original research work.

Smriti

Place: Lucknow

Date: 21/05/2019

(Smriti Singh)

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Smriti

Place : Lucknow

(Smriti Singh)

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LIST OF ABBREVIATIONS

ANOVA	:	Analysis of variance
CD	:	Critical Difference
cm	:	Centimeter
CV	:	Coefficient of variation
FYM	:	Farmyard manure
et al.	:	and others
Fig	:	Figure
g	:	Gram
kg	:	Kilogram
m	:	Meter
ha	:	Hectare
mg	:	Milligram
SE(d)	:	Standard error difference
S.E (m)	:	Standard error mean
D f	:	Degrees of freedom
RBD	:	Randomized Block Design
Vit-C	:	Ascorbic Acid
viz.	:	Namely
vs.	:	Against
No.	:	Number
I.U	:	International unit
M.S.S.	:	Mean sum square
RBD	:	Randomized block design
RH	:	Relative humidity
TSS	:	Total soluble solids
i.e.	:	That is
^{0}B	:	Degree brix

Introduction

"Begin at the beginning, the king said gravely, and go on till you come to the end: then stop."

Chapter I

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench.) belongs to the family of *Malvaceae* being economically important vegetable crop grown in sub-tropical and tropical parts of the world. It is generally an annual plant. It is also known as lady's finger or bhindi, originated in tropical Africa. Because of its richness in nutrition, taste, medicinal and industrial value, okra is one of the most popular vegetable in all sections of people. Okra is cultivated for its fibrous fruits or pods containing round, and circular seeds. The fruits are harvested when immature and eaten as a vegetable. Usually 90-100 days are required for the production of okra. Kharif and Rabi employ the production of okra. Warm and humid atmosphere is favourable for the development of okra crop. Okra is a good source of vitamins, minerals, calories, and amino acids found in seeds and compares favourably with those in poultry, eggs and soybean, **(Thompson, 1949; Schipper, 2000).** All parts of okra (Lady's finger) likes fresh leaves, buds, flowers, pods, stems and seeds can be used for different purposes and hence it is a multipurpose crop in terms of its uses **(Gemede *et al*., 2015).**

Okra *(Abelmoscus esculentus* (L.) Moench.) is one of the most well-known and utilized species of the family Malvaceae in India as well as United States, Spain. It is one of the essentially consumable crop of the India, immature and tender pods can be consumed as the boiled and fried vegetables or could be utilized as it may be added to salads, soups and stews **(Kashif *et* al., 2008)**.

The family of *Malvaceae* constitutes the polyploidy of 2n=8x=72 or 144. There are more than 30 species lying below the genus of *Abelmoschus* in the lacked world and 4 in the former world. From them "*Abelmoschus esculentus"* is the exclusive species existing to be grown much favourably or extensively as commercial vegetable. Further it comes under self-pollinated crop, occurrence of out crossing to an extent of 20 per cent by insects has made okra an often cross - pollinated crop. Okra is known by many local names in different parts of the world. It is called gumbo in the United

States, lady's finger in England, guino - gombo in Spanish, guibeiro in Portuguese and bhindi species in India. It is quite popular in India because of easy

cultivation, dependable yield and adaptability to varying moisture conditions. Even within India, different names have been given in different regional languages **(Chauhan, 1972).**

Okra fruit can be utilized in several ways. The stems and roots of okra are used for bleaching of sugarcane juice from which gur or brown sugar is prepared **(Chauhan, 1972).** Its ripe and tender seeds are roasted, ground and used as a substitute for coffee in some countries. Developed and synthesized naturally stems and fruits containing crude fibre are used in the paper industry. Extracts and elevated juices from the seeds of the okra is an alternative source for edible oil. The edible oil (greenish yellow) has a pleasant taste and odour, and is high in unsaturated fats such as oleic acid and linoleic acid. Okra provides an important source of vitamins, calcium, potassium and other minerals which are often lacking in the diet in developing countries **(IBPGR, 1990).**

At present, injudicious use of fungicides, chemical fertilizers and pesticides are responsible for deterioration of soil health and ultimately our green plants. Fungicides are one of the cheap sources of nutrients. Therefore, to maintain the soil fertility and to supply plant nutrients in balanced proportion for optimum growth, yield and quality of crop, an integrated approach is to be practiced under specific agro-ecological situation through the combined use of organic and inorganic sources of plant nutrients. An improvisation in the yield was observed by the application of vermiwash and vermicompost and along with the dosage of the nitrogen phosphorus and potassium (**Kulkarni *et al.*, 2004, Paramasivan *et al.*, 2006, Maithy and Tripathi, 2009 and Gorakhnath and Singh, 2009).**

Okra [*Abelmoschus esculentus* (L.)Moench.] is as herbaceous annual and export oriented vegetable crop grown in the kharif and rabi seasons, and it is reported to show good response to different plant nutrients. Being native of tropical Africa, it is widely cultivated in India. Uttar Pradesh, Assam, Bihar, Orissa, Maharashtra, West Bengal and Karnataka are important okra producing states. In India, it is grown in an area of 0.36 million hectares with annual production of 3.5 million tones and productivity of 9.72 tons per hectare. In Karnataka it occupies an area of 18,150 hectares with production of 1, 55,940 tones and productivity of 8.75 tons per hectare. Okra is valued for its delicious tender fruits. It is the best source of iodine and calcium. Okra accounts for 60 per cent of export of fresh vegetables excluding potato, onion and garlic **(Sharma and Arora, 1993).**

Maintenance of the spacing which is at the threshold or plant population and nitrogen fertilization dose are most important elements in improving productivity of okra. Optimum plant density is the key element for higher yield of okra, as plant growth, yield and quality are affected by inter and intra-row spacing **(Amjad *et al*., 2002; Paththinige *et al.*, 2008).**

Increase and improvement in the productivity calls for better crop husbandry including the use of optimum rate of nitrogen, phosphorus and potassium. On a basic scale, 20 tons/ha of okra removes about 60, 25 and 90 kilogram of N, P_2O_5 and K_2O/ha respectively **(Prabhakar, 1996).**

Major constraint to get higher productivity is still the limited use of mineral fertilizers, especially phosphorus and potassium due to availability and cost. In India, around 11.90 to 40.69 lakh MT of murate of potash are imported from various countries **(Anon, 2013)** pivot on the demand and supply.

Growth quality and quantity can be improved by the use of essential nutrients because it manages to improve the utilization of important inputs that could be in any form either chemical physical or bio methods **(Akande *et al.*, 2010).**

Considering the expenses and availability of chemical K fertilizers, procurement of alternate indigenous product K ash and limited research work was carried out on this product, the present activity of scrutinizing was taken up to traverse the utilization of K ash organic fertilizer as a substitute of chemical K fertilizer and its effect on growth, nutrient uptake and yield of okra **(Pushpavalli *et al.*, 2014).** Okracontains forskolin (diterpinoid), which is being used to treat several diseases which includes - hypertension, glaucoma, asthma, congestive heart failure and certain type of cancer's **(D'souza,1986).**

The use of organic applications of materials applied to soil not only improvises its calibration status of nutrients but also reduces the incidence of pest **(Adilakshmi *et al.*, 2007).** Improvement of soil fertility through the application of fertilizers has become an essential factor that enables the world to feed billions of people of its population **(Brady and Weil, 1999).**

Soil fertility is usually maintained by the application of organic and inorganic fertilizers **(Okigbo, 1985),** and there is also an improvement in the physical and biological properties of the soils **(Okwuagwu *et al.*, 2003).**

1.1 Okra and its nutritional Values

Composition per 100 g of edible portion of okra contains, Calories 35.0 mg, Calcium 66.0 mg, Moisture 89.6 g, Iron 0.35 mg, Carbohydrates 6.4 g, Potassium 103.0 mg, Protein 1.9 g, Magnesium 53.0 mg, Fat 0.2 g, Copper 0.19 mg, Fibre 1.2 g, Riboflavin 0.01 mg, Minerals 0.7g, Thiamine 0.07 mg, Phosphorus 56.0 mg, Nicotinic acid 0.06 mg, Sodium 6.9 mg, Vitamin C 13.10 mg, Sulphur 30.0 mg and Oxalic acid 8.0 mg **(Gopalan *et al.*, 2007).**

The indiscriminate use of inorganic fertilizer leads to nutrient imbalance in soils, causing ill - effects on soil properties. Hence, there is a need to supplement the inorganic fertilizers along with the application of organic and biofertilizers to the maximum possible level. Making all the nutrient elements available is one of the most important factors for exploiting the yield potential as the imbalanced use of nutrients through chemical fertilizer application alone leads to deficiency symptoms. Consumption of young immature okra pods is important as fresh fruits, and it can be consumed in different forms. Fruits can be boiled, fried or cooked **(Akintoye *et al.*, 2011).**

Indiscriminate use of inorganic fertilizers has resulted in decreased nutrient uptake, poor quality of vegetables and deterioration of soil health. Okra produces fruit for a long time and needs balanced and sufficient supply of nutrients for higher yield and better quality **Ganesh *et al.*, 2000, Agrawal, 2003).**

Inadequate or imbalanced nutrient supply is one of the major constraints in harvesting higher yields. Substitution of high analysis fertilizers like urea and diammonium phosphate for enhancing crop productivity or insufficient use of organic sources of plant nutrients have rendered most of the Indian soils deficient in macro and micro nutrients **(Acharya and Mandal, 2002).**

Large scale use of chemical fertilizers has resulted in the deterioration of soil structure and a decrease in microbial population in the soil **(Ganeshe *et al*., 1998).** Use of chemical fertilizers is associated with other problems like loss of applied nutrients through leaching, volatilization and denitrification of nitrogen and fixation of phosphorus. Besides this, the prices of chemical fertilizers are increasing tremendously and due to inherent financial strains, the marginal farmers are unable to purchase such expensive inputs in time. The continuous and indiscriminate use of inorganic fertilizers has resulted in decreased nutrient uptake and adversely affected the quality of vegetables **(Agarwal, 2003).**

Seed is the important basic input in agriculture and quality seed is very important in crop establishment too. Hence, production of healthy crop depends on many factors of seed and agronomic aspects of cultivation. Fertilizers play a crucial role to meet nutrient requirement of the crop. Persistent nutrient depletion is posing a greater threat to the sustainable agriculture. Therefore, there is an urgent need to reduce the usage of chemical fertilizers and in turn increase the usage of organics, which are needed to improve the yield and quality levels. The aforesaid consequences have paved way to grow okra using different organic sources and biofertilizers, use of organic manure in combination with chemical fertilizers and it helps in improving physic-chemical properties of soil structure, water holding capacity and soil aeration, chemical properties and supply of essential nutrients in balanced ratio, supply of nutrients, slow release of nutrients, stimulation of soil flora and fauna **(Agarwal, 2003).**

Vermicompost, besides being a rich source of micronutrients acts as chelating agent and regulates the availability of metallic micronutrients to the plants and increases the plant growth and yield organic waste from different sources helps in boosting up vegetable crop growth and yield as it contains most of the nutrients essential for plant growth and hence it responds well to the application of both organic manures and inorganic fertilizers. Of late, biofertilizers are gaining importance due to their low cost, non- residual toxicity and capacity to enrich soil fertility in addition to high returns under favourable conditions. Organic manures are known to supply the major nutrients, and micronutrients, apart from improving soil properties and fertility.

However, much information is not available on use of inorganic fertilizers in conjunction with organic manures and biofertilizers in okra seed production. Therefore, there is a need to work the requirement of inorganic fertilizers in conjunction with organic manures and biofertilizers for increased seed yield and quality of okra **(Akbasova *et al*., 2015**).

That of young fruits consists of long chain molecules with a molecular weight of about 170,000 made up of sugar units and amino acids. The main components are galactose (25%), rhamnose (22%), galacturonic acid (27%) and amino acids (11%). The mucilage is highly soluble in water. Its solution in water has an intrinsic viscosity value of about 30% Farmers need adequate resources to replenish soil fertility and maintain the productivity of soil. Really, the green revolution has popularized the use of chemical fertilizers to achieve higher productivity. But due to continuous and indiscriminate use of fertilizers, the natural fertility of soil has been lost and this activity has contaminated our soil, water and food. Therefore farmers are in need of searching alternative to replace the chemical fertilizers. In recent days, the use of organic inputs like FYM, compose vermicompost etc.is becoming popular in the world wide. There is a need of effective technology to deal with disposal of wastes which continues to be a challenge as population increases. Organic manure has been identified as one of the potential processes in managing waste, since it is a natural process, cost effective and required only shorter duration. The application of organic manure helps in increasing the organic matter content of the soil, in maintaining soil natural productivity **(Kumar *et al.,* 2011).**

1.2 Employment of Organic fertilizers

Organic and inorganic fertilizers are essential for plant growth. Both fertilizers supply plants with the nutrients needed for optimum performance. Organic fertilizers have been used for many centuries whereas chemically synthesized inorganic fertilizers were only widely developed during the industrial revolution. Inorganic fertilizer has significantly supported global population growth, it has been estimated that almost half the people on the earth are currently fed as a result of artificial nitrogen fertilizer use **(Erisman *et al*., 2008).**

1.3 Integrated use of organic, inorganic and Biofertilizers contents.

Development of technology is needed for the fulfilment of plant nutrients through organic resources and their application in a balanced way for maintaining soil productivity. Organic farming proves many advantages for soil as well as it improves plant and animal health. It also recycles and regenerate the waste into wealth and can wipe out the use of chemicals in the form of fertilizers or pesticides and help to build the balanced sustainable model for eco-friendly environment. Vermicomposting is a safe and non-polluting method for disposal and recycling of organic waste by its conversion into organic fertilizers. It is an excellent form of natural manure, which is cost-effective, easy to make and effective in promoting waste-management. Vermicomposting application could be one of the most economical and attractive methods of solving the problems like waste disposal and the requirement to increase the organic matter content of soil **(Narkhede *et al*., 2011).**

Growth promoting constituents like enzymes and hormones present in organic manures make them useful for improvement of soil fertility and productivity. Some plant-growth promoters in vermicompost (i.e., auxins, gibberellins, Cytokinin) represent excellent soil conditioners due to its higher porosity, aeration, drainage, water-holding capacity and microbial activity **(Singh *et al.*, 2008).**

The most important elements present in inorganic fertilizers are nitrogen, phosphorus, and potassium which influence vegetative and reproductive phase of plant growth. Compared to inorganic fertilizers the organic fertilizer having lowered the nutrient content, solubility, and nutrient release rates are typically low than inorganic fertilizers and therefore inorganic fertilizers are more preferred than organic fertilizers. Besides this application of organic manures not only produced the highest and sustainable crop yield, but also improved the soil fertility and productivity of land. A soil health for the subsequent crop combination of organic and inorganic sources of nutrients might be helpful to obtain a good economic return with good yield (**Sanwal *et al*., 2007).**

The use of organic manures as a means of maintaining and increasing soil fertility has been advocated **(Alasiri and Ogunkeye, 1999).** Some of these materials have also been found to control pathogens**.**

Organic manures constitute a dependable source of micro and macro nutrients, besides being helpful in building a strong organic matter base, resulting in improvement of soil structural properties like bulk density, porosity, aeration and water holding capacity, regulates soil PH near neutral, maintains soil health, enhances biological diversity and soil micro-flora, reduces nutrient leaching, increase availability and uptake of nutrients leading to sustainable vegetable production, devoid of harmful residues **(Singh *et al.*, 2000; Achary and Mandal, 2002).**

The use of inorganic fertilizers can improve crop yields, soil PH, total nutrient content and nutrient availability **(Akande *et al.*, 2010).**Most especially in the tropics where soils are adversely affected by sub-optimal soil fertility and erosion causing deterioration of the nutrient status and changes in population of soil organisms **(Economic Commission for Africa, 2001).**

But its use is constrained by acidity, scarcity, nutrient imbalance and it is no longer within the reach of poor-resource farmers due to its high cost. When excessively used, it also has a depressing effect on yield. This causes a reduction in number of fruits, delays and reduces fruit setting **(Akande *et al.*, 2010).**

Biofertilizers are useful substitutes to inorganic fertilizers which improves the soil quality. According to the nutrient status of the compost obtained from municipal solid waste and sewage sludge was eminent. Due to increase in prices rate of fertilizers in developing countries the poor farmers are getting highly affected. Although the use of chemical fertilizers, herbicides, pesticides have enhanced the production of farming but there is growing concern over the adverse effects of the use of chemicals on soil productivity and environment quality. Use of chemical fertilizers for a long time has resulted in poor soil health, reduce production, and increase in incidences of pest and disease and environmental pollution **(Ansari and Ismail 2001).**

Biofertilizers are known to play a number of vital roles in soil fertility, crop productivity and production in agriculture as they are ecofriendly and cannot at any cost replace chemical fertilizers that are indispensable for getting maximum crop yields. Some of the important functions or roles of biofertilizers in agriculture are they supplement chemical fertilizers for meeting the integrated nutrient demand of the crops. They can add 20-200 kg N/ha year *(eg. Rhizobium sp.* 50-100 kg N/ha year; *Azospirillum, Azotobacter:* 20-40 kg N/ha /yr; Azolla: 40-80 kg N/ha; BGA :20-30 kg N/ha) under optimum soil conditions and thereby increases 15-25 percent of total crop yield **(Fageria *et al.* 2009).**

Besides being environmentally safe, it increases crop yield and quality **(Fageria *et al.* 2009).** There have been several sources of recommendations of for utilizations of integrated nutrient management systems an earlier study and knowledge have portrayed enhanced development of branches per plant in okra due to foliar fertilization **(Paliwal *et al.* 1999)**. Similarly, it was reported improved days to 50% flowering, plant height, number of branches and fruits per plant and fruit yield in okra using combinations of foliar fertilizer and soil-applied inorganic fertilizer in okra. **(Abasi *et al.*2010).**

Keeping in mind above facts and considering the importance of the above mentioned data following investigation has been designed under the title **" Effect of Organic, Inorganic and Biofertilizers on growth, yield and Quality traits of Okra [*Abelmonschus esculentus* (L.) Moench.]''**

Objectives

- To find out the effect of organic fertilizers on growth, yield and quality traits of okra.
- To investigate the effect of inorganic fertilizers on growth, yield and quality traits of okra.
- To assess the effect of biofertilizers on growth, yield and quality traits of Okra.
- To study the combined effect of organic, inorganic and biofertilizers on growth yield and quality traits of okra.

Review of Literature

"You can't go back and change the beginning, But you can start where you are and change the ending".

Chapter II

Review of Literature

The experimental study on “Effect of organic, inorganic and biofertilizers on growth, yield and quality traits of okra” was a worth exploiting research. In this chapter an attempt has been made to critically examine the available research findings and reviewed briefly the relevant literature pertaining to the present investigation in a summarized and classified manner, so as to use it as a background literature.

Okra [*Abelmoschus esculentus* (L.) Moench.] belongs to the family of *Malvaceae* being economically important vegetable crop grown in sub-tropical and tropical parts of the world. Okra possesses forskolin which is a diterpinoid, which carries several implementation in treatment of several disorders which includes - hypertension, glaucoma, asthma, congestive heart failure and certain type of cancers. The indiscriminate use of inorganic fertilizer leads to nutrient imbalance in soils, causing ill - effects on soil properties. Hence, there is a need to supplement the inorganic fertilizers along with the application of organic and bio - fertilizer to the maximum possible level.

Extensive studies on integrated use of organic, inorganic and biofertilizers have been implemented and performed on various other crops of Malvaceae and other related families the result has been respective to every subsequent crops in some it was found that biofertilizers and organic manure along with RDF could be proclaimed as the best for the crops of Malvaceae family, keeping that in considerations several experiments have been performed.

This experimental design deals with the combination of 16 treatments combinations. The ideology or inspiration of this experimentation actually came with the thorough analysis and study of the review of literature. The underlying review contains the articles from the professional journals with the confined and precise examining of their experimentation. The major findings have been enlisted in this chapter.

2.1 Effect of FYM on growth and yield components

Amran*et al*., (2014) mentioned in a combination that T1 -V_1-NOH-15-without FYM), the another one included T2 -V_1- NOH-15,+Farm yard manure (FYM) 15 t /ha, T3 (V_1(NOH-15) + Farmyard manure {(FYM 25 t /ha), T4 (V2 (SONAL) without FYM}, T5 (V_2(SONAL) + Farm yard manure FYM 15 t /ha), T6 (V_2 (SONAL) + Farm yard manure FYM 25 t /ha), T7 {V_3(OH -2324) without (FYM), T8 -V_3-OH -2324,+ Farm yard manure (FYM) 15 t /ha} and T9 -V_3 -OH -2324, + Farmyard manure (FYM) 25 t /ha) . The least Days for enhancement of growth 3.69 was with treatment T_5 (SONAL+FYM fifteen tone/ha), The highest T.S.S. (^{0}Brix) recorded in the $T_6$was estimated as (2.84), the highest possible number of leaves was (49.35), The highest no of branches that was observed in the okra plant was 2.80, The paramount median number of fruit per plant was23.15, The maximum average fresh weight of fruit was (12.43 g), The maximum fruit yield per plant was (287.61 g) the paramount average of fruit yield / ha was in values 16.25 t./ha The paramount content of acid (ascorbic) was made to be 15.58 mg in the total of 100 g, highest of height of plant that could have been observed was 127.6 cm, and which were then amalgamated to the height of –T9-OH-2324 +25 t/ha FYM , It was the finest outcome of the yield of okra

Poonia *et al*., (2014) performed some basis with the aim of investigation to extract out the attempt of varied branches of fertilizer which are generally organic, inorganic and biofertilizers on management of nutrient solutions in pigeon pea and intercropping systems which are aligned. The outcomes of the study unleashed the application of applied dosage of fertilizers (100 % RDF) to the applied crops showed significant improvement in the final yield viz., groundnut (1295 kilogram per hectare) and pigeon pea (14920 Kilogram per hectare). In manifestation of treatments with organic matters, the prior form of study, organic matters are not showing any significant effect on the improvement of yield as compared to onwards years in both the crops.

Gulshan *et al*, .(2013) performed an experiment which comprised of 60 pots with two different cultivars which were named as "Sabzpari" and "Super Green" of okra species which possessed 5 replicas and followed by 3 treated crops for respective species and to that six harvests. The growth parameters number of leaves 68.01±37.43 and leaf area 70.74±31.87 of cultivar "Super Green" was showed maximum response in manure than cultivar "Sabzpari" 8.11±1.34 and 8.19±5.60, respectively. The vegetative growth of okra cultivars were showed significant response in different concentration of animals manure. Significant variations were found in between the treatments and the different levels of growth harvest ($P \geq 000$). Moreover, the germination response of weeds was also significantly increased with the concentration of animal manure.

Ibrahim *et al.*, (2011) conducted experiments during the 2010 and 2011 cropping seasons to investigate the effect of farmyard manure and weeding regimes on the growth and yield of okra. The study was a factorial experiment laid out in split plot design, replicated thrice. Farmyard manure was assigned as main plot treatments, while weeding regimes was assigned as sub plot treatments. Parameters measured included plant height, number of leaves plant, number of branches plant, leaf area plant, number of pods plant, pod yield /plant and pod yield harvest . The results revealed that these parameters increased significantly with an increase in 1 treatment of both farmyard manure and weeding regimes. The significant increases were attributed to availability of nutrients as well as appropriate timing of weeding which reduced the negative influence of weeds in the field. Higher growth and yield parameters were observed in plots treated with 12 t/ ha of farmyard 1 manure and 3 weeding regimes. Therefore, application of 12 t /ha of farmyard manure and 3 weeding regimes 1 which significantly enhanced growth and yield of okra is recommended to our farmers.

Singh (2004)performed experiments on okra conducted an experiment on integrated nutrient management in okra cultivar P-7. The treatment having FYM + dense organic manure in combinations of all pesticides gave highest yield with good protein content, prolonged shelf life, highest net profit/unit area and per rupee investment over the others. However, treatment having bio - fertilizer + dense organic manure gave highest vitamin C content and low nitrate level in marketable produce.

Paramasivan *et al.*, (2003) worked on okra plant and assessed the effect of organic manures and inorganic fertilizers on yield and economics of okra. The treatment FYM @ 25 t per ha + CCP (composted coir pith) @ 12.5 t per ha + vermicompost (1.5 t/ha)

+ 40:50:30 kg per ha NPK recorded maximum number of branches (3.5), early in days to 50 percent flowering (45.4) and maximum number of fruits per plant (9.9).This was due to integration of organic and inorganic nutrients resulting in better translocation of nutrients under optimum moisture condition of soil leading to availability of nutrients and increased photosynthetic activity etc.

Premsekhar *et al.*, (2003) conducted field experiments on okra to study the influence of different organic manures on the growth, yield and quality of okra var. Arka Anamika. The experiments were conducted in a randomized block design replicated thrice with eleven treatments involving different organic manures along with no manure control. The results showed that FYM 20 t per ha recorded the highest yield of 10.39 t per ha with the BC ratio of 13:6. The crude fibre content of fruits under this treatment was also less when compared to control.

Respiratory processes could be enhanced by the process of direct utilization of Farmyard manure which actually helps by acting upon the cell permeability, they also trigger hormonal growth cell permeability or by hormone growth action. It is a key which provides the amount of nitrogen phosphorus and sulphur content in the forms which are available to give normal provision of decompositions. Alternatively, it provides improvisation on the physical properties to soil such as of soil which includes aggregation and capacity to hold water **(Chandramohan, 2002).**

Rekha and Gopalakrishnan (2001) reported that, longest (26.7 cm) and thickest (17.5 cm) fruits were recorded by FYM (25 t/ha) with inorganic fertilizers (70:25:25 kg NPK/ha) in bitter gourd.

Nanthakumar and Veeraragavathatham (2001) worked for brinjal and recorded significantly higher fruit yield (26.8 t/ha) with application of 100:100:100 kg NPK and 12.5 t FYM per ha as compared to 75:75:100 kg NPK per ha alone (20.1 t/ha) in brinjal.

Renuka and Ravisankar (2001) worked on tomato reported that integrated application of FYM (15 t/ha) with NPK (120:70:70 kg/ha) resulted significantly higher number of branches (3.66) as compared to their individual fertilizer application in tomato.

Rekha and Gopalkrishnan (2001) worked on bitter gourd and noticed that application of organic manures alone (FYM) recorded minimum vine length (5.80 cm) and number of branches per plant (12). While, the treatment which received an additional dose of inorganic fertilizers (70:25:50 kg NPK/ha) recorded maximum vine length (7.10 m) and number of branches (18) in bitter gourd.

Subramanian *et al*.,(2000)In this work found inference that FYM and temperature of sun in the fertilizer schedule not only increased the yield but also improved the soil moisture storage at 31, 31.3 and 31. 6 per cent at decreasing soil depths with 15 cm of downward gaps.

Sutagundi (2000)reported in the case of flowering chilli that early flowering (43.66 days) was recorded in plant receiving FYM (10 t/ha) as compared to 100:50:50 kg NPK per ha (43.75 days) in chilli.

Sutagundi (2000) noticed significantly higher 100 seed weight (0.6 g) with application of FYM (10 t/ha) along with NPK (100:50:50 kg/ha) as compared to their individual application in chilli.

Shashidhara (2000) reported higher seed weight (5.84 g) by applying FYM (5 t/ha) + 50 per cent RDF compared to 50 per cent RDF alone (5.02 g) in chilli.

Naidu *et al*., (1999)performed experiments on okra and observed higher number of fruits per plant (24.3) and fruit yield (149 q/ha) with the application of 80:60:50 kg NPK per ha in addition to 20 t FYM per ha. It was significantly superior over control (17.3 and 100 q respectively) in okra.

Nirmala and Vadivel (1999) performed experiments on cucumber and gave a significant rise in counting of fruits nine/vine with the length of the fruit -11 cm, the inside fruit was found to be 9 cm and the yield of fruit was around -1435 g/vine with the applicability of 30 t FYM along with 35 kilo in gram nitrogen per ha as compared to control in cucumber. They also noticed significantly less number of days to appearance of I flower of female breed -30 and narrower sex ratio-6- with the utilization of FYM(Farmyard manure)-30 t/ha along with 35 kilo in gram of nitrogen per ha as compared to FYM and nitrogen applicable at particular level in cucumber.

Surlekov and Rankov (1989) performed experiments on capsicum mentioned in his work that plant height of around 58.6 cm and emergence of branches was 3.2 with the utilization of farmyard manure at t=20 per every hectare along with 100:80:100 kg N, P_2O_5 and K_2O per ha in the crop of capsicum.

Damke *et al.*, (1988)performed experiments on chilli found out that huge plant height 60.3 cm and therefore, the yield in chilli (1.52 t/ha) with the provision of FYM at 9 t per ha along with 50:50:50 kg of N, P_2O5 and K_2O per ha.

Chatterjee *et al*., (1979) reported essentiality of the nutrient of FYM when calculated was found to be to be 0.63%- per cent N, 0.07 % P and 0.29 % K. Whereas, **Sharma and Mitra (1989)**recorded that FYM (Farmyard Manure) having 26.1 % of Carbon, 1.71 per cent N, 0.24 per cent P and 2.04 percent K on the basis of dry weight. Theratio of C: N was made to 15:1 and the amount of nutrient given or utilized was observed to be in the range 2.4 t per ha FYM were 42.8, 5.9 and 51.1 kilo for grams N, P and K per hectares in unit.

2.2 Effect of FYM on quality parameters

Vijayakumari *et al*., (2007) carried out a study to assess the impact of organic manures on the yield of carrot. The tuber diameter and weight were maximum in $N:P_2O_5:K_2O$ treated pots whereas, carotenoid content and β-carotene contents were maximum in FYM treated pots @ 17.50 g per tonne at TNAU, Coimbatore.

Santosh kumar and Shashidhara (2006) reported from their study on integrated nutrient management in chilli genotypes that the application of FYM @ 10 t per ha along with RDF increased oleoresin content and yield by 16.97 per cent and 124.23 kg per ha, respectively over 100 per cent RDF alone (14.53 per cent and 87.50 kg/ha, respectively).

Deshmukh *et al*. (2005) conducted a field experiment during kharif 2000 to evaluate the response of integrated use of inorganic fertilizers, FYM and PSB alone and in combination on nutrient availability, grain, energy and protein yields and economic feasibility of soybean. Results revealed that application of FYM @ 2.50 t per ha along with RDF (20:40:20 kg N, P2O5, K2O/ha) increased the protein yield (502.30 kg/ha) of soybean compared to RDF (422.77 kg/ha) .

Rajshree *et al*. (2005) reported that the application of FYM @ 7.50 t per ha along with 50 kg per ha nitrogen and 30 kg per ha phosphorus recorded higher protein and oil content (33.32 and 19.35%, respectively) over control and RDF (32.86 and 19.32 % protein and oil content, respectively) in soybean under soybean based cropping system.

Patil *et al*., (2004) conducted an experiment to study the effect of organic and inorganic fertilizers on growth, yield and quality of tomato. Application of FYM (50%) along with half RDF recorded maximum number of fruits per ton and the highest fruit yield, fruit juice, TSS and ascorbic acid content over 100 per cent RDF.

Sutagundi (2000) noticed significantly higher 100 seed weight (0.6 g) with the application of FYM (10 t/ha) along with NPK (100:50:50 kg/ha) as compared to their individual application in chilli.

Shashidhara (2000) reported higher seed weight (5.84 g) by applying FYM (5 t/ha) + 50 per cent RDF compared to 50 per cent RDF alone (5.02 g) in chilli.

Sendur *et al*., (1998)worked out on tomato revealed that, application of organic manure such as FYM, Azospirillum and phosphorus along with recommended dose of fertilizer recorded maximum total soluble solids, ascorbic acid and lycopene content in tomato.

Kumaran *et al*., (1998) reported that quality parameters such as ascorbic acid and lycopene contents were comparatively higher in tomato with best combination of FYM at 15 per tonne, 150:100:50 kg NPK per ha along with biofertilizer (phosphobacteria).

Chavan *et al*., (1997) performed experiments on chilli and recorded higher ascorbic acid when N was applied at 75 kg per ha through FYM and 7 kg per ha through urea in chilli.

Chavan *et al*., (1997)conducted experiments on chilli and ascorbic acid content of chilli (88 mg 100 g1) was increased when nitrogen was applied through FYM and urea compared to fertilizer alone.

Venkatesh (1995) carried out experiments on tomato and grapes and recorded higher TSS was notice with plots received FYM and Azospirillum in tomato and grapes.

Ravindran and Balanambisan (1987) worked on potato and reported that the starch content of potato increased with the increased rate of application of organics viz., FYM @ 5 t per ha (72.50%) and FYM @ 10 t per ha (75 %).

Petkov (1964) performed experiments on capsicum and reported that application of half rotten FYM along with inorganic forms of N, P and K increased the ascorbic acid content of the capsicum fruits.

2.3 Effect of organic fertilizers on development of okra

Abdullah *et al*. (2010) conducted an experiment at University of Guyana, Georgetown focusing on recycling organic waste using vermitechnology and use of vermicompost and vermiwash obtained from the vermitech in varied combinations for exploring the effect on soil and productivity of okra in Guyana. The soil quality was monitored during the experiment along with plant growth parameters of okra. The study revealed that combination organic fertilizers, vermicompost and vermiwash combination compared with control and chemical fertilizers had great influence on plant growth parameters. The average yield of okra during trial showed a significantly greater response in comparison with the control by 64.27%. The fruits were found to have a greater percentage of fats and protein content when compared with those grown with chemical fertilizers by 23.86 and 19.86% respectively.

Alam *et al*., (2007) evaluated the effect of vermicompost and NPKS fertilizers on growth and yield of red amaranth. Application of vermicompost and NPKS significantly influenced the growth and yield of red amaranth. Application of 10 t per ha vermicompost showed better growth and yield than 100% NPKS in red amaranth.

Reddy and Reddy (2005) studied the effect of different levels of vermicompost (0, 10, 20 and 30 t/ha) and nitrogen fertilizer (0, 50, 100, 150 and 200 kg/ha) on the growth and yield of onion (Cv. N - 53). Plant height, number of leaves per plant, leaf area, bulb length, diameter and weight and yield of onion increased significantly with increasing levels of vermicompost from 10 – 30 t per ha and nitrogen fertilizer from 50 – 200 kg/ha.

Das *et al*., (2002) found that application of vermicompost in integrated form in green gram increased the dry matter content, pod yield, plant height, and leaf area and also flowering was earlier by 7 days.

Subbarao *et al*., (2001) reported that the application of vermicompost along with NPK (100:60:60 kg/ha) recorded significantly higher fruit length (10.2 cm), number of fruits per plant (14.3) as compared to NPK alone (8.8 cm, 14.0 and 9.64 t/ha, respectively) in brinjal.

Sreenivas *et al*., (2000) recorded significantly higher fruit weight (225.0 g) and fruit yield (2.03 kg/vine) with the application of vermicompost (10 t/ha) along with 50 per cent RDF (50:25:25 kg N, P_2O_5 and K_2O) in ridge gourd.

Ushakumari *et al*., (1999) carried out a field experiment on amending soils with vermicomposts in conjunction or combination with recommended inorganic fertilizers. Vermicompost applied at the rate of 12 t per ha to field soils together with 100% or 75% of the recommended application rate of inorganic fertilizers significantly increased yields of okra.

Reddy *et al*., (1998) observed that application of 10 t vermicompost + 100% recommended NPK increased the plant height at harvest, days to initial flowering and number of branches per plant, number of pods, number of seeds per pod and yield in pea. Fresh and dry weight and yield of cowpea was higher in soil amended with vermicompost **(Karmegam and Daniel, 2000).**

Pawar *et al*., (1996) observed that the inclusion of vermicompost (2.5 t/ha) along with 100 per cent RDF resulted in additional chilli yield of 1.68 q per ha.

Ushakumari *et al*., (1996) showed that 26 per cent increase in yield of bhindi with the application of vermicompost at the rate of 12 t per ha along with full or 3/4th of the RDF over application of only RDF.

Patil (1995) noticed maximum plant height in onion with the application of vermicompost at 75 and 95 days after planting.

Patil (1995) concluded that number of leaves per plant in potato significantly increased with vermicompost and 50 per cent of recommended dose of fertilizer as compared to control. Application of vermicompost (4 t/ha) along with 50 per cent RDF significantly increased the potato yield (34 t/ha) as compared to control (14.2 t/ha).

Integrated nutrient management on commercial vegetables studied by **Patil (1995)** revealed that the combination of RDF (100:75:100 NPK kg/ha) + 50 per cent recommended dose of vermicompost (2.5 ton/ha) recorded significantly higher number of tomato fruits per plant and average fruit weight over absolute control, RDF, FYM and vermicompost alone but was on par with combined application of organic and inorganic fertilizers.

The complex organic residues are biodegraded by symbiotic association between earthworm and microbes during this process vermicompost or vermicastings are produced. The vermicast apart from increasing the density of microbes also provides sufficient energy for them to remain active. Vermicasting can provide the required nutrients to the plants. It provides the vital macro elements such as N, P_2O_5, K_2O, Ca and Mg and micronutrients such as Fe, Mo, Zn, and Cu etc. The chemical analysis of vermicompost reveals that, the percent N, P_2O_5, K_2O content was 0.8, 1.1 and 0.5 respectively **(Giraddi, 1993).** The vermicompost not only contains higher nitrate nitrogen at the beginning, but it also has greater nitrifying capacity in the corresponding soil. Nitrogen production from mucus, dead earthworm tissue and vermicast amounted to 180 kg per ha per year.

Haung*et al*., (1987) revealed that application of vermin compost (6.5 t/ha) increased vine length (7.0 cm) and decreased the internodal length (7.4 cm) over control in cucumber.

Bano and Kale (1987) reported that the application of vermicompost along with chemical fertilizer was recorded higher yield of brinjal and radish. Application of vermicompost in cucumber increased the yield by 42.5 per cent over control **(Huang and Zhao, 1987).**

Kale *et al*., (1987) observed an increase in number of inflorescence per plant as well as early flowering in salvia.

2.4 Effect of biofertilizers

Kucey *et al*., (1989) reported that, insoluble inorganic phosphate compounds are made available to the plants when PSM alone was inoculated into soil. Phosphorus solubilization in soil under green house or field conditions is much more difficult to prove than solubilization of P in solution culture, but due to the addition of PSM to soil several studies shown that there are plant growth responses

The cost of inorganic fertilizers has been increasing to an extent that they are out of reach of the poor and small farmers. It has become impractical to apply such costly input for a crop of marginal returns. The use of biofertilizers in such situation is therefore, a practically paying proposal. P-solubilizers are biofertilizers which solubilize the phosphorus in soil and make it available for plants. It has been reported to be beneficial and economical on several crops. They improve the growth, yield quality as well as the productivity of the crop.

Effect of inoculation of phosphate solubilizers on plant growth and yield **Geresten (1948)** for the first time demonstrated the increased uptake of P and enhanced grain yield due to inoculation of seedlings with PSM or PSB. Since then, beneficial effect of inoculation of soil with PSM or PSB along with application of insoluble forms of P sources such as rock phosphate, tricalcium phosphate and bone meal has been reported in plant species **(Ahmed and Jha, 1968; Loheuarete and Berthelin, 1988).**

Kandasamy *et al.* (1985) Reported that in Chilles according to an increase in seedling length in chilli (19.7 cm) and brinjal (14.9 cm) was observed when soil was inoculated with mycorrhiza and 20 hosphor bacteria in nursery.

Kundu *et al*. (1984) Noticed that inoculation of rice seedlings with mixed cultures of Azotobacter, rice, Pseudomonas striata and Aspergillus awamori increased grain and straw yield and uptake of N and p under greenhouse condition.

K**halafallah *et al*., (1982)** reported that increased P uptake and plant growth has been reported increased in various crops inoculated with phosphate solubilizing microorganisms.

Raj *et al*., (1981) observed that increased plant height and P uptake by finger millet and also increased p availability in soil by inoculating the crop with Bacillus circulars and applying 32 P labelled super phosphate and tricalcium phosphate under greenhouse condition

Basavana (1980) stated that the phosphorus concentration, total phosphorus uptake and the dry matter of maize plant increased on application of rock phosphate with P solubilizing bacteria and fungi.

2.5 Effect of nitrogen, phosphorus and potassium on growth, yield parameters

Khetran *et al*., (2017) a field study was conducted at Vegetable Seed Production Farm Quetta to examine the effect of different doses of NPK fertilizers on seed yield of okra. The experiment was randomized complete block design. There were five treatments and four replications. Data showed that yield of green pods per plant increased with the increase of fertilizers while data regarding number of seed/pod showed the significant difference among all means. M5 occupied the highest while M_1 lowest position. Data regarding seed yield per plant showed highly significant results from table of analysis of variance. Mean values indicated that M_5 and M_3 stood at per likewise, M_4 and M_2 behaved same. M_5 got position at top while M_1 stood at the bottom in which, no dose of fertilizer was used. Furthermore, there had no effect of NPK fertilizers with different levels to increase the weight at 1000-seeds.

Meena *et al*.,(2017) determined that minimum days (39.73) required for opening flower from sowing were recorded under application of 90 kg N + 60 kg P_2O_5+ 60 K_2O ha-1, followed by application of 90 kg Nitrogen ha-1 (41.22 days), whereas the maximum days (44.21) were noted under absolute control. Similarly, the Plant height was recorded the maximum under application of 90 kg N + 60 kg P_2O_5+ 60 K_2O ha-1, after 40 days (28.10 cm), 60 days (75.40 cm) and 80 days (106 cm) and seed germination (91.96 %).

Amongst fruit characters the maximum length of fruits (13.93 cm), diameter of fruits (2.6 cm), fruit yield plant-1 (258.18 g) and number of fruits plant-1 (30.54) were recorded under application of 90 kg N + 60 kg P_2O_5 + 60K_2O kg ha-1 . The maximum yield (172.12 q ha-1) was obtained under application of 90 kg N + 60 kg P2O5 + 60 K2O ha-1 followed by application of 90 kg N + 60 P2O5 ha-1 (163.12 q ha-1) and the maximum number of seeds fruit-1 was recorded (56.46) under application of 90 kg N + 60 kg P2O5 + 60 K2O ha-1 . Application of 90 kg N + 60 kg P2O5 + 60 K_2O ha-1 recorded significantly higher net returns (123084.10 Rs ha-1) and B: C ratio (2.13) which was found statistically superior over other treatments.

Khetran *et al., (*2016) reported that a trial was conducted on okra at Vegetable Seed Production Farm Quetta to investigate the effect of different doses of NPK fertilizers on growth of okra. The experiment was Randomized complete block design. There were five treatments and four replications. Total experimental units were 20 (including control in which there was no fertilizer application). Data regarding height of plant revealed that M_5 had significant superiority over other means. M_5 was at the top position and M_1 was at the bottom because there was no application of fertilizers. Analysis of variance regarding number of flowers per plant indicated highly significant results for fertilizer treatments for this factor of study. It was also noted from that with increase of fertilizer applications, number of flower increased accordingly while results expressed the more the fertilizer better length of green pods. K is needed for good quality.

Pal *et al*., (2016) performed experiment on okra they found that if the herb yield evaluated and weighed and ranked according to the treatments, we found that the economically viable150 kg urea,250 kg phosphorus and 150 kg Potash per hectare could be recommended for obtaining 19200 kg of green herb yield ha-1. In case N fertilization is necessary according to soil testing, recommendations should be followed.

Philip *et al.*, (2010) performed experiment on chilli and they found that the treatment was be performed in the replicates to obtain a total of 48 plots in sub categories .result obtained gave the interpretation that yield components such as the total amount of fruit present over the stem per sample significant effect on that growth was obtained in DAS at 2008 .The total number of fruits per Individual plants showed significant interactions fresh weight per hectare were also observed.

Feroz *et al.,* (2009) reported that the highest yield (16.73 t/ha) was obtained from 100 kg N/ha, which was statistically identical to 120 kg per hectare. In case of phosphorus, the highest yield of 15.77 t/ha was obtained from 120 kg P_2O_5 / ha and was closely followed by the dose of 100 kg P/ha (4.73 t/ha).

Considering the treatments combination, the highest yield (19.22 t/ha) was produced by N-100 and P-120 and there were no significant variations among N-100 P-100, N-120 P-100 and N-120 P-120. The highest gross return (Tk.193200) and net return (Tk.146l40) were obtained from N-100 and P-120. The B:CR was also higher (4.08) under the same treatments combination.

Mishra *et al*., (2009) reported that an experiment was conducted on okra cv. VRO-6 at Indian Institute of Vegetable Research, Varanasi during summer season of 2006-07 and 2007-08. The results revealed significant improvement in all the growth and yield parameters over recommended dose of N P K. The maximum length of fruit, diameter of fruit, fresh weight of fruit, dry weight of fruit and yield was recorded with application of vermicompost @ 2.5 t/ha+ NPK (120:60:60 kg/ha)+PSB+ Azotobacter over rest of the treatments. The maximum net profit Rs 40,332.53 and cost: benefit ratio 1:1.06 was recorded under the source treatment.

Dharmatti. (1986) performed experiments on bell pepper and chilli they found that maximum seed yield of bell pepper (84.89 kg/ha) at 200:112.5:75 kg NPK per ha. **Belichki. (1988)** recorded more number of fruits per plant (43.30 bell prepared chilli with application of N, P and K each at 320:320 and 80 kg per ha, respectively.

Pandey *et al.*,(1980) observed significantly higher number of fruits per plant (15), fruit length (12.5 cm) and fruit girth (5.2 cm) with the application of 120:50 kg nitrogen and phosphorus per hectare over control in okra.

Sutapradia (1979) examined the effect of combination of manure and NPK (complex fertilizer, 15:15:15) on the growth of tomatoes. The study revealed that combination of manure at 30 ton/ha and NPK at 100 kg per ha gave highest yield in tomatoes.

2.6 Effect of Vermicompost on the crop development of Okra

Kumar *et al.,* (2018) performed experiment on okra and found that the treatments comprised of NPK, Azospirillum, PSB and VAM including control. Result raveled that under floral characters, 100% RDF + VAM resulted minimum days to 1st (39.60) and 50% flowering (42.20) and for yield attributes minimum days to 1 st edible fruit harvesting (46.60) was recorded under 100% RDF + VAM and 100% RDF + PSB recorded for maximum fruit length (11.56 cm) whereas, maximum fruit diameter (1.92 cm), fresh fruit weight (14.20 g), number of fruits/plant (18.80), fruit yield/plant (266.96 g) and maximum fruit yield/hectare (131.83 q) was recorded under 100% RDF + Azospirillum

Rathava *et al., (*2018) studied of okra plant they found in present investigation that application of 100 per cent RDF significantly increased number of pod per plant (9.12), yield per plant (137.91g), yield per plot (2.80kg)and yield per hectare (115.06q) and days taken to last picking (103.54). Application of Azotobacter @ 20 ml/kg seed increased number of pod per plant (8.40), yield per plot (2.75kg) and yield per hectare (113.26q) whereas, combined application of Azotobacter + PSB @ 20 ml/kg seed should be significantly increased yield per plant (133.68g) and days taken to last picking (101.60). The application of 100 per cent RDF and combined application of Azotobacter @ 20 ml/kg seed should be significantly increased the gross return, net return and benefit cost ratio in okra cv. GAO_5 during Kharif season. This was actually benefit to cost ratio.

Rekha *et al*., (2018) performed experiments on capcicum and reported that 50% of vermicompost was compared with plant growth enhancers on the exo-morphological features of *C. annuum*. A significant plant growth was recorded in plants treated with Vermicompost. The present study aims to promote soil health and its plant growth providing effects further substantiating the use of organic amendments instead of fertilizers. Vermicompost contains a combination of macro- and micro-nutrients and the uptake of the nutrients has a positive effect on plant nutrition, growth, photosynthesis and chlorophyll content of the leaves.

Yadav *et al.,(*2017) in a report mentioned application of cent kg N ha -1 (T_3 or T_3)amalgamated raised and superb two of the growth attributes viz., .height of plant at

30 and 60 DAS and at harvest, amount of branches in each plant, leaf area, chlorophyll content and yield attributes like (number of fruits, on the each fruit length, the weight of fruit, yield of fruit per plant and per plot number one and fruit yield ha-1 as compared to control (T_0), 60 kg(T_1) and 80 kg N ha-1 (T_2). Similarly, results also showed that application of vermicompost @ 5 t ha-1 + Azotobacter significantly increased the above growth and yield attributes as compared to rest of treatments. Application of 100 kg Nha-1 with vermicompost @ 5 t ha-1 + Azoctobacter proved the best treatment combination in terms of fruit yield, fruits yield ha-1 in comparison to the treatments combinations.

Akbasova *et al.*, (2015)performed experiment on okra and potato beet and found that the effect and influence of vermicompost which was derived on the criteria of manure obtained from camel, yield and quality of potatoes and beets was investigated. The raise of crop yield from roots which was in between 1.5-2.5 which contributed in the formation of grey soil at the rate of 8t/hectare. The inference came out that vermicompost as biofertilizer showed superrise, as it possess higher quality of nitrogen potassium and phosphorus and naturally developed humid acids when brought in comparison with the conventional or older ways of compost to conventional compost. Vermicompost has a direct physiological effect on plants; it stimulates the development of root systems and reduces the harmful effects of pollutants.

Shama and Gogoi (2015) designed a study of okra to understand the effects of different soil organic amendments on germination and seedling vigour of Okra (*Abelmoschus esculentus* L.). Five treatments with organic amendments (farmyard manure, vermicompost and biochar) and mineral fertilizers were designed in randomized block design with three replications. Results showed that organic amendments significantly enhanced per cent seed germination and emergence speed index compared to inorganic fertilizer. Highest homogeneity of seed germination (CV_{gt} = 20.74) was observed in vermicompost. Plant height, root length and leaf area were higher in vermicompost and biochar than farmyard manure. Both allocation of biomass to above ground parts and Dickson quality index were highest in seedlings from the plots amended with vermicompost. The study revealed that compared to biochar, vermicompost and farmyard manure significantly enhanced the germination and growth of okra seedling, but the stimulation was best in vermicompost-amended plots.

Sahu *et al.,* (2014) reported that the experiment of okra plant was conducted in a Randomized Block Design with ten treatments and replicated thrice. The treatments include different biofertilizers (Azospirillum, Azotobacter and PSB) with inorganic fertilizers (N, P, and K). The results showed that application of PSB along with Azotobacter and full dose of nitrogen, potash and half dose of phosphorus resulted significantly vigorous growth and also increased yield of okra.

Indra kumar Singh *et al*., (2009) reported In this investigation, vermicompost treatment (T_2) recorded the highest in all observations except germination (Gm), height of plant (HT), number of leaves per plant (NL), length of leaves (LL), width of leaves (WL), number of pods per plant (NPP), length of root (LR), number of Nodules (NN) over the all other treatments.

Surindra Suthar (2009) reported the garlic very favorable effect of compost made from vermi kind of manure and farm yard manure which has been relatively composted This action was performed by the combination of several of the fertilizers which are actually responsible for good growth Farm yield manure, on the field of Garlic (*Allium stivum L.*).

Altogether six experimental plots were prepared: T_1 (the esteemed growth of NPK), T_2 (the compost formed by vemification which was performed at the 15/hectare), T_3(20 t per ha vermicompost), T_4 (15 t per ha vermicompost + 50% NPK), T_5 (15 t per ha farmyard manure), and T_6 (farmyard manure 15 t per ha + 100% recommended NPK) to test the plant production patterns, under field conditions. The highest range of some plant parameters i.e. root length, shoot length, leaf length, fruit weight, number of cloves in garlic fruit and number of leaves per plant was in the T_4 treatment plot. Also, the average fruit weight was approximately 26.4 % greater in T_4 than recommended NPK treatment plot (T_1).

Omtoso *et al., (*2007) performed experiment on okra and found that NPK fertilizers LD88 were treated with the different levels of N, P, K –Fertilizer rate – which was 0,150 and 300 kg NPK ha^{-1} and two different methods of fertilizer application included ring and band method as major considerable factors .The result indicated that the fertilizers N, P, K significantly helped in the enhancement of growth parameters and the method of ring application appeared more appropriate.

2.7 Integrated use of organic inorganic fertilizers and biofertilizers for crop development of Okra

Bamborita *et al*. (2018) performed an experiment on okra and found that vermicompost @ 6 t ha-1 significantly increased yield plant-1 (311.46 g), ha-1 (141.48 q) and picking-1 (6.11 kg) of okra. However, among the quality parameters the highest protein (1.97%) content and the lowest crude fiber content (1.54%) of fruit recorded under vermicompost which was at par with poultry manure.

The highest nitrogen (0.315%), phosphorus (0.653%) and potassium (1.761%) content and uptake of nitrogen (45.81 kg ha-1), phosphorus (93.91 kg ha-1) and potassium (253.28 kg ha-1) also observed in vermicompost closely followed by poultry manure treatment. The maximum net returns (Rs 205928 ha-1) were obtained with vermicompost whereas poultry manure was superior in Benefit-cost ratio with the value 3.01. Among different biofertilizers combined use of Azospirillum+PSB recorded significantly higher yield (326.01 g plant-1, 134.91 q ha-1 and 5.83 kg picking-1) quality parameters (protein %); nitrogen, phosphorus, potassium content and uptake; net returns (` 207634 ha-1) and Benefitcost ratio (3.36) of okra and the lowest crude fibre. Whereas superior values regarding the yields observed in the treatments receiving the combination of vermicompost @ 6 t ha-1 and Azospirillum+PSB.

Ghosh *et al*., (2018) reported in the experiment comprised of seven treatments viz., T_1-Control, T_2- 100% NPK, T_3- 50 % vermicompost + 50 % NPK (chemical fertilizer), T_4- 50 % FYM + 50 % NPK (chemical fertilizer), T_5- Biochar + 50 % NPK (chemical fertilizer), T_6- Azotobacter liquid bio-fertilizer + 50 % NPK (chemical fertilizer) and T_7- Zinc Solubilizing Bacteria liquid bio-fertilizer + 50 % NPK (chemical l fertilizer) which were replicated thrice. Number of fruits per plant, fruit length (cm), average fruit weight (g), fruit per plant (kg) and yield (t ha-1) were recorded maximum with treatment T_3 (50 % vermicompost + 50 % NPK).

Anand *et al*., (2016) reported that poultry manure and neem cake along with inorganic fertilizer i.e. urea and their various combination levels on the yield performance of okra. Eleven treatments were arranged in randomized block design with three replications. The vegetative growth parameters and yield of okra var.- Parbhani Kranti was significantly influenced due to different sources of nitrogen. The maximum values of growth parameters like Plant height 101.51 cm, number of leaves 14.94, leaf area 282 cm^2, number of branches 2.20 number of nodes (19.86) per plant and yield 159.12 q ha1 were recorded in the treatment of 60% N through neem cake and 40% N through urea. The keeping quality of fruits was significantly varies among the treatments and storage conditions used. The maximum keeping quality was 4.27, 4.67 and 5.13 days were found in open bag, paper bag and polythene bags of storage conditions respectively in the treatment of $T_{11.}$

Amran *et al*., (2014) mentioned in a combination that T_1-V_1-NOH-15-without (FYM), the another one included T_2 -V_1- NOH-15,+Farm yard manure (FYM)15 t /ha, T_3 (V_1(NOH-15) + Farmyard manure (FYM) 25 t /ha), T_4 (V2 (SONAL) without FYM), T_5 (V_2(SONAL) + Farmyard manure (FYM 15 t /ha), T_6 (V_2 (SONAL) + Farmyard manure(FYM 25 t /ha), T_7 (V_3(OH -2324) without (FYM), T_8 -V_3-OH -2324,+ Farmyard manure(FYM 15 t /ha) and T_9 -V_3 -OH -2324, + Farmyard manure (FYM) 25 t /ha) . The least Days for enhancement of growth 3.69 was with treatment T_5 (SONAL+FYM fifteen tone/ha), The highest T.S.S. (^{0}Brix) recorded in the T_6 was estimated as (2.84), the highest possible number of leaves was (49.35), The highest no of branches that was observed in the okra plant was -2.80, The paramount median number of fruit per plant was23.15, The maximum average fresh weight of fruit was (12.43 g), The maximum fruit yield per plant was (287.61 g) the paramount average of fruit yield / ha was in values 16.25 t./ha The paramount content of acid (ascorbic) was made to be -15.58 mg in the total of 100 g highest of height of plant that could have been observed was -127.6 cm, and which were then amalgamated to the height of –T_9-OH-2324 +25 t/ha FYM , It was the finest outcome of the yield of okra.

Gulshan *et al*.,(2013)performed an experiment which comprised of 60 pots with two different cultivars which were named as “SabzPari” and “Super Green” of okra species which possessed 5 replicas and followed by 3 treated crops for respective species and to that six harvests.. The growth parameters number of leaves

68.01±37.43 and leaf area 70.74±31.87 of cultivar “Super green” was showed maximum response in manure than cultivar “Sabzpari” 8.11±1.34 and 8.19±5.60, respectively. The vegetative growth of Okra cultivars were showed significant response in different concentration of animals manure. Significant variations were found in between the treatments and the different levels of growth harvest (P≥000). Moreover the germination response of weeds was also significantly increased with the concentration of animal manure

Mal *et al.*, (2013) Performed experiment on okra and found that the effect of diazotrophsan fertilizers on yield attributing characters and economics of okra cultivation was evaluated. Application of highest dose of NPK @100% in combination with vermicompost (5 t ha−1) and biofertilizers with FYM increased the fruit yield of okra (cultivar Mahyco-10) considerably with yield varying between 80.00 q ha−1 to 227.13 q ha−1 and 80.49 q ha−1 to 229.62 q ha−1 during 2010 and 2011 respectively. In okra cv. Utkal Gaurav the fruit yield varied from 47.68 q ha−1 to 129.84 q ha−1 in 2010 and 47.27 q ha−1 to 131.35 q ha−1 in 2011.

Ibrahim *et al.*,(2011) conducted the experiments during the 2010 and 2011 cropping seasons to investigate the effect of farmyard manure and weeding regimes on the growth and yield of okra. The study was a factorial experiment laid out in split plot design, replicated three times. Farmyard manure was assigned as main plot treatments, while weeding regimes was assigned as sub plot treatments. Parameters measured included plant height, number of leaves plant, number of branches plant, leaf area plant, number of pods plant, pod yield plant and pod yield harvest. The results revealed that these parameters increased significantly with an increase in first treatments of both farmyard manure and weeding regimes. The significant increases were attributed to availability of nutrients as well as appropriate timing of weeding which reduced the negative influence of weeds in the field. Higher growth and yield parameters were observed in plots treated with 12 t ha of farmyard 1 manure and 3 weeding regimes. Therefore, application of 12 t ha of farmyard manure and 3 weeding regimes 1 which significantly enhanced growth and yield of okra is recommended to our farmers.

Subramanian *et al.*, (2000) in his work found inference that FYM and sun temperature in the fertilizer schedule not only increased the yield but also improved the soil moisture storage at 31, 31.3 and 31. 6 per cent at decreasing soil depths with 15 cm of downward gaps.

Respiratory processes could be enhanced by the process direct utilization of Farmyard manure which actually helps by acting upon the cell permeability, they also trigger hormonal growth cell permeability or by hormone growth action. It is a key which provides the amount of nitrogen phosphorus and Sulphur content in the forms which are available to give normal provision of decompositions .Alternatively, it provides improvisation of the physical properties to soil such as of soil which includes aggregation, and capacity to hold water **(Chandramohan, 2002).**

Chatterjee *et al*., (1979) reported essentiality of the nutrient of FYM when calculated was found to be to be 0.63%- per cent N, 0.07 % P and 0.29 % K. Whereas, **Sharma and Mitra (1989)** recorded that FYM (Farmyard manure) having 26.1 % of Carbon, 1.71 per cent N, 0.24 per cent P and 2.04 per cent K on the basis of dry weight. Theratio C: N was made to 15:1 and the amount of nutrient given or utilized was observed to be in the range 2.4 t per ha FYM were 42.8, 5.9 and 51.1 kilo for grams N, P and K per hectares in unit.

2.8 Effect of FYM on growth and yield components

Harish (2011) worked on brinjal and found the effect of organic nutrient management in brinjal and reported that maximum plant height was recorded in treatment RDF + FYM. (60.2 And 74.0 cm, respectively) both at 60 and 90 DAP. Treatment RDF + FYM recorded maximum number of branches (14.6 and 23.3 branches/ plant), number of leaves (66.8 and 93.2 leaves/ plant), leaf area (142.3 and 167.1 $cm^{2)}$, dry matter production (13.8 and 17.8 g), number of fruits per plant (undamaged) (30.2) and maximum fruit yield (25.5 t/ ha).

Singh (2004) carried out experiments on okra conducted an experiment on integrated nutrient management in okra cultivar P-7. The treatment having FYM + dense organic manure in combinations of all pesticides gave highest yield with good protein content, prolonged shelf life, highest net profit/unit area and per rupee investment over the others. However, treatment having bio - fertilizer + dense organic manure gave highest vitamin C content and low nitrate level in marketable produce.

Paramasivan *et al.*,(2003) conducted experiments on okra reported that assessed the effect of organic manures and inorganic fertilizers on yield and economics of okra. The treatment FYM @ 25 t per ha + CCP (composted coir pith) @ 12.5 t per ha + vermicompost (1.5 t/ha) + 40:50:30 kg per ha NPK recorded maximum number of branches (3.5), early in days to 50 per cent flowering (45.4) and maximum number of fruits per plant (9.9).This was due to integration of organic and inorganic nutrients resulting in better translocation of nutrients under optimum moisture condition of soil leading to availability of nutrients and increased photosynthetic activity etc.

Premsekhars *et al.* (2003) performed experiments on okra conducted field experiments to study the influence of different organic manures on the growth, yield and quality of okra var Arka Anamika. The experiments were conducted in a randomized block design and replicated thrice with eleven treatments involving different organic manures along with no manure control. The results showed that FYM 20 t per ha recorded the highest yield of 10.39 t per ha with the BC ratio of 3.56. The crude fiber content of fruits under this treatment was also less when compared to control ratio 13.6

Nanthakumar and Veeraragavathatham (2001) Performed experiments onbrinjal recorded significantly higher fruit yield (26.8 t/ha) with application of 100:100:100 kg NPK and 12.5 t FYM per ha as compared to 75:75:100 kg NPK per ha alone (20.1 t/ha) in brinjal.

Rekha and Gopalakrishnan (2001) Performed experiments on bitter ground and reported that, longest (26.7 cm) and thickest (17.5 cm) fruits were recorded by FYM (25 t/ha) with inorganic fertilizers (70:25:25 kg NPK/ha) in bitter gourd.

Renuka and Ravisankar (2001) Performed experiments on tomato reported that integrated application of FYM (15 t/ha) with NPK (120:70:70 kg/ha) resulted significantly higher number of branches (3.66) as compared to their individual fertilizer application in tomato.

Rekha and Gopalkrishnan (2001) Performed experiments on bitter ground reported that application of organic manures alone (FYM) recorded minimum vine length (5.80 cm) and number of branches per plant (12). While, the treatment which received an additional dose of inorganic fertilizers (70:25:50 kg NPK/ha) recorded maximum vine length (7.10 m) and number of branches (18) in bitter gourd.

Sahoo and Panda (2000) carried out an experiment on maize, chilli and recorded higher seed yield (3269 kg/ha) with the application of N, P_2O_5, K_2O at 80, 40, 40 kg along with FYM at 5 t per ha compared to control (1323 kg/ha) and inorganic fertilizers (3036 kg/ha) alone in maize

Sutagundi (2000) Performed experiments on flower chilli reported that early flowering (43.66 days) was recorded in plant receiving FYM (10 t/ha) as compared to 100:50:50 kg NPK per ha (43.75 days) in chilli.

Sutagundi (2000) Performed experiments on chilli and noticed significantly higher 100 seed weight (0.6 g) with application of FYM (10 t/ha) along with NPK (100:50:50 kg/ha) as compared to their individual application in chilli.

Shashidhara (2000) Performed experiments on chilli and reported higher seed weight (5.84 g) by applying FYM (5 t/ha) + 50 per cent RDF compared to 50 per cent RDF alone (5.02 g) in chilli.

Naidu *et al*., (1999) Performed experiments on okra and observed higher number of fruits per plant (24.3) and fruit yield (149 q/ha) with the application of 80:60:50 kg NPK per ha in addition to 20 t FYM per ha. It was significantly superior over control (17.3 and 100 q respectively) in okra.

Nirmala and Vadivel (1999) Performed experiments on cucumber reported significant rise in counting of fruits nine/vine with the length of the fruit 11 cm, the inside fruit was found to be 9 cam and the yield of fruit was around 1435 g/vine with the applicability of 30 t FYM along with 35 kilo in gram nitrogen per ha as compared to control in cucumber. They also noticed significantly less number of days to appearance of I flower of female breed -30 and narrower sex ratio-6- with the utilization of FYM(Farmyard manure) 30 t/ha along with 35 kilo in gram of nitrogen per ha as compared to FYM and nitrogen applicable at particular level in cucumber.

Surlekov and Rankov (1989) Performed experiments on chilli and mentioned in his work that plant height of around 58.6 cm and emergence of branches was 3.2 with the utilization of farmyard manure at t=20 per every hectare along with100:80:100 kg N, P_2O_5 and K_2O per ha in the crop of capsicum.

Damke *et al.*, (1988) Performed experiments on chilli and found out that huge plant height 60.3 cm and therefore the yield in chilli(1.52 t/ha) with the provision of FYM at 9 t per ha along with 50:50:50 kg of N, P_2O5 and K_2O per ha.

2.9 Effect of FYM on quality parameters

Vijayakumari *et al.*, *(*2007) performed experiments on carrot carried out a study to assess the impact of organic manures on the yield of carrot. The tuber diameter and weight were maximum in N:P_2O_5:K_2O treated pots whereas; carotenoid content and β-carotene contents were maximum in FYM treated pots @ 17.50 g per tonne at TNAU, Coimbatore.

Santoshkumar and Shashidhara (2006) conducted experiments on chilli reported from there on integrated nutrient management in chilli genotypes that the application of FYM @ 10 t per ha along with RDF increased oleoresin content and yield by 16.97 per cent and 124.23 kg per ha, respectively over 100 per cent RDF alone (14.53 per cent and 87.50 kg/ha, respectively).

Deshmukh *et al*., (2005)carried out the experiments on soybean conducted a field experiment during kharif 2000 to evaluate the response of integrated use of inorganic fertilizers, FYM and PSB alone and in combination on nutrient availability, grain, energy and protein yields and economic feasibility of soybean. Results revealed that application of FYM @ 2.50 t per ha along with RDF (20:40:20 kg N, P2O5, K2O/ha) increased the protein yield (502.30 kg/ha) of soybean compared to RDF (422.77 kg/ha).

Rajshree*et al*., (2005) performed experiments on soybean reported that the application of FYM @ 7.50 t per ha along with 50 kg per ha nitrogen and 30 kg per ha phosphorus recorded higher protein and oil content (33.32 and 19.35%, respectively) over control and RDF (32.86 and 19.32 % protein and oil content, respectively) in soybean under soybean based cropping system.

Shashidhara (2000) performed experiments on chilli reported higher seed weight (5.84 g) by applying FYM (5 t/ha) + 50 per cent RDF compared to 50 per cent RDF alone (5.02 g) in chili. Patil *et al*. (2004) conducted an experiment to study the effect of organic and inorganic fertilizers on growth, yield and quality of tomato. Application of FYM (50%) along with half RDF recorded maximum number of fruits per tonne and the highest fruit yield, fruit juice, TSS and ascorbic acid content over 100 per cent RDF.

Sutagundi (2000) performed experiments on chilli noticed significantly higher 100 seed weight (0.6 g) with the application of FYM (10 t/ha) along with NPK (100:50:50 kg/ha) as compared to their individual application in chill.

Kumaran *et al*., (1998) performed experiments on tomato reported that quality parameters such as ascorbic acid and lycopene contents were comparatively higher in tomato with best combination of FYM at 15 per tonne, 150:100:50 kg NPK per ha along with biofertilizer (phosphobacteria).

Sendur *et al*., (1998) revealed that, application of organic manure such as FYM, Azospirillum and phosphorus along with recommended dose of fertilizer recorded maximum total soluble solids, ascorbic acid and lycopene content in tomato.

Chavan *et al*., (1997)performed experiments on chilli recorded higher ascorbic acid when N was applied at 75 kg per ha through FYM and 7 kg per ha through urea in chilli.

Chavan *et al*., (1997) performed experiments on chilli Ascorbic acid content of chilli (88 mg 100 g1) was increased when nitrogen was applied through FYM and urea compared to fertilizer alone.

Venkatesh (1995) performed experiments on tomato and grapes reported higher TSS was notice with plots received FYM and Azospirillum in tomato and grapes, respectively.

Ravindran and Balanambisan (1987) performed experiments on potato reported that the starch content of potato increased with the increased rate of application of organics viz., FYM @ 5 t per ha (72.50%) and FYM @ 10 t per ha (75 %).

Petkov (1964) reported that application of half rotten FYM along with in organic forms of N, P and K increased the ascorbic acid content of the capsicum fruits.

2.10 Effect of organic fertilizers on development of okra

Abdullah *et al*., (2010) conducted an experiment at University of Guyana, Georgetown focusing on recycling organic waste using vermitechnology and use of vermicompost and vermiwash obtained from the vermitech in varied combinations for exploring the effect on soil and productivity of Okra in Guyana. The soil quality was monitored during the experiment along with plant growth parameters of Okra. The study revealed that combination organic fertilizers, vermicompost and vermiwash combination compared with control and chemical fertilizers had great influence on plant growth parameters. The average yield of okra during trial showed a significantly greater response in comparison with the control by 64.27%. The fruits were found to have a greater percentage of fats and protein content when compared with those grown with chemical fertilizers by 23.86 and 19.86% respectively.

Alam *et al*., (2007) evaluated the effect of vermicompost and NPKS fertilizers on growth and yield of red amaranth. Application of vermicompost and NPKS significantly influenced the growth and yield of red amaranth. Application of 10 t per ha vermicompost showed better growth and yield than 100% NPKS in red amaranth.

Reddy and Reddy (2005) studied the effect of different levels of vermicompost (0, 10, 20 and 30 t/ha) and nitrogen fertilizer (0, 50, 100, 150 and 200 kg/ha) on the growth and yield of onion (Cv. N - 53). Plant height, number of leaves per plant, leaf area, bulb length, diameter and weight and yield of onion increased significantly with increasing levels of vermicompost from 10 – 30 t per ha and nitrogen fertilizer from 50 – 200 kg/ha.

Das *et al*., (2002) found that application of vermicompost in integrated form in green gram increased the dry matter content, pod yield, plant height, and leaf area and also flowering was increased.

Subbarao *et al*., (2001) performed experiments on brinjal reported that the application of vermicompost along with NPK (100:60:60 kg/ha) recorded significantly higher fruit length (10.2 cm), number of fruits per plant (14.3) as compared to NPK alone (8.8 cm, 14.0 and 9.64 t/ha, respectively) in brinjal.

Sreenivas *et al*., (2000) performed experiments on ridge gourd recorded significantly higher fruit weight (225.0 g) and fruit yield (2.03 kg/vine) with the application of vermicompost (10 t/ha) along with 50 per cent RDF (50:25:25 kg N, P_2O_5 and K_2O) in ridge gourd.

Ushakumari *et al*., (1999) performed experiments on okra carried out a field experiment on amending soils with vermicomposts in conjunction or combination with recommended inorganic fertilizers. Vermicompost applied at the rate of 12 t per ha to field soils together with 100% or 75% of the recommended application rate of inorganic fertilizers significantly increased yields of okra.

Rama Chandra reddy *et al*., (1998) observed that application of 10 t vermicompost + 100% recommended NPK increased the plant height at harvest, days to initial flowering and number of branches per plant, number of pods, number of seeds per pod and yield in pea. Fresh and dry weight and yield of cowpea was higher in soil amended with vermicompost **(Karmegam and Daniel, 2000).**

Pawar *et al*., (1996) conducted experiments on chilli observed that the inclusion of vermicompost (2.5 t/ha) along with 100 per cent RDF resulted in additional chilli yield of 1.68 q per ha.

Ushakumari *et al*., (1996)) carried out the experiments on okra and showed that 26 per cent increase in yield of bhindi with the application of vermicompost at the rate of 12 t per ha along with full or 3/4th of the RDF over application of only RDF.

Patil (1995) noticed maximum plant height in onion with the application of vermicompost at 75 and 95 days after planting.

Patil (1995) performed experiments on potato concluded that number of leaves per plant in potato significantly increased with vermicompost and 50 per cent of recommended dose of fertilizer as compared to control. Application of vermicompost (4 t/ha) along with 50 per cent RDF significantly increased the potato yield (34 t/ha) as compared to control (14.2 t/ha).

Integrated nutrient management on commercial vegetables studied by **Patil (1995)** revealed that the combination of RDF (100:75:100 NPK kg/ha) + 50 per cent recommended dose of vermicompost (2.5 ton/ha) recorded significantly higher number of potato fruits per plant and average fruit weight over absolute control, RDF, FYM and vermicompost alone but was on par with combined application of organic and inorganic fertilizers.

The complex organic residues are biodegraded by symbiotic association between earthworm and microbes during this process vermicompost or vermicastings are produced. The vermicast apart from increasing the density of microbes also provides sufficient energy for them to remain active. Vermicasting can provide the required nutrients to the plants. It provides the vital macro elements such as N, P_2O_5, K_2O, Ca and Mg and micronutrients such as Fe, Mo, Zn, Cu etc. The chemical analysis of vermicompost reveals that, the per cent N, P_2O_5, K_2O content was 0.8, 1.1 and 0.5 respectively **(Giraddi, 1993).** The vermicompost not only contains higher nitrate nitrogen at the beginning, but it also has greater nitrifying capacity in the corresponding soil. Nitrogen production from mucus, dead earthworm tissue and vermicasts amounted to 180 kg per ha per year.

Bano and Kale (1987) reported that the application of vermicompost along with chemical fertilizer recorded higher yield of brinjal and radish. Application of vermicompost in cucumber increased the yield by 42.5 per cent over control **(Huang and Zhao, 1987).**

Haung *et al*., (1987)) performed experiments on cucumber repeated that application of vermin compost (6.5 t/ha) increased vine length (7.0 cm) and decreased the internodal length (7.4 cm) over control in cucumber.

2.11 Effect of biofertilizers

The cost of inorganic fertilizers has been increasing to an extent that they are out of reach of the poor and small farmers. It has become impractical to apply such costly input for a crop of marginal returns. The use of biofertilizers in such situation is therefore a practically paying proposal. P-solubilizers are biofertilizers which solubilize the phosphorus in soil and make it available for plants. It has been reported to be beneficial and economical on several crops. They improved the growth, yield as well as the productivity of the crop.

Department of Horticulture, Haryana (2018) reported that vegetables are most important component of a balanced diet and act as a protective food. India occupies a prime position in the world in vegetable production and 2nd largest producer of vegetable next to china. India produces about 7905000 million tons of vegetables from an area 465000 million hectares, and productivity 17t/h.

Yasin *et al.*,(2012) mentioned in their work that crop plants necessitate vital nutrients like Phosphorus and nitrogen for their enhancement and development. They mentioned through their work that biofertilizers can tremendously decrease the need or utilization of synthetic fertilizers without hampering the yield of crop. Bio-fertilizers possess extraordinary tendency for decreasing the essentiality of artificial or lab made fertilizers without compromising on crop yield. Bio-fertilizers contain plant growth promoting rhizobacteria (PGPR) viz; Azotobacter, Azospirillum and phosphorus solubilizing bacteria (PSB) i.e. Pseudomonas sp. and Bacillus sp. having the ability of atmospheric nitrogen fixing and solubilizing the soil phosphorus, respectively. Consequently, they fulfill the nitrogen and phosphorus requirement of cereals and also improved the soil fertility. So the utilization of nitrogen fixing and phosphorus solubilizes bacteria as bio-fertilization has gigantic potential for using the atmospheric nitrogen and making use of fixed phosphorus present in the soil in crop production without causing any harmful effects on aerial and soil environment. Bio-fertilizers are more economical due to their low market prices comparing synthetic fertilizers, helpful in improving soil structure and the restoration of environment for leveraging agriculture.

Bhatt *et al.*, (2010) reported that Bio fertilizers are mainly constituted of selected living cells of microbes which provide the plants with nutrients through their root system. The microbes in these fertilizers use different mechanisms to provide nutrients to the plants. They are capable of nitrogen fixing, phosphate solubilizing, phosphate mobilizing, and promotion of rhizobacteria.

Mahato*et al.*, (2009) reported that among the biofertilizers, 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.

Besides nitrogen fixation, Azotobacter also produces thiamin, 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 Azotobacteria enhances plant growth is not yet fully understood. Three possible mechanisms have been proposed: N2 fixation; delivering combined nitrogen to the plant; the production of phytohormone-like substances that alter plant growth and morphology, and bacterial nitrate reduction, which increases nitrogen accumulation in inoculated plants [42]

Effect of inoculation of phosphate solubilizers on plant growth and yield **Geresten (1948)** for the first time demonstrated the increased uptake of P and grain yield due to inoculation of seedlings with PSM. Since then, beneficial effect of inoculation of soil with PSM along with application of insoluble forms of P sources such as rock phosphate, tricalcium phosphate and bone meal has been reported in plant species **(Ahmed and Jha, 1968; Loheuarete and Berthelin, 1988).**

Kucey *et al*., (1989) reported that, insoluble inorganic phosphate compounds are made available to the plants when PSM alone was inoculated into soil. Phosphorus solubilization in soil under green house or field conditions is much more difficult to prove than solubilization of P in solution culture, but due to the addition of PSM to soil several studies shown that there are plant growth responses.

Kundu *et al*., (1984) noticed that inoculation of rice seedlings with mixed cultures of Azotobacter chroococcum, Pseudomonas striata and Aspergillus awamori increased grain and straw yield and uptake of N and p under greenhouse condition.

An increase in seedling length in chilli (19.7 cm) and brinjal (14.9 cm) was observed when soil was inoculated with mycorrhiza and phosphobacteria in nursery **(Kandasamy *et al*., 1985).**

K**halafallah *et al*., (1982)** reported that increased P uptake and plant growth has been reported in various crops inoculated with phosphate solubilizing microorganisms.

Raj *et al*., (1981) observed that increased plant height and P uptake by finger millet and also increased p availability in soil by inoculating the crop with Bacillus circulans and applying 32 P labeled super phosphate and tricalcium phosphate under greenhouse condition.

Basavana (1980) stated that the phosphorus concentration, total phosphorus uptake and the dry matter of maize plant increased on application of rock phosphate with P solubilizing bacteria and fungi.

Effect of nitrogen, phosphorus and potassium on growth, yield parameters

Dharmatti. (1986) reported the maximum seed yield of bell pepper (84.89 kg/ha) at 200:112.5:75 kg NPK per ha. **Belichki. (1988)** recorded more number of fruits per plant (43.30) in chili with application of N, P and K each at 320:320 and 80 kg per ha, respectively.

Pandey *et al*.,(1980) observed significantly higher number of fruits per plant (15), fruit length (12.5 cm) and fruit girth (5.2 cm) with the application of 120:50 kg nitrogen and phosphorus per hectare over control in okra.

Sutapradia (1979) examined the effect of combination of manure and NPK (complex fertilizer, 15:15:15) on the growth of tomatoes. The study revealed that combination of manure at 30 ton/ha and NPK at 100 kg per ha gave highest yield in tomatoes.

2.12 Effect of vermicompost on the crop development of okra

Yadav *et al*., *(*2017) in a report mentioned application of cent kg N ha -1 (T3)amalgamated raised and superb two of the growth attributes viz., height of plant at 30,60 DAS and at harvest, amount of branches in each plant, leaf area, chlorophyll content and yield attributes like (Number of fruits, on the each fruit length, the weight of fruit, yield of fruit on plot number one and fruit yield ha-1 as compared to control (T0), 60 kg(T1) and 80 kg N ha-1 (T2). Similarly, results also showed that application of vermicompost @ 5 t ha-1 + Azotobacter significantly increased the above growth and yield attributes as compared to rest of treatments. Application of 100 kg Nha-1 with vermicompost @ 5 t ha-1 + Azoctobacter proved the best treatment combination in terms of fruit yield per plot, fruits yield ha-1 in comparison to other treatment combinations.

Akbasova *et al*., (2015) reported that the effect and influence of vermicompost which was derived on the criteria of manure obtained from camel, yield and quality of potatoes and beets was investigated. The raise of crop yield from roots which was in between 1.5-2.5 which contributed in the formation of grey soil at the rate 0f 8t/hectare .the inference came out that vermicompost as biofertilizer showed superbrise, as it possess higher quality of nitrogen potassium and phosphorus and naturally developed humid acids when brought in comparison with the conventional or older ways of compost to conventional compost. Vermicompost has a direct physiological effect on plants; it stimulates the development of root systems and reduces the harmful effects of pollutants.

Suthar *et al*., (2005) observed the highest values for seed yield, seed recovery percentage, test weight, seed vigour index and standard germination percentage were higher under 10th June planting and N:P:K:Zn at the rate of 125:62.5:62.5:25 kg per ha, respectively than other treatments in brinjal Cv. BR-112.

Prabhu *et al*., (2003) reported that increased N and P rates increased the root lengths when N:P at 200:100 kg per ha was applied in brinjal hybrid COBH-1.

Majumdar and Gupta (2000) estimated that about 50% of the fertilizer leaches down into the soil and has started showing its effects on human health in the form of diseases such as methemoglobinemia in children.

Materials and Methods

Research is too see what everybody else has seen, and to think what nobody else has thought.

Chapter III

Materials & Methods

An evaluation based experimentation entitled "Studies on Effect of Organic, Inorganic and Biofertilizer on growth, Yield and Quality traits of Okra [*Abelmoschus esculentus* (L.) Moench.] was conducted during the year 2016-2017 and also in the year 2017-2018. The experiment was carried out at the Horticulture Research Farm-II of the Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow.

This chapter gives a contingent picture of the methods and materials utilized and experimental techniques adopted during the entire course of investigation. The climatic and edaphic condition prevailing there in during the crop period has also been mentioned at suitable place with befitting diagrams and tables. The details of the methodology adopted in this investigation have been presented under following heads.

3.1 Location of the experiment

The scrutiny under above topic was performed at the Horticulture Research Farm –II of the Department of Horticulture, Baba Saheb Bhimrao Ambedkar University, Vidya Vihar, RaeBareli Road, Lucknow (U.P) India. The experimental field is located approximately 10 Km from Lucknow railway station charbagh on the Rae Bareli Road towards the South City of the Lucknow. It is also well connected by Bijnaur-Kanpur Road. It is situated at 26.7697^0N and 80.9262^0E .The region lies 111 m above the sea level.

3.2 Climatic and weather conditions

Subtropical climate prevails in Lucknow region of Uttar Pradesh where actually the research activity was carried out**.** Both the extreme weather conditions (summers and winters) are experienced by the city. The city experiences the moderate rainfall in some months of year. **Lucknow** has a humid subtropical **climate** with cool, dry winters from mid- November to February and dry, hot summers from late March to June. ... Summers are extremely hot with **temperatures** ranging from 40 °C .

Meteorological Data for the for the year 2016-2017 and 2017-2018

Table 3.1 Average meteorological Data for the year 2016-2017

Period		Mean temperature (°C)		Relative Humidity (%)		Wind velocity(km\hr)	Total Rainfall (mm)
Month	**Day**	**Maximum**	**Minimum**	**Maximum**	**Minimum**		
JULY-AUGUST 2016	**30 to 05**	33.00	25.60	94.00	69.00	2.00	0.00
	06 to 12	33.90	26.30	91.00	71.00	2.80	0.00
	13 to 19	32.10	25.50	88.00	79.50	2.60	0.00
	20 to 26	34.70	25.30	88.00	72.00	2.70	0.00
AUGUST- SEPT 2016	**27 to 02**	34.60	25.11	91.00	72.00	1.60	0.00
	03 to 09	33.30	25.90	87.00	60.00	4.80	0.00
	10 to 16	33.30	25.30	91.00	73.00	2.00	0.00
	17 to 23	33.40	25.50	95.00	79.00	1.20	0.00
Oct-16	**01 to 07**	35.20	25.20	96.00	66.00	1.30	0.00
	08 to 14	33.40	24.90	94.00	62.00	1.30	0.00
	15 to 21.	33.20	21.80	83.00	52.00	1.60	0.00
	22 to 25	33.00	17.90	95.00	39.00	0.90	0.00
OCT-NOV 2016	**26 to 04**	31.30	16.50	95.00	34.00	1.50	0.00
	05 to 11	28.90	14.00	97.00	35.00	0.70	0.00
	12 to 18	29.00	12.80	96.00	47.00	1.20	0.00
	19 to 25	28.00	11.70	97.00	37.00	0.90	0.00
NOV - DEC 2016	**26 to 02**	26.90	11.20	94.00	38.00	1.40	0.00
	03 to 09	20.50	10.60	95.00	58.00	1.00	0.00
	10 to 16	22.20	10.60	98.00	76.00	1.00	0.00
	17 to 23	23.60	8.80	99.00	58.00	0.90	0.00

Period		Mean temperature (°C)		Relative Humidity (%)		Wind velocity(km\hr)	Total Rainfall (mm)
Month	**Day**	**Maximum**	**Minimum**	**Maximum**	**Minimum**		
	24 to 31	22.20	8.10	96.00	76.00	1.30	0.00
Jan-17	**01 to 07**	19.60	9.10	97.00	58.00	0.90	0.00
	08 to 14	20.20	9.40	97.00	46.00	1.10	0.00
	15 to 21.	22.40	5.50	92.00	66.00	1.80	0.00
	22 to 28	25.90	5.70	95.00	75.00	1.70	0.00
JAN - FEB 2017	**29 to 04**	23.10	9.80	95.00	42.00	2.00	0.00
	05 to 11	25.60	8.60	96.00	41.00	1.70	0.00
	12 to 18	26.10	9.90	93.00	43.00	3.40	0.00
	19 to 25	28.90	10.00	96.00	54.00	1.60	0.00
FEB- MAR 2017	**26 to 04**	30.00	12.50	82.00	39.00	4.20	0.00
	05 to 11	28.90	12.70	74.00	42.00	40.00	0.60
	12 to 18	28.40	13.40	67.00	30.00	4.10	0.70
	19 to 25	33.40	11.10	65.00	24.00	4.70	0.00
MAR -APR 2017	**26 to 01**	38.20	17.00	54.00	33.00	4.10	0.00
	02 to 08	38.70	19.30	72.00	23.00	5.30	0.00
	09 to 15	37.30	21.80	52.00	24.00	2.20	0.00
	16 to 22	38.70	18.60	72.00	20.00	4.90	0.00
	23 to 30	38.70	24.40	51.00	17.00	4.20	0.00

Table 3.2 Average meteorological Data for the year 2017-2018

Period		Mean temperature (°C)		Relative Humidity (%)		Wind velocity(km\hr)	Total Rainfall (mm)
Month	**Day**	**Maximum**	**Minimum**	**Maximum**	**Minimum**		
JULY-AUGUST 2017	**30 to 05**	33.00	25.60	94.00	69.00	2.00	0.00
	06 to 12	33.90	26.30	91.00	71.00	2.80	0.00
	13 to 19	32.10	25.50	88.00	79.50	2.60	0.00
	20 to 26	34.70	25.30	88.00	72.00	2.70	0.00
AUGUST- SEPT 2017	**27 to 02**	34.60	25.11	91.00	72.00	1.60	0.00
	03 to 09	33.30	25.90	87.00	60.00	4.80	0.00
	10 to 16	33.30	25.30	91.00	73.00	2.00	0.00
	17 to 23	33.40	25.50	95.00	79.00	1.20	0.00
Oct-17	**01 to 07**	35.20	25.20	96.00	66.00	1.30	0.00
	08 to 14	33.40	24.90	94.00	62.00	1.30	0.00
	15 to 21.	33.20	21.80	83.00	52.00	1.60	0.00
	22 to 25	33.00	17.90	95.00	39.00	0.90	0.00
OCT-NOV 2017	**26 to 04**	31.30	16.50	95.00	34.00	1.50	0.00
	05 to 11	28.90	14.00	97.00	35.00	0.70	0.00
	12 to 18	29.00	12.80	96.00	47.00	1.20	0.00
	19 to 25	28.00	11.70	97.00	37.00	0.90	0.00
NOV - DEC 2017	**26 to 02**	26.90	11.20	94.00	38.00	1.40	0.00
	03 to 09	20.50	10.60	95.00	58.00	1.00	0.00
	10 to 16	22.20	10.60	98.00	76.00	1.00	0.00
	17 to 23	23.60	8.80	99.00	58.00	0.90	0.00
	24 to 31	22.20	8.10	96.00	76.00	1.30	0.00

Period		Mean temperature (°C)		Relative Humidity (%)		Wind velocity(km\hr)	Total Rainfall (mm)
Month	Day	Maximum	Minimum	Maximum	Minimum		
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	08 to 14	20.20	9.40	97.00	46.00	1.10	0.00
	15 to 21.	22.40	5.50	92.00	66.00	1.80	0.00
	22 to 28	25.90	5.70	95.00	75.00	1.70	0.00
JAN - FEB 2018	**29 to 04**	23.10	9.80	95.00	42.00	2.00	0.00
	05 to 11	25.60	8.60	96.00	41.00	1.70	0.00
	12 to 18	26.10	9.90	93.00	43.00	3.40	0.00
	19 to 25	28.90	10.00	96.00	54.00	1.60	0.00
FEB- MAR 2018	**26 to 04**	30.00	12.50	82.00	39.00	4.20	0.00
	05 to 11	28.90	12.70	74.00	42.00	40.00	0.60
	12 to 18	28.40	13.40	67.00	30.00	4.10	0.70
	19 to 25	33.40	11.10	65.00	24.00	4.70	0.00
MAR -APR 2018	**26 to 01**	38.20	17.00	54.00	33.00	4.10	0.00
	02 to 08	38.70	19.30	72.00	23.00	5.30	0.00
	09 to 15	37.30	21.80	52.00	24.00	2.20	0.00
	16 to 22	38.70	18.60	72.00	20.00	4.90	0.00
	23 to 30	38.70	24.40	51.00	17.00	4.20	0.00

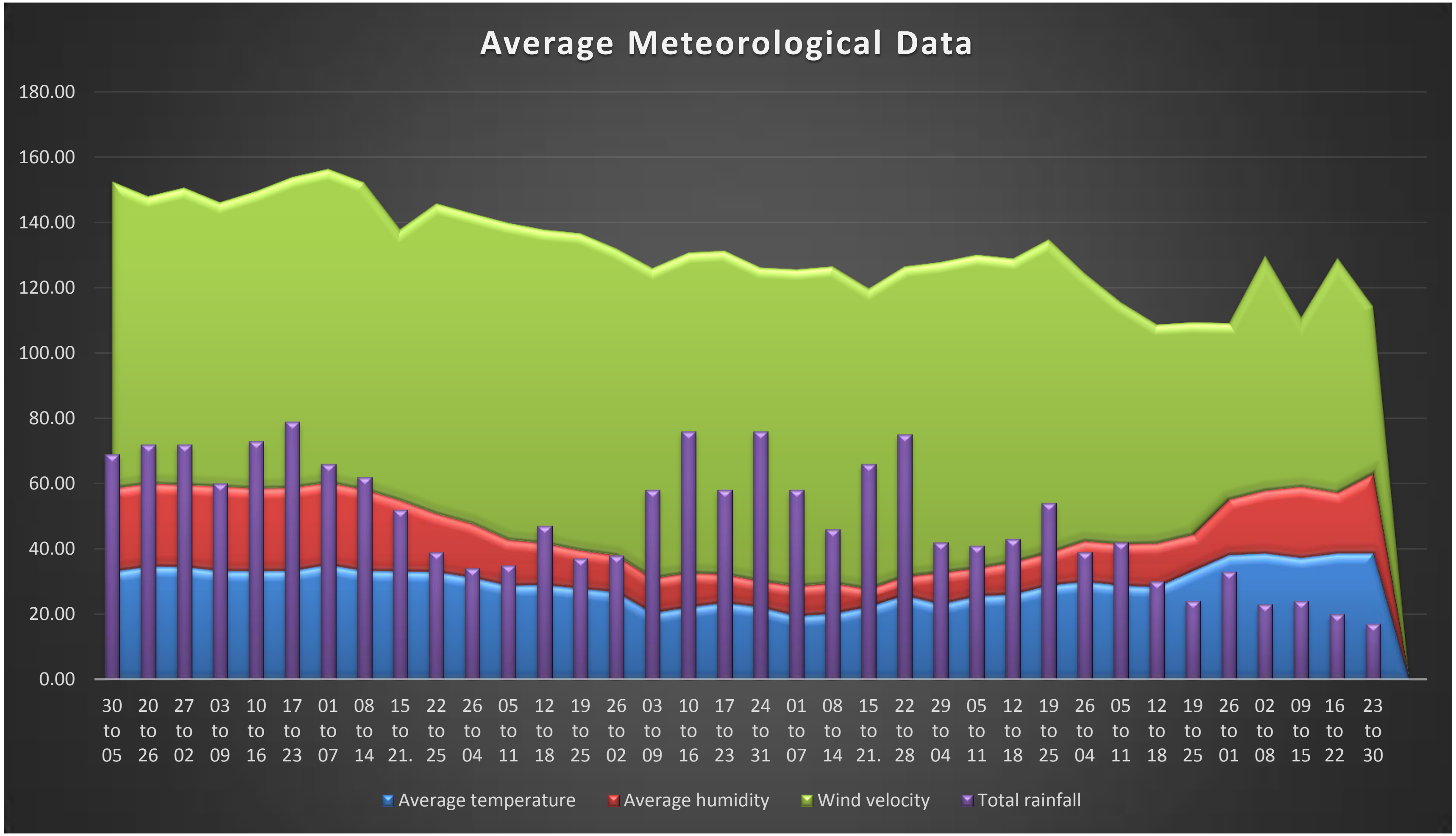


Fig 3.1: Average meteorological data for the year 2016-2017 and 2017-2018

3.3 Physiographic conditions of the experimental site

Water content, salinity, acidity, available nutrients, bulk density is some of the very crucial factors which play an important role in the growth of the plant other than climatic conditions. For this purpose edaphic conditions were monitored. The soil was found to be loamy clay. A mixed soil sample was collected randomly from the okra field at the Horticulture Research Farm –II from the depth of 0-15 cm before incorporating the seeds .These samples were blended together .The representative samples each of 5gms were taken and samples were analysed in the Laboratory of Regional Research Station of Indian Institute of Sugarcane Research Lucknow in order to determine some initial fertility level of the soil. The prominent data on soil analysis and methods employed are descripted in the table below.

Table 3.3: Soil analysis data and methods employed

Soil Properties	**2016-17**	**2014-15**	**Methods Employed**
Bulk Density	1.28	1.32	**Tube Core method (Baruah and Barthakur)**
PH	7.25	7.30	**Jackson (1973)**
Organic carbon	0.35	0.41	**Walkley and Black's rapid titration method (Piper**
Available nitrogen (kg/ha)	372.96	362.27	**Alkaline Potassium permanganate method (Subbiah and Asija,1956)**
Available potassium (kg/ha)	110.18	114.21	**Ammonium acetate (1N)extraction and determination by using Flame photometer (Jackson,1973)**
Sulphur	11.78	12.08	**Tandon (1993)**

3.4 Experimental details

The experiment considered of 16 treatments combinations of organic, inorganic and biofertilizers were tested on okra .The organic manures were applied for 30 days before sowing biofertilizers were applied as soil treatment at the time of sowing and inorganic fertilizers were applied soon at the time of sowing**.**

3.5 Treatment details

The Investigation procedure included ministration of chemical fertilizers, organic manures, and biofertilizers over the land on which the seeds of the okra were to be incorporated. The Recommended Dosage of Fertilizers with combinations of organic and inorganic fertilizers as well as biofertilizers were incorporated to the 48 plots whereas apart from these three plots only constituted either of Vermicompost (V.C.), Farmyard manure (FYM) or Neem Cake. Biofertilizers such as Azotobacter (Azo),Phosphate solubilizing bacteria (PSB) and Vesicular Arbuscular Mycorrhizae(VAM)

3.5.1 Treatments Combinations

Table 3.4: Treatments combinations of study

S.No.	Symbol	Treatments Combinations
1.	T_1	Control
2.	T_2	FYM
3.	T_3	Vermicompost
4.	T_4	Neemcake
5.	T_5	50%RDF+FYM
6.	T_6	50%RDF+Vermicompost
7.	T_7	50%RDF+Neemcake
8.	T_8	75%RDF+FYM
9.	T_9	75%RDF+Vermicompost
10.	T_{10}	75%RDF+Neemcake
11.	T_{11}	50%RDF+Azobacter
12.	T_{12}	50%TDF+PSB
13.	T_{13}	50%RDF+VAM
14.	T_{14}	75%RDF+Azobacter
15.	T_{15}	75%RDF+PSB
16	T_{16}	75%RDF+VAM

Fig 3.4 (A): Field View of the experiment during experimentation course.

Fig 3.4 (B): Initial View of the Layout plan during 2016-2017 and 2017-2018.

Fig 3.4 (c): picture showing the activities of sowing of seeds and view of the field 10-15 days after seed sowing.

3.5.2 Design and Layout

The field Experiment comprised of 16 treatments combinations and conducted in randomized block design with three replications.

3.5.3 Details of Layout

1. Net Plot size-2.40 m*1.5m (3.6m^2)

2. Row to Row distance -60 cm

3. Plant to plant distance -30 cm

3.5.4 Treatment Basis:

The requirement of the RDF for the cultivar, choosing cultivar, the dosage of biofertilizers were some of the building block basis. The idea of these criteria is mentioned below in this table.

Table 3.5: Basis of Treatment

Soil Properties	2016-17	2014-15	Methods Employed
Bulk Density	1.28	1.32	**Tube Core method (Baruah and Barthakur)**
PH	7.25	7.30	**Jackson (1973)**
Organic carbon	0.35	0.41	**Walkley and Black's rapid titration method (Piper**
Available nitrogen (kg/ha)	372.96	362.27	**Alkaline Potassium permanganate method (Subbiah and Asija,1956)**
Available potassium (kg/ha)	110.18	114.21	**Ammonium acetate (1N)extraction and determination by using Flame photometer (Jackson,1973)**
Sulphur	11.78	12.08	**Tandon (1993)**

3.6 Cultural practices

3.6.1 Land preparation

Okra does not exhibit any growth performance in sandy to clay soils therefore area possessing such soil was avoided. The land area with slightly alkaline soil was preferred.

One deep ploughing was performed in the summer which was followed by 2 to 3 light ploughings to obtain the tilt. The level of the land was then maintained after the last ploughing.

3.6.2 Description of okra cultivar

The okra (Kashi Pragati) a standard cultivar was chosen for the experimentation and it was first identified by the Indian Institute of Vegetable Research in the year 2002, The plant type is short intermodal with approximately120-140 cm of height, the fruit colour is dark green while number of ridges on fruits are around 5, number of fruit per plant is generally in the range of 20-25 coming to the fruit, the fruit length is around

11-13 cm while fruit weight and fruit diameter 10-12gm and 1.15-1.40 cm .The used crop variety is disease resistant to YVMV (Yellow vein mosaic virus) and OLCV .

3.6.3 Manure and fertilizers incorporated in land

The manure and fertilizer application although is based upon the seasons, climatic conditions and soil fertility. 20-30 tons of well decomposed FYM was employed 100 Kg/ha of Nitrogen, 60 kg of P_2O_5/ha FYM was thoroughly filled with 50 kg K_2O/ha as this much amount is sufficient. The complete dose of phosphatic and potassic fertilizer and one third dose of nitrogenous fertilizer was applied in the last ploughing. The remaining dose of nitrogenous fertilizer was applied at the last ploughing. In order to avoid leaching losses in the rainy seasons Nitrogen was applied in 4-5 split doses.

3.6.4 Sowing

The seeds of okra were preferably applied 30 cm apart in order to provide more care as it is spring-summer crop; the ridges were made 60 cm apart.

The ridges run south to north and the seeds were sown on the side of the ridge facing the East in accordance of avoiding .

3.6.5 Plant protection and intercultural operations

Seeds which had to be incorporated in the lands were treated with 0.2% bavistin solution which helped them to activate germination procedure and also initially it rescued seedlings from pathogen seedling. The soil was treated with furadan as 20 K.g. a.i./ha (20-22 kg product) which helped it to protect itself against from root-knot nematodes and other pests which effects root and shoots of plant during initial days of its emergence. Wettable sulphur spray was given at the rate of 2gm/litre at fortnight intervals along with bavistin and benlate at the rate of 2gm/l to provide resistance against powdery mildews. To protect blights dithane Z 78 and dithane M 45 was sprayed at the rate of 2gm /L other treatments against insects and pests were provided resistance by 2 ml/l of malathion for sequential 5 days.

3.6.6 Harvesting and threshing

Harvesting was performed in the morning so that hairs on fruit could easily be removed. Fruits were harvested by bending the pedicel with slight jerk. The green colour fresh pods were removed from the plant when their length was observed around 6-8 cm.

3.6.7 Post harvest management

For the sample evaluation 6-8 cm long fruits were sorted out. Longer fruits can be used for fresh markets therefore preferable testing's on these samples actually will entail the correct information**.**

Fig 3.4(D): Picture showing tagging process in the field and data recorded on vegetative parameter.

3.7 Collection of experimental data

Five plants were selected randomly from net plot area in each plot and tagged with a label for recording observations on various growth, yield and quality parameters as per the schedule of observations.

3.7.1 Vegetative Characters and physical attributes

Five plants were selected at random and labelled in each net plot for recording observations on vegetative growth parameters viz., days to germination (50%), days to germination (100%), plant height (cm), stem diameter (cm), number of branches per plant, number of leaves, number of nodes per plant, intermodal length (cm).

i. Days to germination (50%)

The days taken to germination of fruit initiation to half grown in each selected plants of plots were recorded from the date of sowing and expressed as days to germination 50%.

ii. Days to germination (100%)

The days taken days to germination of fruit initiation to fully grown (6-8 cm) in each selected plants of plots were recorded from the date of sowing and expressed as days to germination 100%.

iii. Plant height (cm)

The plant height was measured from ground level to the tip of the main stem at 30, 60 and 90 interval of days after sowing. The average height was computed and expressedin centimetres.

iv. Stem diameter (cm)

The five stems were marked for measuring the stem diameters. The girth was measured at the centre of the stem where the maximum of it could have been calculated with the help of vernier callipers. The mean stem girth was computed and expressed in centimetres.

v. Number of branches per plant

Out of every slot five plants were chosen and their numbers of branches were counted manually and then their average was taken out. Hence the average numbers of branches were obtained.

Vi. Number of leaves per plant

The number of leaves present in five randomly selected and tagged plants was counted manually. The average was worked out and expressed as number of leaves per plant at 30, 60 and 90 days after sowing

VII .Number of nodes per plant

The number of nodes present in five randomly selected and tagged plants was counted manually. The average was worked out and expressed as number of nodes per plant at 30, 60 and 90 days after sowing.

VIII. Internodal Length (cm)

The intermodal length is the length between the two successive nodes. Intermodal length was measured manually in five randomly selected and tagged plants. . The average was worked out and expressed as intermodal length at 90 days after sowing.

3.8 Flowering, fruiting and yield characters

IX. Days to first flowering

The days taken by the plant to produce first flower in each plot was recorded from the date of sowing and expressed as days to first flowering.

X. Days to 50 per cent flowering

The days taken for 50 per cent of the plants to produce first flower in each plot was recorded from the date of sowing and expressed as days to 50 per cent flowering.

XI. Number of fruits per plant

Number of fruits per plants were counted manually on each plot and five plants were chosen to give the count.

XII. Fruit weight (g)

After the harvest from five plants, five fruits were selected at random for recording the weight of the fruit. The weight of the fruit was measured from the tip of fruit to the point of attachment to the pedicel. The mean of five fruits was computed and expressed in cm.

XIII. Fruit Length

After the harvest from five plants, five fruits were selected at random to measure the height of the fruit. The length of the fruit was measured from the tip of fruit to the point of attachment to the pedicel this was done with the cm scale. The mean of five fruits was computed and expressed in cm**.**

XIV. Fruit diameter (cm)

After the harvest from five plants, five fruits were selected at random to measure the diameter of the fruit. The girth of the fruit was gauged from one section in reverse to that point this was done with the help of Verniercallipers. The mean of five fruits was computed and expressed in cm**.**

XV. Days to first picking

The days to first picking were counted from the days they were sowed to day when the fruit of length 6-8 cm were observed the fruits were then given a slight jerk.

XVI. Fruit yield per plant (kg)

After the fruiting was observed the plant appeared with around 5-6 fruit samples onto the stem of the plant five random plants on different plots were chosen on which the number of fruits were observed and computed the average fruiting were noted down.

XVII. Fruit yield per hectare

The numbers of fruits per hectare were counted according the average fruiting per plot and then it was grossly estimated that how many fruit could be present in hectare of area.

XVIII. Number of seeds **per fruit**

The seeds were extracted from the fruits of five earlier randomly tagged plants. The number of seeds from each fruit was counted manually The average number of seeds per fruit was computed and expressed in countings.

Fig 3.4 (E): Observation recorded on various physico-chemical parameters of okra plant

3.9 Bio-chemical aspects

I. T.S.S. (Brix)

II. Ascorbic acid (mg/ 100 gm)

III. Total sugars (%)

IV. Reducing sugar (%)

V. Non reducing sugar (%)

3.10 Bio-chemical aspects

3.10.1 Sample preparation of Okra for various biochemical tests.

A 6-8 cm long fruit sample was taken

↓

The fruit sample was squeezed with the help of the muslin cloth

↓

The extract were collected for further biochemical tests.

3.10.2 TSS (^{0}Brix)

- The Okra was crushed and then was filtered with the help of muslin cloth.
- The filterate was then placed over refract meter.
- Total soluble Solids were measured at room temperature with the help of a Hand (0-32)/Abbe (0-100) refract meter equipped with a % scale.
- Temperature correction was made with 20 ^{0} C as standard temperature.
- The refract meter was properly cleaned after every observation

3.10.3 Ascorbic acid content

Ascorbic acid content was determined with Indophenol method

5ml of standard ascorbic acid was taken and to that 5ml of $HPO_3$the micro burette was filled with the dye. The standard was titrated against the Indophenol until the light pink colour appeared. The dye equivalent was calculated as =0.5/Titre

3.10.4. Preparation of Sample:

10 grams of sample was taken to that 3% MPA was added to make volume of 100 ml. It was mixed thoroughly in case of solids and semi-solids and filter and then centrifuged because it was needed.

Procedure

- 10 grams of okra were taken and it was properly crushed and the extracted with the help of the muslin cloth.
- It was then titrated against sodium 2, 6-dichlorophenol dye.
- The titre value was then noted down.

Calculation

$$\textbf{Ascorbic acid (mg/100 gm)} = \frac{\textbf{Titer x dye equivalent x dillution}}{\textbf{Wt. of the sample}}\textbf{x100}$$

3.10.5 Sugar (%)

Sugar was estimated by the method of Lane and Eynon 1923. Fhatman or estimation of reducing sugar 10 gram of fresh Okra was homogenized in varying blender using distilled water. Filter the mixture with Whatman paper No 40. The final volume was made upto 250 ml. 5ml of Fehling A (containing 34.64gm of crystalline copper sulphate in 500 ml of water) and 5 ml Fehling 13' (containing 173 gm Sodium potassium tartar ate and 50 gram of NaOH 500 ml of water) solution were taken in conical flask and titrated in boiling condition against the Aliquot present in the burette using Methylene blue as a indicator. A brick red colour obtained due to precipitation of cuprous oxide indicates the end point. The volume of the solution was noted for the calculation of reducing sugar. Standardize the 1:1 mixture of Fehling A and Fehling B solution used above 0.2% standard dextrose solution

$$\%\ \textbf{reducing sugar} = \frac{\textbf{mg of dextrose x volume made up}}{\textbf{Titre x weight of sampe taken x 1000}}\textbf{x100}$$

Total sugar and non-reducing sugar

For the total sugar 50 ml of aliquots was mixed with 5 ml of dilute HCL (3:1), water and coc. HCl) and whole mixture was kept overnight for hydrolysis after 24 hours neutralizes, the sample with NaHCO3 and volume was made up to 100 ml filled this into burette and titrated against Fehling A and Fehling B solution as an above for determination of reducing sugar as invert sugar.

% Non –reducing sugar = (% total invert sugar -% reducing sugar)

% Total sugars =% non-reducing sugar +% reducing sugar

3.11 Statistical Analysis

The data hence obtained on various evaluations which were assessed during the two were subjected to statistical analysis by applying the procedure proposed by Gomez and Gomez (1984) .The standard error of mean (SE±)was calculated for each item by study and critical difference (CD) at 5 % level of significance was also worked out for comparative analysis of treatment means, wherever the 'F' test was useful the has been suitably explained with the help of charts and figures.

Experimental Findings

"Torture the data, and it will confess to anything."

"Science makes all its progress, through the exact measurement of mathematical formulae"

Chapter IV

Experimental Findings

The experimental findings obtained from the present investigation entitled " Effect of Organic, Inorganic and Biofertilizers on growth, yield and quality traits of okra [*Abelmoschus esculentus* (l.) Moench.] during the period of experimentations.

The experiments were conducted as per methods embellish in the preceding Chapter. The experimental year of sowing were **2016-2017** and **2017-2018**. The response to different treatments viz., organic, inorganic manures and biofertilizers (control, Farm yard manure, Vermicompost, Neemcake, 50% RDF + Farmyard Manure, 50%RDF + Vermicompost, 50% RDF+Neemcake, 75% RDF + FYM, 75% RDF + Vermicompost, 75% RDF + Neemcake, 50%RDF+Azotobacter, 50% RDF+PSB, 50% RDF+VAM,75% RDF+Azotobacter,75% RDF+PSB, 75% RDF + VAM) is illustrated by using tables and graphs at appropriate places. The experimental findings have been presented in this chapter.

The analysis of variance was carried out for 23 parameters i.e. days to 50 % germination, days to 100 % germination, plant height at 30, 60, 90 DAS, number of leaves per plant at 30, 60, 90 DAS, number of branches per plant at 30, 60, 90 DAS, number of nodes per plant at 30, 60, 90 DAS, intermodal length (cm), days to first flowering, days to 50% flowering, number of fruits per plant, fruit weight (g), fruit length(cm), fruit diameter(cm), days to first picking, number of seeds per fruit, T.S.S (^{0}Brix), ascorbic acid, total sugars, reducing sugar, non-reducing sugar respectively.

4.1 Physical Attributes

4.1.1 Days to germination 50%

The days taken days to germination 50% of fruit initiation to half grown in each selected plants of plots were recorded from the date of sowing and expressed as days to germination50%.The best result of the treatments combinations has been observed under the T_{15}(75% RDF + PSB) followed by T_{14} (75%RDF + Azotobactor) and T_9 (75% RDF + Vermicompost) in both the years of germination 2016-2017 and 2017-

2018. Infact T_{16}(75%RDF + VAM) also shows nearly the similar result .when no combinations were used i.e. control treatment shows the poor result followed by T_4 (Neemcake). T_{15} took minimum days to 50% germination 5.50 and 5.30 during both of the years of experimentation respectively .And control treatment took maximum days 7.00 and 7.10 to days to germination 50% followed by T_4(Neemcake) respectively .

The mean value of the minimum days to 50%germination has been recorded under T_{15} (75%RDF + PSB) and maximum number of days taken to 50 % germination has been noted down in T_1(control).

Table: 4.1 Effect of organic, inorganic and bio- fertilizer on days to 50 % germination as influenced by the treatments

S.No	Treatments	2016-17	2017-18	Pooled
1	T_1 (Control)	7.00	7.10	7.05
2	T_2 (FYM)	6.60	6.40	6.50
3	T_3 (Vermicompost)	6.50	6.30	6.40
4	T_4 (Neemcake)	6.80	6.12	6.46
5	T_5 (50% RDF + FYM)	6.20	6.30	6.25
6	T_6 (50% RDF+ Vermicompost)	6.10	6.00	6.05
7	T_7 (50% RDF+ Neemcake)	6.40	6.50	6.45
8	T_8 (75% RDF +FYM)	5.80	5.90	5.85
9	T_9 (75% RDF+Vermicompost)	5.70	5.50	5.60
10	T_{10} (75% RDF+Neemcake)	6.30	6.80	6.55
11	T_{11} (50% RDF+Azotobactor)	6.00	6.10	6.05
12	T_{12} (50% RDF+PSB)	5.90	5.60	5.75
13	T_{13} (50% RDF+VAM)	6.10	6.20	6.15
14	T_{14} (75% RDF+Azotobactor)	5.60	5.40	5.50
15	T_{15} (75% RDF+PSB)	**5.50**	**5.30**	5.40
16	T_{16} (75% RDF+VAM)	5.80	5.90	5.85
SE(m)		0.30	0.34	0.22
SE(d)		0.42	0.47	0.31
CD(P=0.05)		0.86	0.97	0.63

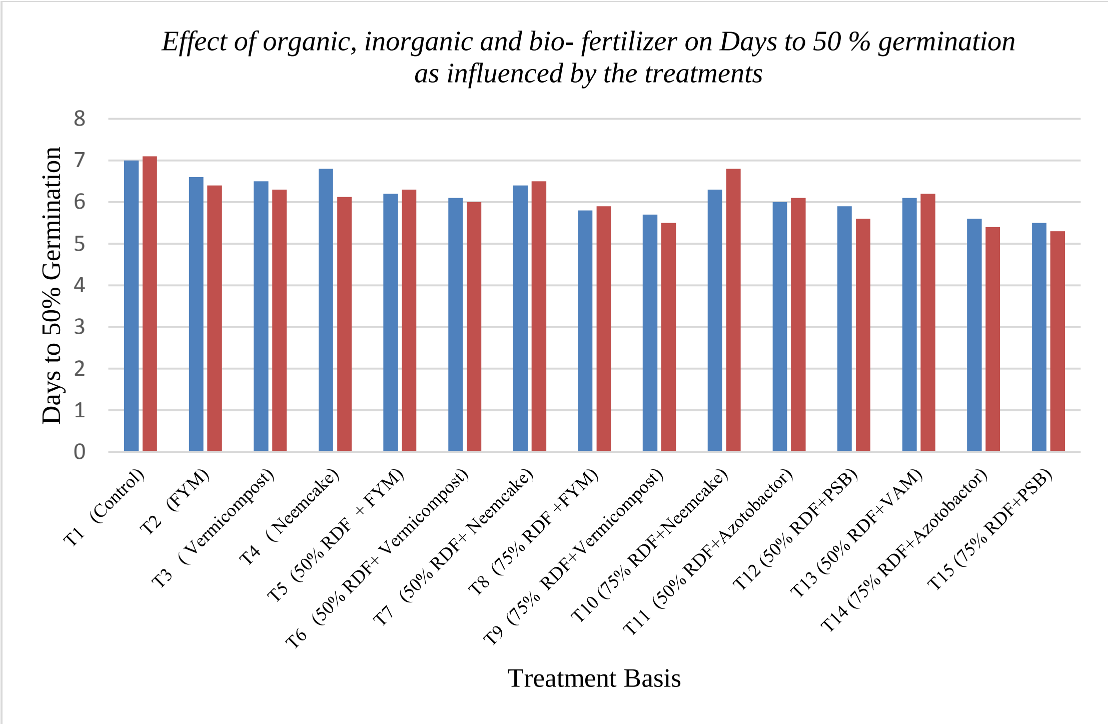


Fig.4.1: Effect of organic, inorganic and bio- fertilizer on Days to 50 % germination as influenced by the treatments

4.1.2 Daysto100 % germination

Days to 100 % germination was observed around 10-11 days of sowing, with the T_{15} (75% RDF + PSB) in both the years 2016-2017 and minimum number of days 10.30 and 10.10 were used by T_{15} (75%RDF+PSB), during both of the years of experimentation respectively .optimum days 13.00 and 13.10 for days to 100 % germination of Okra was achieved by control treatment followed by T_4(Neemcake) during both the years of experimentation respectively .andT_{14}(75%RDF + Azotobactor) nearly took similar amount of durations.

The mean value of the minimum days to 100% germination has been recorded under T_{15} (75% RDF + PSB) and maximum number of days taken to 100 % germination in control.

Table: 4.2 Effect of organic, inorganic and bio-fertilizer on days to 100 % germination as influenced by the treatments.

	Treatments	2016-17	2017-18	Pooled
T_1	Control	**13.00**	**13.10**	**13.05**
T_2	FYM	12.30	12.00	12.15
T_3	Vermicompost	11.80	11.50	11.65
T_4	Neemcake	12.50	12.80	12.65
T_5	50% RDF + FYM	11.40	11.30	11.35
T_6	50% RDF+ Vermicompost	11.20	11.00	11.10
T_7	50% RDF+ Neemcake	11.70	11.80	11.75
T_8	75% RDF +FYM	10.70	10.50	10.60
T_9	75% RDF+Vermicompost	10.50	10.60	10.55
T_{10}	75% RDF+Neemcake	11.50	11.70	11.60
T_{11}	50% RDF+Azotobacter	10.90	10.60	10.75
T_{12}	50% RDF+PSB	10.80	10.50	10.65
T_{13}	50% RDF+VAM	11.10	11.40	11.25
T_{14}	75% RDF+Azotobacter	10.40	10.30	10.35
T_{15}	75% RDF+PSB	**10.30**	**10.10**	**10.20**
T_{16}	75% RDF+VAM	10.60	10.80	10.70
SE(m)		0.50	0.59	0.38
SE(d)		0.70	0.83	0.54
CD(P=0.05)		1.44	1.70	1.07

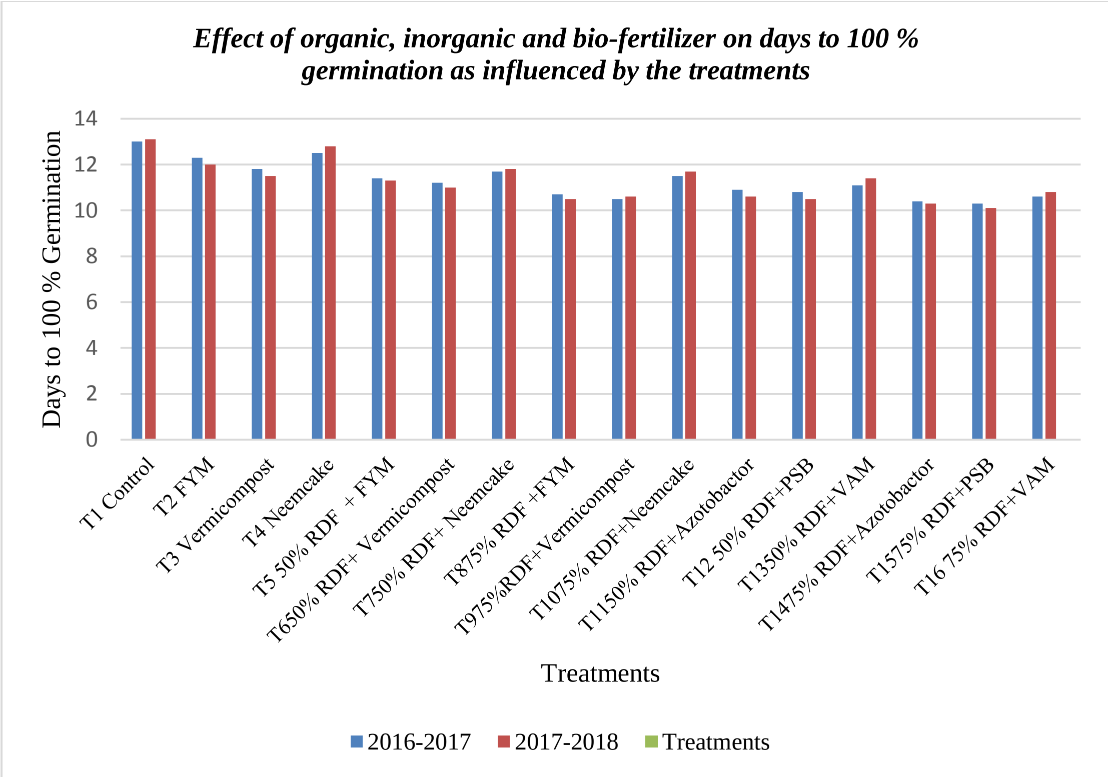


Figure 4.2 Effect of organic, inorganic and bio-fertilizer on Days to 100 % germination as influenced by the treatments

Table: 4.3Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on plant height (cm) at 30 DAS(Days after sowing), 60 DAS, 90 DAS, during the year 2016-2017 and 2017-2018

S.No.	Treatment No.	Treatments	Plant height at 30 DAS			Plant height at 60 DAS			Plant height at 90 DAS		
			2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
1	T_1	Control	28.30	30.33	29.31	52.10	55.10	53.60	87.80	88.00	87.90
2	T_2	FYM	29.00	32. 12	30.56	58.00	61.90	59.95	91.00	92.15	91.57
3	T_3	Vermicompost	31.76	32.97	32.36	59.90	62.30	61.10	91.90	93.30	92.60
4	T_4	Neemcake	28.98	30.15	29.56	56.00	59.25	57.62	89.10	89.90	89.50
5	T_5	50% RDF + FYM	34.12	36.99	35.55	63.24	66.45	64.84	97.00	98.90	97.95
6	T_6	50% RDF+Vermicompost	35.97	38.10	37.03	66.00	69.90	67.95	97.90	98.70	98.30
7	T_7	50% RDF+ Neemcake	32.10	34.54	33.32	60.70	61.00	60.85	92.00	92.90	92.45
8	T_8	75% RDF +FYM	36.89	39.00	37.94	68.90	68.55	68.72	98.00	100.10	99.05
9	T_9	75% RDF+Vermicompost	40.00	42.89	41.44	71.36	75.20	73.28	97.70	100.50	99.10
10	T_{10}	75% RDF+Neemcake	32.35	35.70	34.02	61.00	61.90	61.45	94.15	95.00	94.57

S.No.	Treatment No.	Treatments	Plant height at 30 DAS			Plant height at 60 DAS			Plant height at 90 DAS		
			2016-17	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
11	T_{11}	50% RDF+Azotobactor	35.90	37.12	36.51	67.90	68.90	68.40	95.90	98.50	97.20
12	T_{12}	50% RDF+PSB	36.00	39.80	37.90	68.00	70.12	69.06	96.00	99.20	97.60
13	T_{13}	50% RDF+VAM	34.00	37.00	35.50	66.10	67.12	66.61	94.10	95.00	94.55
14	T_{14}	75% RDF+Azotobactor	41.90	43.20	42.55	71.90	73.89	72.89	98.00	101.10	99.55
15	T_{15}	75% RDF+PSB	**42.40**	**45.10**	**43.75**	**72.00**	**75.80**	**73.90**	**98.90**	**102.20**	**100.55**
16	T_{16}	75% RDF+VAM	37.10	39.15	38.12	70.50	71.90	71.20	98.20	99.90	99.05
SE(m)			0.94	1.16	0.74	1.32	1.56	1.00	1.90	2.12	1.40
SE(d)			1.33	1.64	1.04	1.86	2.20	1.42	2.68	3.00	1.98
CD(P=0.05)			2.72	3.36	2.08	3.81	4.50	2.84	5.48	6.14	3.96

4.3.1 Plant height in (cm) in first 30 days of sowing

Plant height of the selected plants was measured with help of measuring scale in centimeters. So, the maximum plant height 42.40and 45.10 was attained with the combination of T_{15} (75% RDF + PSB) in both the consecutive years 2016-17 and 2017-18, respectively. While the rest gave near about similar results, the second best result was obtained in T_{14}(75%RDF+Azotobacter) while the third best result was given by T_9 (75% RDF+Vermicompost).The minimum plant height 28.30 and 30.33 was attained by the T_1 (control) followed by T_4(Neemcake) during both the years of experimentation respectively . While the suitable application in this procedure was found to be by the application of 75% RDF in addition to the PSB the integrated use of these two have shown much difference in plant height when compared to the control, rest all other gave near about the similar results.

Maximum average plant height at 30 DAS 43.75 during both the years was recorded in treatment combination T_{15} (75% RDF + PSB) and minimum in control.

4.3.2 Plant height in (cm) in first 60 days of sowing

The data recorded on plant height after 60 days of sowing depicted in table 4.3 and graphically represented in figure 4.3 revealed that after 60 days also the result was quite similar to the result of 30 days to sowing 75% additionally with PSB gave the height near about double to 30 days in both the year when the average value was pooled out. This plant height was accompanied by the height of plant of the plot which was provided treatment with T_{14}(75% RDF and Azotobacter.) Maximum plant height 72.00 and 75.80 was observed in T_{15} (75% RDF + PSB), while the minimum plant height 52.10 and 55.10 was recorded in T_1 (control) in both the consecutive years of experimentation .

Mean value 73.90of plant height at 60DAS was recorded highest in T_{15} (75% RDF + PSB) of the both years. And minimum 53.60 pooled value of plant height has been observed in T_1 (control)

4.3.3 Plant height in (cm) in first 90 days of sowing.

Data referred in table 4.3 and figure 4.3 depicted the average plant height after 90 days of sowing No changes were observed from the earlier results 75% RDF and PSB combination was found to be the best one at last day of reading. To plant height the weakest result was shown by the control treatment.

Highest plant heights 98.90 and 102.20 at 90 days after sowing was noted in T_{15} (75% RDF + PSB) and lowest plant heights 87.80 and 88.00 was recorded in T_1 (control) both the years of experimentation respectively .

Highest mean value**100.55** of plant height at 90 days of sowing was recorded in T_{15} (75% RDF + PSB) in both the years .and lowest mean value 87.90 of plant height was noticed in T_1 (control).

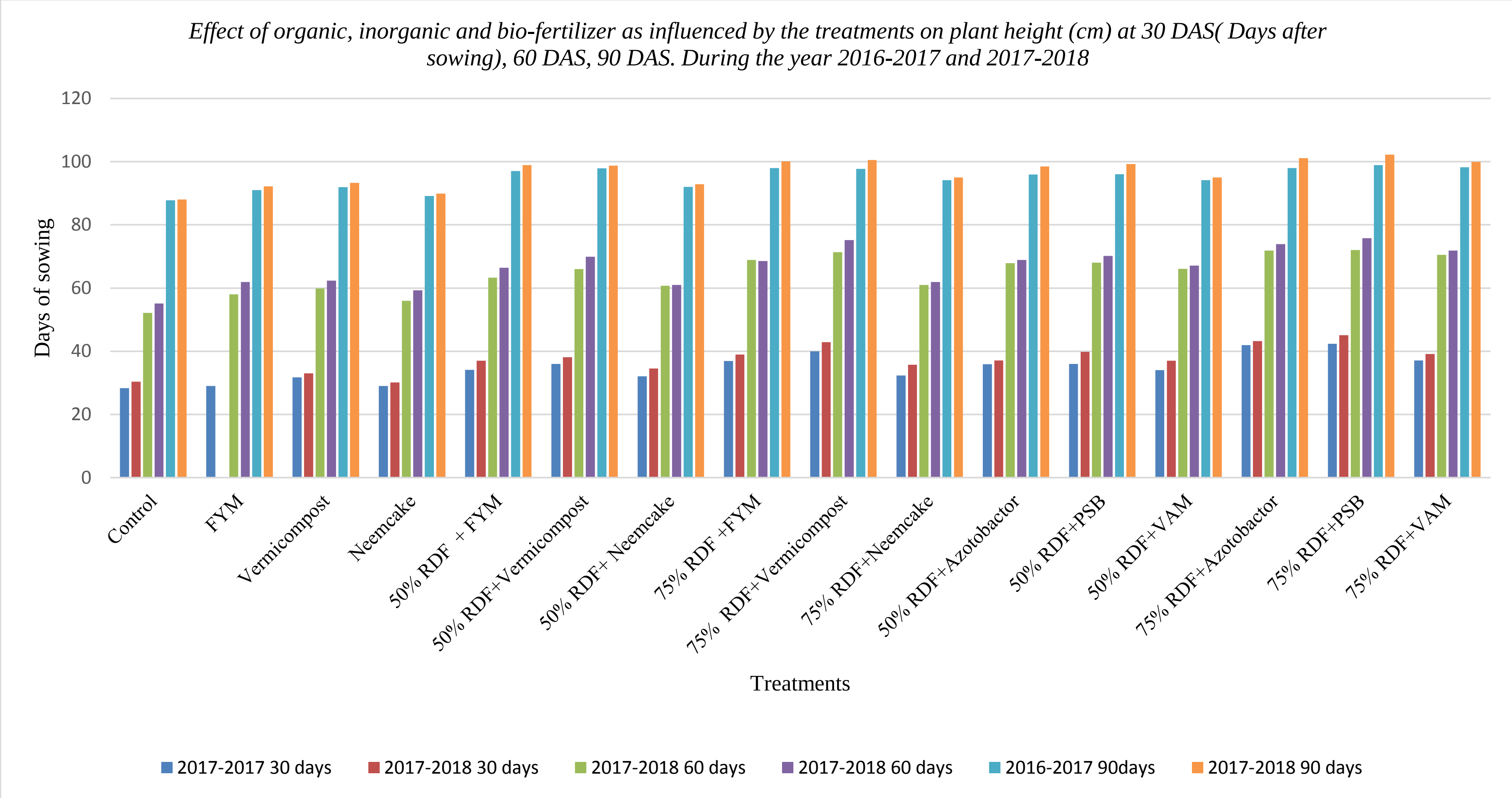


Figure 4.3: Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on plant height (cm) at 30 DAS (Days after sowing), 60 DAS, 90 DAS. During the year 2016-2017 and 2017-2018

4.4 Stem diameter (cm)

Data referred in table 4.4 and figure 4.4 pertaining the average stem diameter with the help of verniercallipers From each plot five plants were chosen for the calculation of the girth the strongest girth was found to be 2.50 and 2.53in T_{15} (75% RDF + PSB) during both the consecutive years 2016-17 and 2017-18, respectively. The weakest girth 1.80 and 1.82 was given by the T_1(control) when no fertilizer is applied in both the years of experimentation. Farmyard manure and vermicompost were also not able to produce good girth result. Strongest average stem diameter 2.51 during both the years of experimentation was observed in treatment combination T_{15} (75% RDF + PSB) and minimum in control.

Table: 4.4 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on stem diameter (cm)

	Treatments	2016-17	2017-18	Pooled
T_1	Control	**1.80**	**1.82**	**1.81**
T_2	FYM	1.84	1.85	1.84
T_3	Vermicompost	1.90	1.92	1.91
T_4	Neemcake	1.84	1.58	1.71
T_5	50% RDF + FYM	2.31	2.33	2.32
T_6	50% RDF+ Vermicompost	2.32	2.45	2.38
T_7	50% RDF+ Neemcake	1.92	1.93	1.92
T_8	75% RDF +FYM	2.39	2.41	2.40
T_9	75% RDF+Vermicompost	2.44	2.48	2.46
T_{10}	75% RDF+Neemcake	2.00	2.10	2.05
T_{11}	50% RDF+Azotobactor	2.37	2.41	2.39
T_{12}	50% RDF+PSB	2.38	2.42	2.40
T_{13}	50% RDF+VAM	2.34	2.35	2.34
T_{14}	75% RDF+Azotobactor	2.47	2.50	2.48
T_{15}	75% RDF+PSB	**2.50**	**2.53**	**2.51**
T_{16}	75% RDF+VAM	2.40	2.41	2.40
SE(m)		0.10	0.11	0.07
SE(d)		0.14	0.16	0.10
CD(P=0.05)		0.29	0.33	0.21

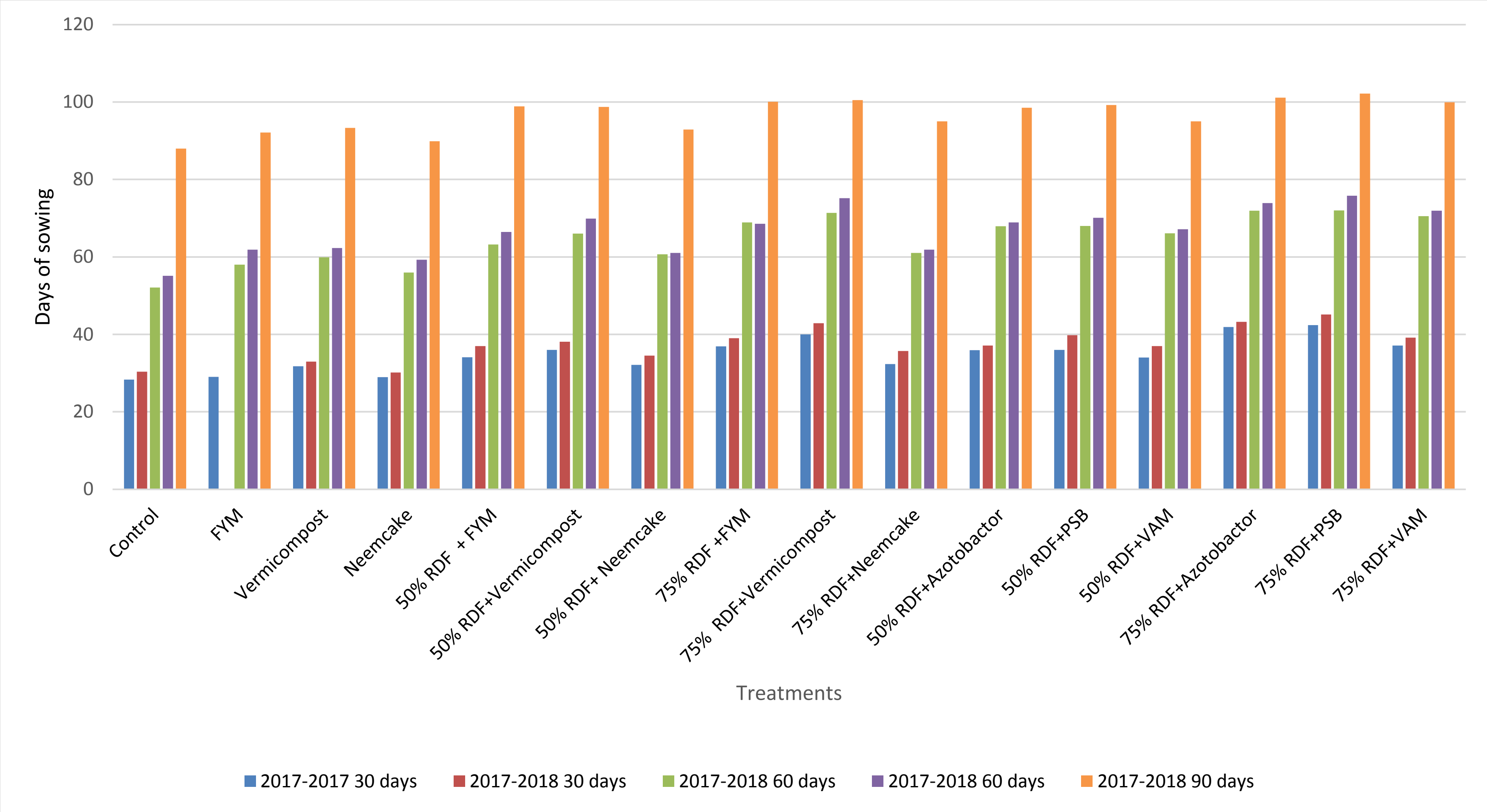


Figure 4.4 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on stem diameter (cm)

4.5 Effect of organic, inorganic and biofertilizers on number of branches at 30 DAS,60 DAS and 90 DAS

4.5.1.Number of branches per plant at 30 DAS

Data collected on account of Number of branches after 30 days after sowing under the influence of organic, inorganic and biofertilizers through different sources has been arranged in table 4.5 and in graph 4.5.

This data summarized in table 4.5 as well as in graph 4.5 significantly showed variations under various treatment combinations of organic, inorganic and biofertilizers. The maximum counting of number of branches 2.42 and 2.50 and the minimum counting of number of branches 1.45 and 1.49 were recorded in T_1(control) during both the consecutive years 2016-17 and 2017-18, respectively .

Table 4.5 also indicate that Maximum average value2.46 for number of branches in T_{15} (75% RDF + PSB) while minimum 1.47 in control during both the years of experimentation.

4.5.2. Number of branches per plant at 60 DAS

Data regarding the number of branches at 60 days after sowing is showed clearly in table 4.5 and also graphically represented in figure 4.5

The maximum number of branches 3.40 and 3.52 per plant has been noted in T_{15} (75% RDF + PSB) followed by T_{14} (75% RDF + Azotobactor) and the minimum number of branches 2.71 and 2.73 were counted in T_1 (control) followed by T_4 (Neemcake) during both the years of experimentation respectively .

Maximum average value 3.46 for number of branches in T_{15} (75% RDF + PSB) while minimum mean value for number of branches 1.47 in control during both the years of experimentation.

4.5.3. Number of branches per plant at 90 DAS.

Data conjuncted for the number of branches at 90 days after sowing is depicted in table 4.5 and also graphically represented in figure 4.5

It is evident from the data showed in table 4.5 that the number of branches showed variations under various treatment combinations of organic, inorganic and biofertilizers. T_{15} (75% RDF + PSB) obtained maximum number of branches 4.92 and 5.10 followed by T_{14} in which maximum number of branches are 4.89 and 4.94 during both the years of research trial. Whereas minimum number of branches 3.95 and 3.98 is recorded under T_1 (control) followed by T_4 (Neemcake) during both the consecutive years.

Pooled data depicted in table 4.5 clearly showed that maximum pooled value of number of branches 5.01 was .calculated in T_{15} (75% RDF + PSB) and minimum 3.96 in T_1 (control).

Table 4.5: Effect of organic, inorganic and biofertilizers on no of branches at 30 DAS, 60 DAS and 90 DAS

S.No.	Treatment No.	Treatments	Number of Branches at 30 DAS			Number of Branches at 60 DAS			Number of Branches at 90 DAS		
			2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
1	T_1	Control	1.45	1.49	1.47	2.71	2.73	2.72	3.95	3.98	3.96
2	T_2	FYM	1.58	1.64	1.61	2.82	2.86	2.84	4.10	4.16	4.13
3	T_3	Vermicompost	1.64	1.71	1.67	2.85	2.91	2.88	4.12	4.18	4.15
4	T_4	Neemcake	1.52	1.54	1.53	2.72	2.79	2.75	4.00	4.10	4.05
5	T_5	50% RDF + FYM	1.91	1.96	1.93	3.10	3.14	3.12	4.42	4.48	4.45
6	T_6	50% RDF+Vermicompost	1.95	2.00	1.97	3.12	3.19	3.15	4.48	4.53	4.50
7	T_7	50% RDF+ Neemcake	1.69	1.72	1.70	2.88	2.91	2.89	4.19	4.22	4.20
8	T_8	75% RDF +FYM	2.18	2.22	2.20	3.26	3.31	3.28	4.75	4.81	4.78
9	T_9	75% RDF+Vermicompost	2.32	2.40	2.36	3.33	3.41	3.37	4.88	4.94	4.91
10	T_{10}	75% RDF+Neemcake	1.80	1.83	1.81	3.00	3.10	3.05	4.30	4.34	4.32

S.No.	Treatment No.	Treatments	Number of Branches at 30 DAS			Number of Branches at 60 DAS			Number of Branches at 90 DAS		
			2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
11	T_{11}	50% RDF+Azotobactor	2.10	2.18	2.14	3.18	3.24	3.21	4.62	4.70	4.66
12	T_{12}	50% RDF+PSB	2.14	2.19	2.16	3.22	3.30	3.26	4.68	4.76	4.72
13	T_{13}	50% RDF+VAM	2.00	2.10	2.05	3.16	3.19	3.17	4.50	4.54	4.52
14	T_{14}	75% RDF+Azotobactor	2.38	2.45	2.41	3.36	3.42	3.39	4.89	4.94	4.91
15	T_{15}	75% RDF+PSB	**2.42**	**2.50**	**2.46**	**3.40**	**3.52**	**3.46**	**4.92**	**5.10**	**5.01**
16	T_{16}	75% RDF+VAM	2.25	2.29	2.27	3.28	3.30	3.29	4.79	4.84	4.81
SE(m)			0.12	0.12	0.08	0.12	0.13	0.09	0.19	0.20	0.13
SE(d)			0.17	0.18	0.12	0.18	0.19	0.13	0.27	0.28	0.19
CD(P=0.05)			0.34	0.37	0.24	0.36	0.39	0.26	0.55	0.59	0.39

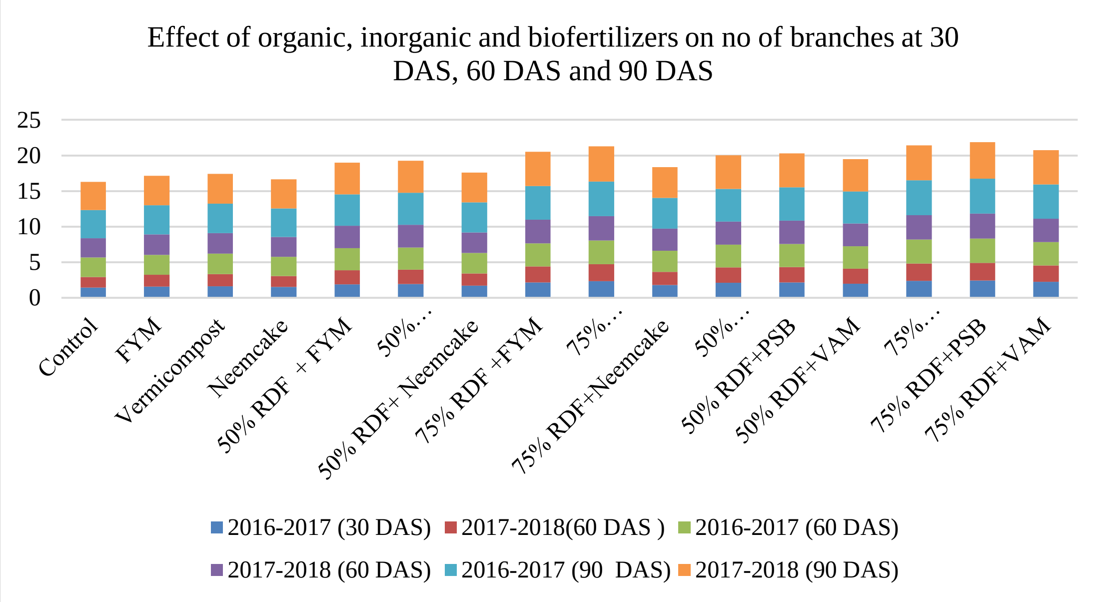


Figure 4.5 Effect of organic, inorganic and biofertilizers on no of branches at 30 DAS, 60 DAS and 90 DAS during the year2016-17 and 2017-18

4.6 Number of leaves per plant

4.6.1. Number of leaves per plant at 30 DAS.

The data on number of leaves per plant as influenced by application of organic, inorganic and biofertilizers are presented in Table 4.6 and Fig.4.6.

Number of leaves per plant differed significantly dueto application of organic, inorganic nutrients and biofertilizers. Plants supplied with T_{15} (75% RDF + PSB) recorded significantly higher number of leaves per plant 14.76and 16.96 during both the consecutive years of experimentation respectively . The least number of leaves per plant 10.98 and 11.00 were noticed in T_1 (control).

Pooled data of number of leaves presented in table 4.6 that the maximum counting 15.86 of number of leaves were found in T_{15} (75% RDF + PSB) and minimum 10.99 in control.

4.6.2. Number of leaves per plant at 60 DAS.

Data compiled on number of leaves per plant under the influence of various sources of organic, inorganic and biofertilizers has been depicted in table 4.6 and graphically presented in table 4.6

It is clear from the table 4.6 that maximum counting of number of leaves 32.90 and 36.90 was noticed in T_{15} (75% RDF + PSB) and minimum number of counting i.e.21.90 and 22.10 recorded in T_1 (control). During both successive years of experimentation respectively.

Maximum pooled value 34.90 and was noticed in T_{15} (75% RDF + PSB) and minimum pooled value 22.00 was observed in control treatment having no combination of fertilizers .

4.6.3. Number of leaves per plant at 90 DAS.

The data on number of leaves per plant as effected by the application of organic, inorganic and biofertilizers are presented in Table 4.6 and Fig.4.6.

It is direct from the table 4.6 that maximum counting of number of leaves 46.90 and 49.35 was noticed in T_{15} (75% RDF + PSB) and minimum number of counting 32.10 and 34.00 recorded in T_1 (control). During both progressive years of experimentation respectively.

Maximum pooled value 48.12was noticed in T_{15} (75% RDF + PSB) and minimum pooled value 33.05 was observed in control treatment having no combination of fertilizers.

Table:4. 6 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of leaves at 30 DAS (Days after sowing), 60 DAS, 90 DAS. During the year 2016-2017 and 2017-2018

S.No.	Treatment No.	Treatments	Number of Leaves at 30 DAS			Number of Leaves at 60 DAS			Number of leaves at 90 DAS		
			2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
1	T_1	Control	10.98	11.00	10.99	21.90	22.10	22.00	32.10	34.00	33.05
2	T_2	FYM	11.50	11.78	11.64	25.00	27.00	26.00	36.21	39.12	37.66
3	T_3	Vermicompost	11.82	11.85	11.83	25.70	27.90	26.80	37.00	39.34	38.17
4	T_4	Neemcake	11.25	11.90	11.57	22.80	22.99	22.89	34.10	35.00	34.55
5	T_5	50% RDF + FYM	12.49	12.94	12.71	28.00	29.21	28.60	41.00	45.90	43.45
6	T_6	50% RDF+Vermicompost	12.75	13.73	13.24	28.86	30.13	29.45	41.90	44.40	43.15
7	T_7	50% RDF+ Neemcake	11.89	11.92	11.90	26.88	27.95	27.41	37.30	38.90	38.10
8	T_8	75% RDF +FYM	13.40	15.10	14.25	30.90	33.40	32.15	43.36	45.12	44.24
9	T_9	75% RDF+Vermicompost	13.98	15.90	14.94	32.00	35.18	33.59	45.00	47.90	46.45

S.No.	Treatment No.	Treatments	Number of Leaves at 30 DAS			Number of Leaves at 60 DAS			Number of leaves at 90 DAS		
			2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
10	T_{10}	75% RDF+Neemcake	12.20	12.65	12.42	27.89	29.00	28.44	38.98	40.15	39.56
11	T_{11}	50% RDF+Azotobactor	13.21	13.92	13.56	30.00	33.20	31.60	43.00	46.21	44.60
12	T_{12}	50% RDF+PSB	13.25	14.52	13.88	30.10	33.00	31.55	43.10	47.00	45.05
13	T_{13}	50% RDF+VAM	13.00	13.89	13.44	28.90	29.90	29.40	42.42	43.21	42.81
14	T_{14}	75% RDF+Azotobactor	14.30	15.97	15.13	32.20	34.31	33.25	46.10	48.90	47.50
15	T_{15}	75% RDF+PSB	**14.76**	**16.96**	**15.86**	**32.90**	**36.90**	**34.90**	**46.90**	**49.35**	**48.12**
16	T_{16}	75% RDF+VAM	13.79	15.61	14.70	31.59	33.40	32.49	43.90	44.20	44.05
SE(m)			0.24	0.30	0.19	0.84	1.07	0.67	1.29	1.63	1.02
SE(d)			0.34	0.42	0.27	1.19	1.52	0.95	1.82	2.31	1.45
CD(P=0.05)			0.70	0.87	0.54	2.43	3.12	1.91	3.73	4.73	2.90

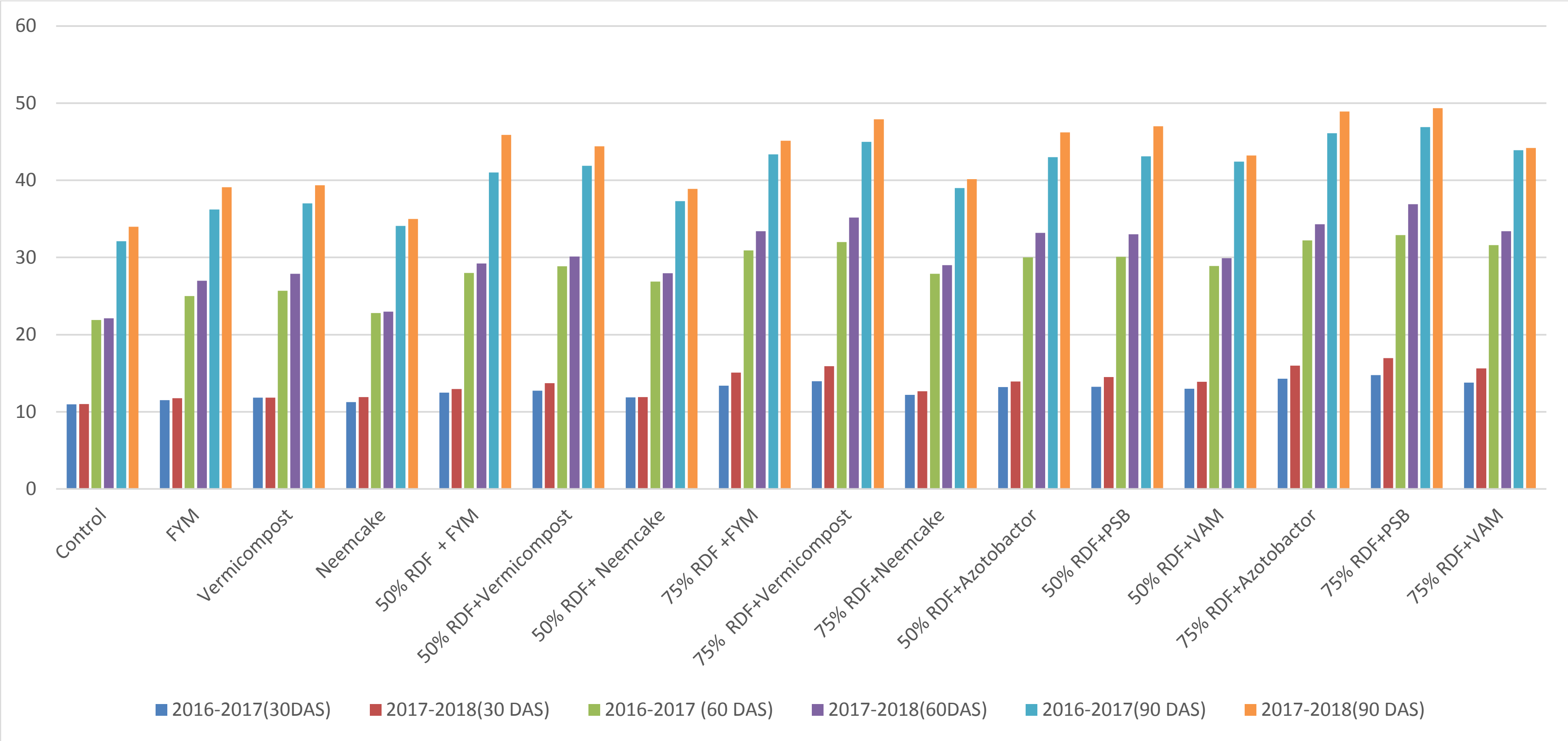


Fig 4.6: Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of leaves at 30 DAS, 60 DAS 90 DAS during the year 2016-2017 and 2017-2018.

4.7 Number of nodes per plant

4.7.1 Number of nodes per plant at 30 DAS

Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of nodes at 30 DAS (Days after sowing), during the year 2016-2017 and 2017-2018.

The data on number of nodes per plant as influenced by application of organics, inorganic and biofertilizers are presented in Table 4.7 and graphically presented in figure 4.7. The data on number of nodes as influenced by organic, inorganic nutrients and biofertilizers exhibited non-significant difference.

However, treatment T_{15} (75% RDF +PSB) recorded maximum number of nodes per plant4.75 and 4.85 and T_1 (control) recorded minimum number of nodes per plant 2.60 and 2.68 respectively, during both of the progressive years of experimentation. Number of nodes compared to all other treatments highest number of nodes were found to be given by the combination of 75 % RDF and PSB, which proved out to be the best combination that came out.

Maximum mean performance on number of nodes per plant 4.80 during both the years was noticed in T_{15} (75 RDF +PSB) and minimum mean performance on number of nodes per plant 2.64 in control treatment which is free from any combination of fertilizers.

4.7.2 Number of nodes per plant at 60 DAS

Data regarding the number of nodes per plant under the influence of integrated nutrient management in various treatments are transparently interpreted in table 4.7 and graphically arranged in figure 4.7

Maximum number of nodes per plant 10.20 and 10.40 has been put down in T_{15} (75% RDF +PSB) and minimum number of nodes per plant 5.90 and 5.98 has been noticed in T_1 (control) respectively, during the both years of research experimentation.

Maximum pooled value of number of nodes per plant 10.30 and the minimum pooled value of number of nodes per plant 5.94 during both of the successive years of experiment work were recorded in T_{15} (75% RDF +PSB) and T_1 (control) respectively.

4.7.3 Number of nodes per plant at 90 DAS

The data on number of nodes per plant as influenced by the application of organic, inorganic and biofertilizers are presented in Table 4.7 and Fig.4.7

It is evident from the table 4.7 that maximum counting of number of nodes per plant 19.80 and 19.98 were noticed in T_{15} (75% RDF + PSB) and minimum number of counting 12.80 and 12.85 recorded in T_1 (control). During both successive years of experimentation.

Maximum mean value 19.89were noticed in T_{15} (75% RDF + PSB) and minimum pooled value 12.82were observed in control treatment having no combination of fertilizers .

Table: 4.7 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of nodes at 30 DAS(Days after sowing), 60 DAS, 90 DAS. during the year 2016-2017 and 2017-2018.

	Treatments	**Number of Nodes at 30 DAS**			**Number of Nodes at 60 DAS**			**Number of Nodes at 90 DAS**		
		2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1	**Control**	**2.60**	**2.68**	**2.64**	**5.90**	**5.98**	**5.94**	**12.80**	**12.85**	**12.82**
T_2	**FYM**	2.97	3.00	2.98	6.75	6.88	6.81	13.80	13.91	13.85
T_3	**Vermicompost**	3.02	3.06	3.04	6.80	6.99	6.89	13.90	14.00	13.95
T_4	**Neemcake**	2.86	2.89	2.87	6.50	6.55	6.52	12.91	12.99	12.95
T_5	**50% RDF + FYM**	3.20	3.35	3.27	7.30	7.39	7.34	15.64	15.78	15.71
T_6	**50% RDF+Vermicompost**	3.25	3.70	3.47	7.61	7.79	7.70	16.53	16.90	16.71
T_7	**50% RDF+ Neemcake**	3.05	3.10	3.07	6.90	6.97	6.93	14.70	14.85	14.77
T_8	**75% RDF +FYM**	3.95	4.01	3.98	8.25	8.45	8.35	18.60	18.95	18.77
T_9	**75% RDF+Vermicompost**	4.30	4.38	4.34	8.50	8.65	8.57	18.91	19.00	18.95
T_{10}	**75% RDF+Neemcake**	3.15	3.25	3.20	7.15	7.24	7.19	14.95	15.03	14.99
T_{11}	**50% RDF+Azotobactor**	3.65	3.75	3.70	7.90	7.98	7.94	17.22	17.32	17.27
T_{12}	**50% RDF+PSB**	3.80	3.94	3.87	8.00	8.16	8.08	17.41	17.57	17.49
T_{13}	**50% RDF+VAM**	3.45	3.47	3.46	7.65	7.79	7.72	16.90	17.05	16.97
T_{14}	**75% RDF+Azotobactor**	4.50	4.62	4.56	9.90	10.00	9.95	19.30	19.77	19.53
T_{15}	**75% RDF+PSB**	**4.75**	**4.85**	**4.80**	**10.20**	**10.40**	**10.30**	**19.80**	**19.98**	**19.89**
T_{16}	**75% RDF+VAM**	4.15	4.18	4.16	8.30	8.40	8.35	18.70	18.84	18.77
	SE(m)	0.17	0.19	0.12	0.23	0.26	0.17	0.61	0.63	0.43
	SE(d)	0.25	0.26	0.18	0.33	0.37	0.24	0.86	0.89	0.61
	CD(P=0.05)	0.51	0.55	0.36	0.68	0.75	0.49	1.76	1.82	1.22

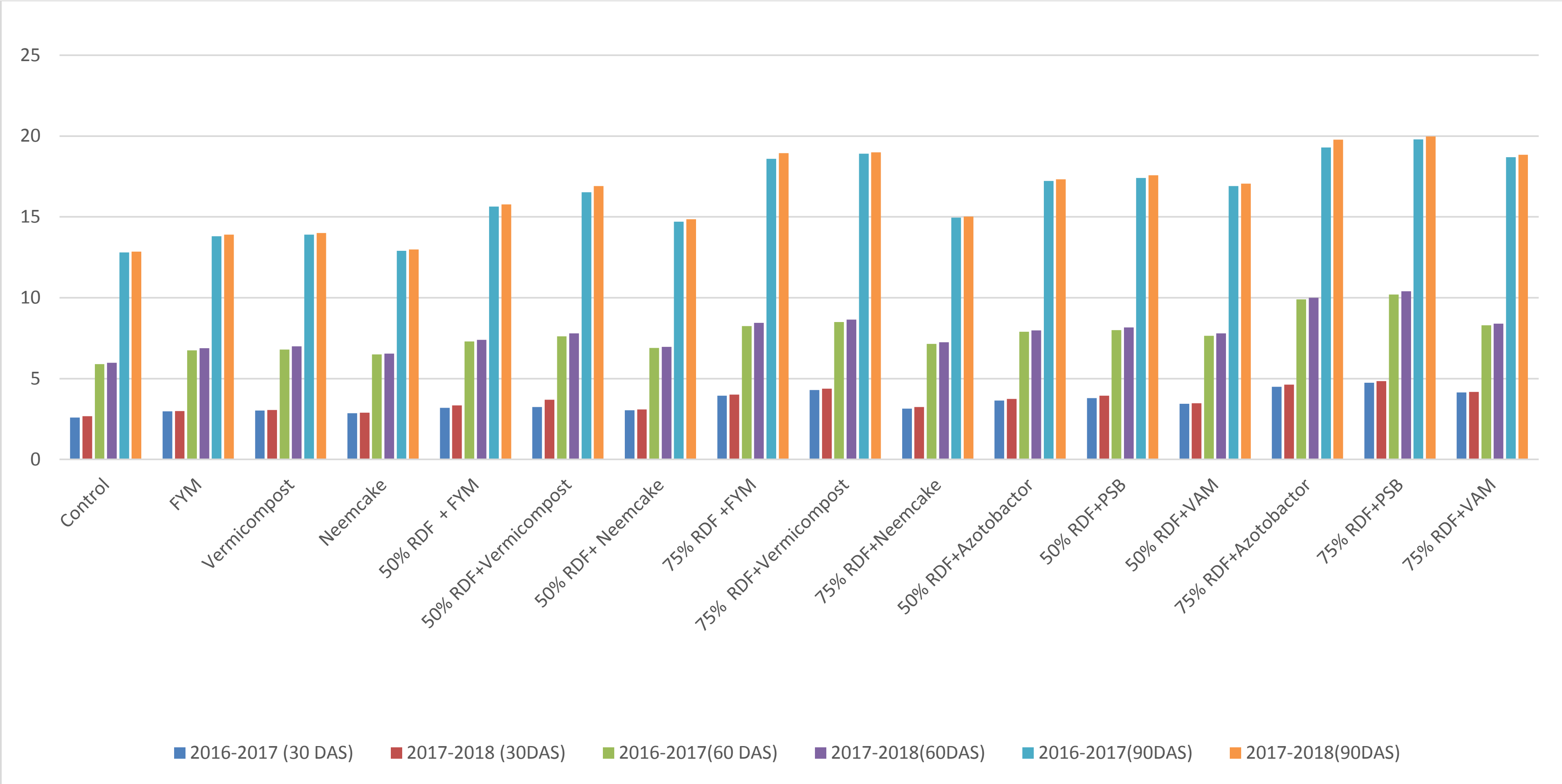


Figure 4. 7 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of nodes at 30 DAS (Days after sowing), 60 DAS, 90 DAS. During the year 2016-2017 and 2017-2018.

4.8.Internodal Length (cm)

Data referred in table 4.8 and figure 4.8 presented the average intermodal length as influenced by different nutrient sources from organic, inorganic and biofertilizers. The internodal length was calculated with the help of the scale and the distance between the two consecutive nodes were calculated. Like other experimentation in this also significant results were found in T_{15} (75 %RDF with PSB) which was found to be 7.26 and 8.26 and the least of the result 4.00 and 4.12 was attained by theT_1 (control) during the both years of experimentation. Pooled data depicted in table 4.8 clearly revealed that maximum intermodal average length 7.76 was recorded in T_{15} (75 %RDF with PSB) and minimum intermodal average length 4.06 was recorded in T_1 (control)

Table: 4.8 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments onInternodal length (cm) during the year 2016-2017 and 2017-2018

	Treatments	**2016-17**	**2017-18**	**Pooled**
T_1	Control	**4.00**	**4.12**	**4.06**
T_2	FYM	4.65	4.90	4.77
T_3	Vermicompost	4.80	5.10	4.95
T_4	Neemcake	4.20	4.80	4.50
T_5	50% RDF + FYM	5.21	5.99	5.60
T_6	50% RDF+ Vermicompost	5.42	6.60	6.01
T_7	50% RDF+ Neemcake	4.95	5.00	4.97
T_8	75% RDF +FYM	6.65	7.10	6.87
T_9	75% RDF+Vermicompost	7.00	8.25	7.62
T_{10}	75% RDF+Neemcak	5.00	6.12	5.56
T_{11}	50% RDF+Azotobactor	6.21	7.00	6.60
T_{12}	50% RDF+PSB	6.42	7.40	6.91
T_{13}	50% RDF+VAM	5.90	6.10	6.00
T_{14}	75% RDF+Azotobactor	7.10	8.21	7.65
T_{15}	75% RDF+PSB	**7.26**	**8.26**	**7.76**
T_{16}	75% RDF+VAM	6.92	7.00	6.96
SE(m)		0.12	0.17	0.10
SE(d)		0.17	0.25	0.15
CD(P=0.05)		0.35	0.51	0.30

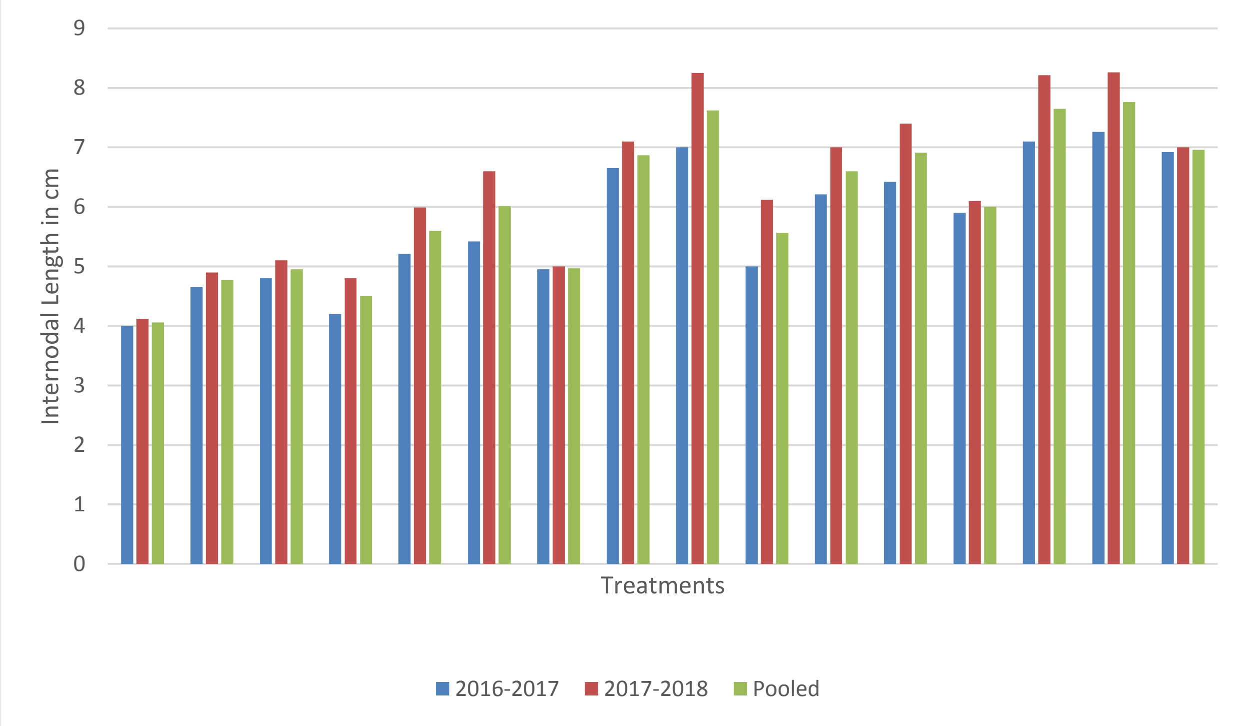


Figure 4.8 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments onInternodal length (cm) during the year 2016-2017 and 2017-2018.

4.9.1 Number of Days taken to first flowering

Data collected towards the number of days taken to first flowering to study the effect of different treatment combinations of fertilizers and manures have been arranged in table 4.9 and graphically displayed in figure 4.9.

The least number of days 41.00 and 40.00 respectively taken to first flowering in Okra plant by incorporation of organic, inorganic and biofertilizers were best studied at T_{15} (75 % RDF + PSB)the second best combination proved out to be T_{14} (75 % RDF + Azotobactor) out of all these the longer number of days result was given by T_1 (control).The least number of days taken for the first flowering 41.00 and 40.00 were recorded in T_{15} (75 % RDF + PSB) and longer number of days taken 44.90 and 45.91 for the first flowering were observed in T_1 (control) respectively, during both the years of experimentation .

Minimum pooled number of days taken 40.50 to first flowering were noticed in T_{15} (75 % RDF + PSB) and maximum average number of days taken 45.40 to first flowering were recorded in control

4.9.2. Number of days taken to 50 % flowering.

Data assembled in connection with number of days taken to 50% flowering as affected by the application of organic, inorganic and biofertilizers have been presented in Table 4.9 and graphically displayed in Figure 4.9 .

Data in referred Table 4.9 revealed that least number of days 41.00 and 40.00 taken to 50 % flowering was first seen in T_{15}(75% RDF + PSB) followed by T_{14}(75% RDF +Azotobacter) and longer number of days 44.90 and 45.91 for 50% flowering has been noted down in T_1(control) during both years of experimentation respectively .

Least mean value of number of days taken 40.50 to 50% flowering has been recorded in T_{15}(75% RDF + PSB) and longer pooled value for number of days 45.40taken to 50% flowering has been observed in T_1(control) during the entire two year course of experimentation work.

Table: 4.9 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on days to first flowering & days to 50% during the year 2016-2017 and 2017-2018

	Treatments	**Days to first flowering**			**Days to 50% flowering**		
		2016-17	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
T_1	**Control**	**44.90**	**45.91**	**45.40**	**50.00**	**51.25**	**50.62**
T_2	**FYM**	44.73	43.13	43.93	49.81	48.17	48.99
T_3	**Vermicompost**	44.67	42.07	43.37	49.76	48.67	49.21
T_4	**Neemcake**	44.85	43.90	44.37	49.88	49.10	49.49
T_5	**50% RDF + FYM**	44.20	42.08	43.14	48.56	47.25	47.90
T_6	**50% RDF+Vermicompost**	43.90	41.12	42.51	48.35	47.10	47.72
T_7	**50% RDF+ Neemcake**	44.42	43.89	44.15	49.45	48.90	49.17
T_8	**75% RDF +FYM**	42.50	41.77	42.13	47.77	46.70	47.23
T_9	**75% RDF+Vermicompost**	42.00	40.00	41.00	46.45	44.12	45.28
T_{10}	**75% RDF+Neemcake**	44.08	43.98	44.03	49.21	48.89	49.05
T_{11}	**50% RDF+Azotobactor**	43.20	42.15	42.67	48.00	46.18	47.09
T_{12}	**50% RDF+PSB**	43.07	41.17	42.12	47.90	46.00	46.95
T_{13}	**50% RDF+VAM**	43.67	42.76	43.21	48.12	47.95	48.03
T_{14}	**75% RDF+Azotobactor**	41.10	40.25	40.67	46.25	44.15	45.20
T_{15}	**75% RDF+PSB**	**41.00**	**40.00**	**40.50**	**46.10**	**44.21**	**45.15**
T_{16}	**75% RDF+VAM**	42.19	42.00	42.09	47.33	46.90	47.11
	SE(m)	0.73	0.74	0.51	0.75	0.83	0.55
	SE(d)	1.04	1.05	0.72	1.06	1.18	0.78
	CD(P=0.05)	2.12	2.14	1.45	2.18	2.42	1.57

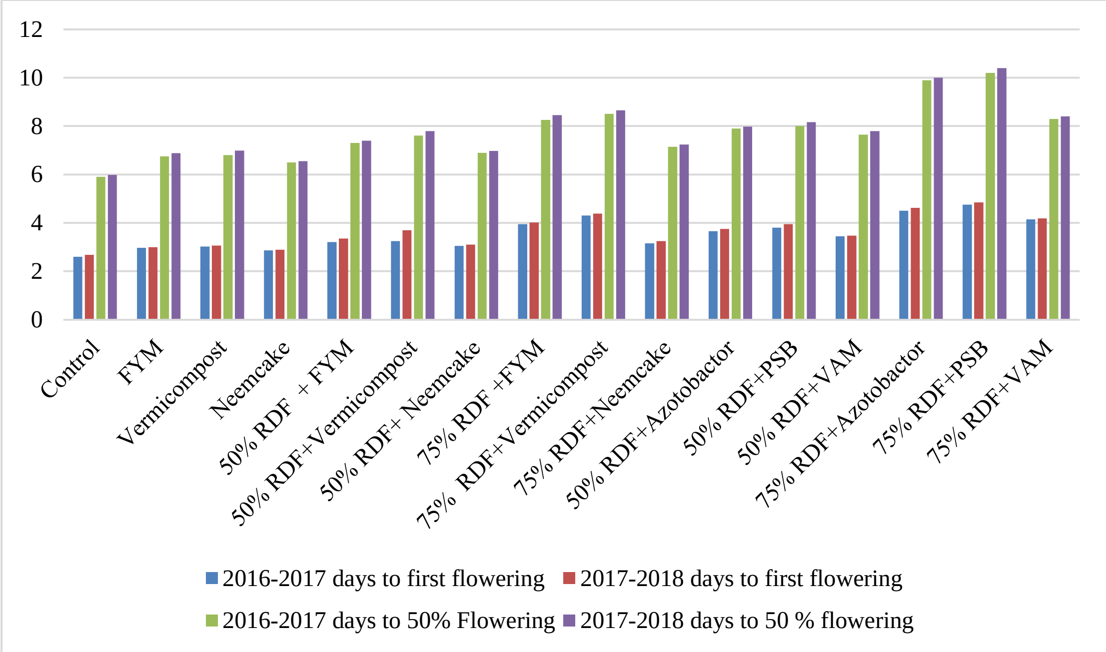


Figure 4.9 Effect of organic, inorganic and Biofertilizer as influenced by the treatments on days to first flowering and days to 50 % flowering during the year 2016-2017 and 2017-2018

4.10. Number of Fruits per plant

Data computed regarding number of fruits per plant in okra due to application of integrated nutrient management nutrient sources with different treatments combinations at different doses has been clearly presented in table 4.10 and graphically illustrated in figure 4.10.

The maximum number of fruits 18.33 and 18.45 harvested from the okra plants were counted in T_{15} (75% RDF + PSB) and the minimum number of fruits 12.55 and 12.65 were counted in T_1 (control) respectively, during the both years of trial experiment work.

Data of mean value is transparently showed in table 4.10 that the maximum average value 18.39 of number of fruits per plant is counted in T_{15} (75% RDF + PSB) and minimum pooled value 12.60 of number of fruits per plant is counted in T_1 (control) respectively, during the both years of trial experiment work

Table: 4.10 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of fruits per plant during the year 2016-2017 and 2017-2018

S.No.	Treatment No.	Treatments	2016-17	2017-18	Pooled
1	T_1	Control	**12.55**	**12.65**	**12.60**
2	T_2	FYM	13.00	13.15	13.07
3	T_3	Vermicompost	13.13	13.18	13.15
4	T_4	Neemcake	12.79	12.88	12.83
5	T_5	50% RDF + FYM	14.95	15.05	15.00
6	T_6	50% RDF+ Vermicompost	15.22	15.34	15.28
7	T_7	50% RDF+ Neemcake	13.70	13.79	13.74
8	T_8	75% RDF +FYM	17.12	17.17	17.14
9	T_9	75% RDF+Vermicompost	18.00	18.10	18.05
10	T_{10}	75% RDF+Neemcak	13.94	14.02	13.98
11	T_{11}	50% RDF+Azotobactor	16.00	16.11	16.05
12	T_{12}	50% RDF+PSB	16.35	16.43	16.39
13	T_{13}	50% RDF+VAM	15.56	15.67	15.61
14	T_{14}	75% RDF+Azotobactor	18.10	18.20	18.15
15	T_{15}	75% RDF+PSB	**18.33**	**18.45**	**18.39**
16	T_{16}	75% RDF+VAM	17.25	17.37	17.31
SE(m)			0.51	0.59	0.38
SE(d)			0.72	0.84	0.54
CD(P=0.05)			1.48	1.72	1.09

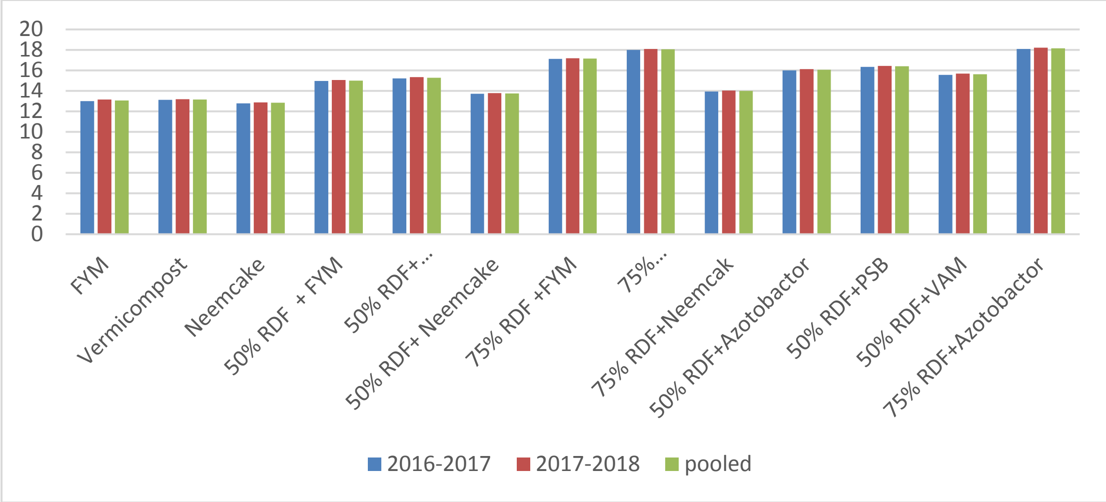


Figure 4.10 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of fruits per plant during the year 2016-2017 and 2017-2018

4.11.1. Fruit weight (g)

The data obtained for fruit weight under the effect of organic,inorganic and biofertilizers in various treatments combinations has been showed in Table 4.11 and graphically presented in Figure 4.11.

Critical analysis of data displayed in table 4.11 brought tangible impact on fruit weight due to organic, inorganic and biofertilizers application. Highest fruit weight 14.90 and 14.96 was recorded in T_{15}(75 % RDF + PSB) followed by T_{14} (75% RDF + Azotobactor) during both the years of experimentation. Lowest values 10.88 and 11.12 for the fruit weight was noticed in T_1(control) during the years 2016-17 and 2017-18 respectively .

Average performance of fruit weight during both the years was also significant under various treatment combinations. Maximum average fruit weight 14.93 was obtained in T_{15}(75 % RDF + PSB) and minimum average value 11.00 for fruit weight has been recorded under T_1 (control).

4.11.2. Fruit length (cm)

The data registered on fruit length due to influence of different treatment combinations of organic, inorganic and biofertilizers described in table 4.11 and graphically depicted in figure 4.11.

The record embodied in table 4.11 indicated that different treatments combinations played a significant role on fruit length. The longest fruit length 13.25 and 14.01 was recorded in T_{15} (75 % RDF + PSB) followed by T_{14}(75 % RDF + Azotobactor) i.e. 13.18 and 14.00 respectively during the course of experimentation .

And the lowest fruit length 8.27 and 8.00 hasbeen put down followed by 8.60 and 9.02 in T_4 (Neemcake) respectively during both the progressive years of experimentation.

Highest mean value of fruit length 13.63 followed by 13.59 during both the years was recorded in treatment combinationT_{15} (75 % RDF + PSB) and lowest mean value 8.13 of fruit length was recorded in T_1(control).

4.11.3.Fruit diameter (cm)

The data analysed for fruit diameter under the effect of organic, inorganic and biofertilizers in various treatments combinations has been showed in Table 4.11 and graphically presented in Figure 4.11.

Analysis of data displayed in table 4.11 brought concrete impact on fruit diameter due to organic, inorganic and biofertilizers application. Highest fruit diameter 2.22 and 2.25 was recorded in T_{15} (75 % RDF + PSB) followed by T_{14} (75% RDF + Azotobactor) during both the successive years of experimentation. Lowest values 1.97 and 1.99 for the fruit diameter was noticed in T_1(control) during the years 2016-17 and 2017-18 respectively.

Pooled performance of fruit weight during both the years was also significant under various treatment combinations. Maximum average fruit diameter 2.23 was obtained in T_{15}(75 % RDF + PSB) and minimum average value 1.98 for fruit diameter has been recorded under T_1 (control).

Table: 4.11 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on fruit weight (g), fruit length (cm) & fruit diameter (cm) respectively, during the year 2016-2017 and 2017-2018

S.No.	Treatment No.	Treatments	Fruit Weight (g)			Fruit Length (cm)			Fruit Diameter (cm)		
			2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
1	T_1	Control	10.88	11.12	11.00	8.27	8.00	8.13	1.97	1.99	1.98
2	T_2	FYM	11.10	11.21	11.15	9.12	9.28	9.20	2.00	2.02	2.01
3	T_3	Vermicompost	11.22	11.29	11.25	9.88	10.00	9.94	2.01	2.12	2.06
4	T_4	Neemcake	11.00	11.08	11.04	8.60	9.02	8.81	2.00	2.03	2.01
5	T_5	50% RDF + FYM	12.22	12.30	12.26	11.00	11.15	11.07	2.05	2.08	2.06
6	T_6	50% RDF+Vermicompost	12.33	12.42	12.37	11.10	11.12	11.11	2.06	2.10	2.08
7	T_7	50% RDF+ Neemcake	11.67	11.76	11.71	10.12	11.00	10.56	2.01	2.06	2.03
8	T_8	75% RDF +FYM	13.89	14.00	13.94	12.12	12.00	12.06	2.06	2.08	2.07
9	T_9	75% RDF+Vermicompost	14.25	14.33	14.29	13.10	13.15	13.12	2.11	2.17	2.14
10	T_{10}	75% RDF+Neemcake	11.88	11.94	11.91	10.36	10.11	10.23	2.03	2.09	2.06
11	T_{11}	50% RDF+Azotobactor	12.85	12.95	12.90	11.17	11.95	11.56	2.02	2.10	2.06
12	T_{12}	50% RDF+PSB	13.15	13.24	13.19	12.00	12.15	12.07	2.04	2.15	2.09
13	T_{13}	50% RDF+VAM	12.61	12.70	12.65	11.25	11.45	11.35	2.00	2.15	2.07
14	T_{14}	75% RDF+Azotobactor	14.65	14.74	14.69	13.18	14.00	13.59	2.18	2.22	2.20
15	T_{15}	75% RDF+PSB	**14.90**	**14.96**	**14.93**	**13.25**	**14.01**	**13.63**	**2.22**	**2.25**	**2.23**
16	T_{16}	75% RDF+VAM	14.00	14.10	14.05	12.25	12.37	12.31	2.09	2.00	2.04
SE(m)			0.37	0.39	0.26	0.41	0.45	0.30	0.02	0.03	0.02
SE(d)			0.52	0.55	0.37	0.59	0.64	0.43	0.03	0.04	0.02
CD(P=0.05)			1.06	1.13	0.74	1.21	1.32	0.86	0.07	0.08	0.05

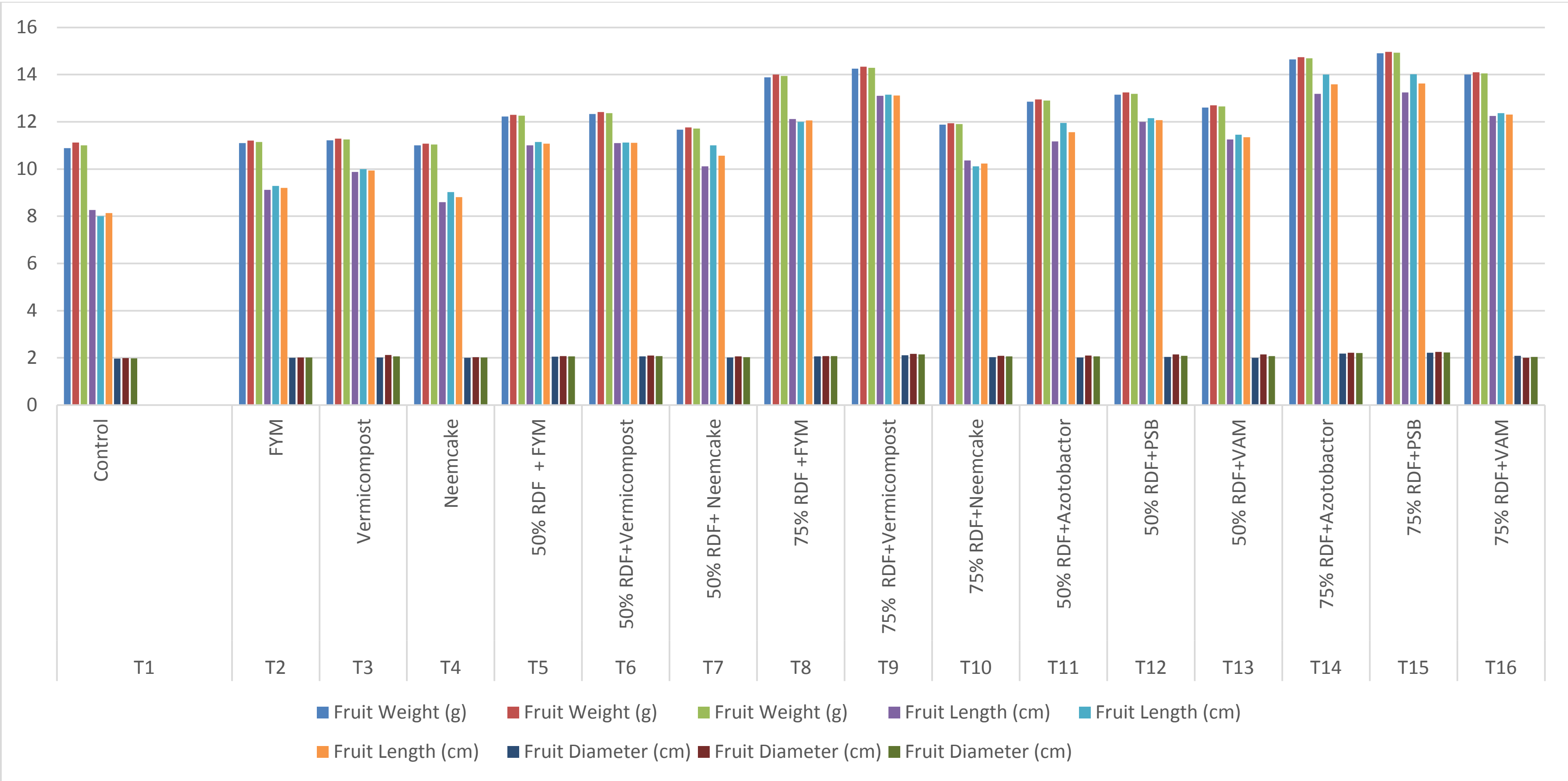


Figure 4.11 Effect of organic, inorganic and biofertilizers as influenced by the treatments on fruit weight (g), fruit length (cm) & fruit diameter (cm) respectively, during the year 2016-2017 and 2017-2018

4.12 Days to First picking

Data assembled regarding days to first picking in okra as influenced by organic, inorganic and biofertilizers under different treatment combinations have been depicted in Table 4.12 and graphically displayed in Figure 4.12

Table 4.12 transparently shows that the minimum number of days to first picking 62.60 and 62.10 has been observed in T_{15} (75 % RDF + PSB) and the maximum number of days to first picking has been recorded 66.60 and 66.20 in T_1(control) respectively during both of the successive years of experimentation . Minimum pooled value of number of days to first picking 62.35 was noticed in T_{15}(75 % RDF + PSB) and maximum pooled value of number of days 66.40 to first picking has been recorded in T_1(control) respectively

Table: 4. 12 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on days to first picking during the year 2016-2017 and 2017-2018

S.No.	Treatment No.	Treatments	2016-17	2017-18	Pooled
1	T_1	Control	**66.60**	**66.20**	**66.40**
2	T_2	FYM	65.90	65.40	65.65
3	T_3	Vermicompost	65.80	65.10	65.45
4	T_4	Neemcake	66.00	65.80	65.90
5	T_5	50% RDF + FYM	65.20	65.00	65.10
6	T_6	50% RDF+ Vermicompost	65.00	64.70	64.85
7	T_7	50% RDF+ Neemcake	65.60	65.40	65.50
8	T_8	75% RDF +FYM	64.20	63.90	64.05
9	T_9	75% RDF+Vermicompost	63.90	63.30	63.60
10	T_{10}	75% RDF+Neemcak	65.40	65.20	65.30
11	T_{11}	50% RDF+Azotobactor	64.80	64.40	64.60
12	T_{12}	50% RDF+PSB	64.50	64.20	64.35
13	T_{13}	50% RDF+VAM	64.90	64.70	64.80
14	T_{14}	75% RDF+Azotobactor	63.30	63.00	63.15
15	T_{15}	75% RDF+PSB	**62.60**	**62.10**	**62.35**
16	T_{16}	75% RDF+VAM	64.00	63.80	63.90
SE(m)			0.67	0.41	0.39
SE(d)			0.95	0.58	0.55
CD(P=0.05)			1.94	1.19	1.11

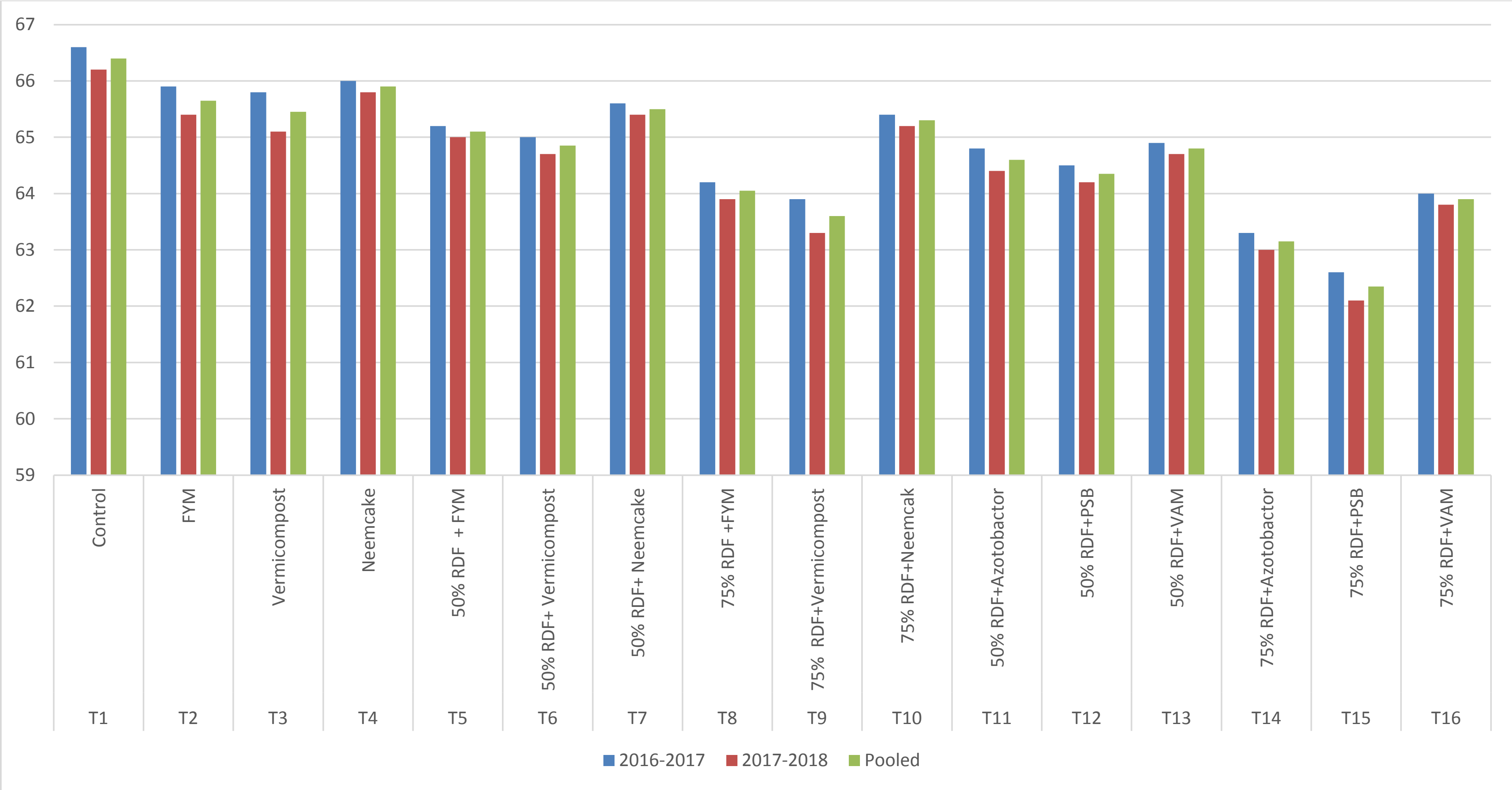


Fig 4.12: Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on days to first picking during the year 2016-2017 and 2017-2018

4.13.1 Fruit yield per plant (kg)

Data portrayed to average fruit yield per plant as influenced by organic, inorganic and biofertilizers application have been arranged in Table 4.13 and graphically presented in Figure 4.13.

Table 4.13 clear cut showed the effect of organic, inorganic and biofertilizer on fruit yield per plant .Fruit yield per plant, fruit yield per plot, fruit yield per hectare were the three parameters which were compared in this experiment. The highest fruityield0.273 and 0.276 per plant was obtained inT_{15}(75% RDF + PSB) followed by 0.273 and 0.276 in T_{14}(75 % RDF + Azotobactor) during the year 2016-2017 and 2017-2018 respectively. The least value 0.136 and 0.140 of all results were found to be in T_1(control) followed by 0.140 and 0.142 in T_4(Neemcake) during both the successive years of experimentation research respectively .

The highest pooled data 0.274 of fruit yield per plant has been recorded in T15(75% RDF + PSB)during both of the years of experimentation and lowest pooled data 0.134 has been noticed in control treatment.

4.13.2 Fruit yield per plot (kg)

Data gathered on account of fruit yield per plot as influenced by different sources of organic, inorganic and biofertilizers have been depicted in Table 4.13 and graphically showed in Figure 4.13

On analyzing the data it was found that there was a marked variation in yield per plot under all the treatments combinations. Table 4.13 clearly showed the highest yield per plot 5.460 and 5.520 inT_{15} (75% RDF + PSB) in year 2016-17and 2017-18 respectively. Lowest yield 2.720 and 2.800 has been found in T_1 (control) during both the years of experimentation respectively.

Highest average value 5.490 for yield per plot during both the years of experimentation was recorded in T_{15} (75% RDF + PSB) and lowest average value 2.760 for yield per plot during both the years of experimentation was noticed in T1 (control).

4.13.3 Fruit yield per hectare (q/ha)

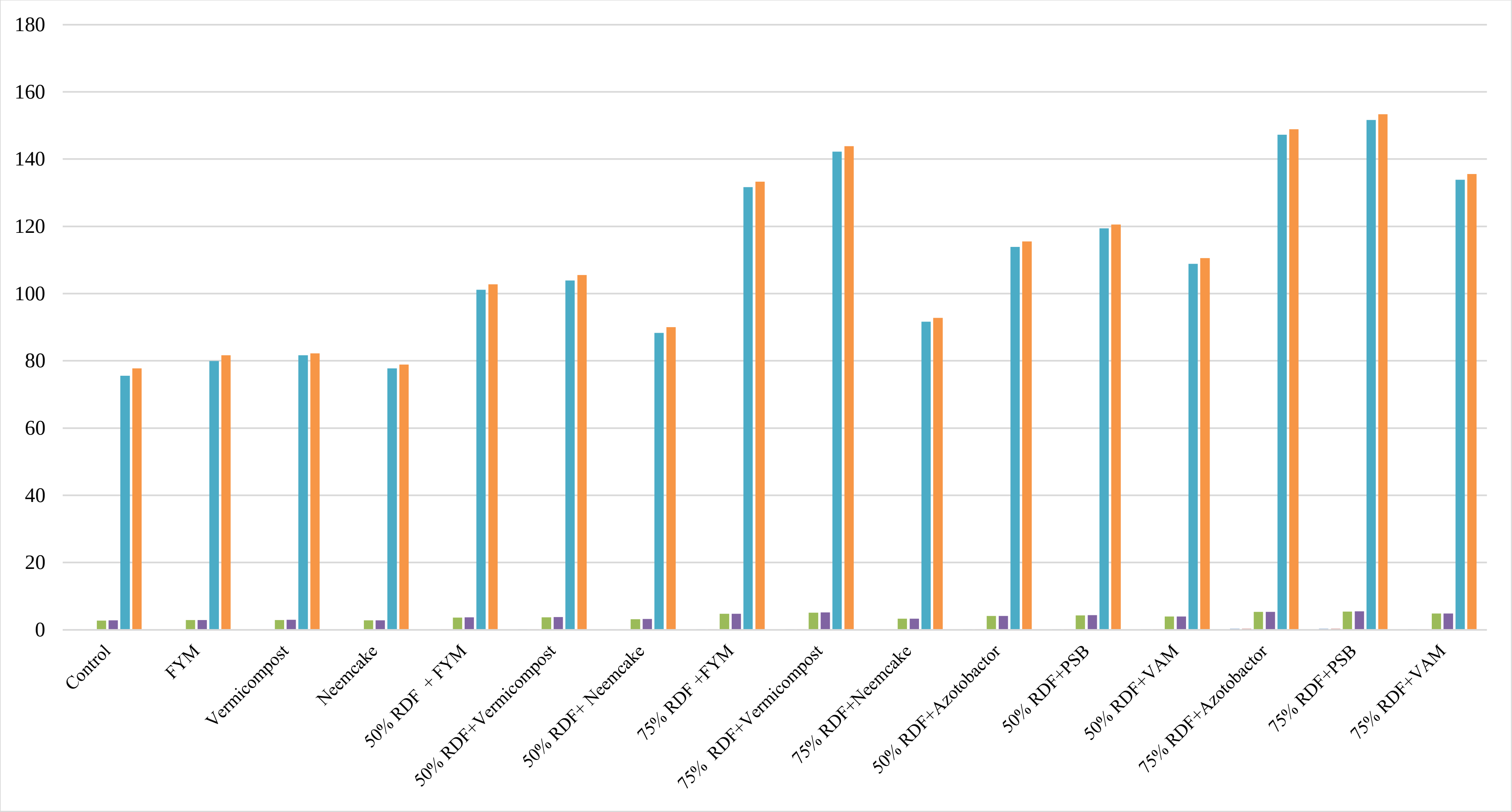
Data compiled on account of fruit yield per hectare as influenced by the integrated nutrient management under different treatments has been portrayed in Table 4.13 and graphically illustrated in Figure 4.13.

Critical analysis of data mentioned in table 4.13 brought impact on fruit yield per hectare due to organic, inorganic and biofertilizers applications. Highest fruit yield 151.660 and 153.330 per hectare was recorded inT_{15} (75% RDF + PSB) followed by T_{14} (75% RDF + Azotobactor) during both the years respectively. Lowest values 75.550and 77.770 respectively in the year 2016 -17 and 2017-18 for fruit yield per hectare was noticed in T_1 (control) .

Average performance of fruit yield per plot was also significant under various treatments combinations. Highest average value152.495 of fruit yield per hectare during both the successive years of experimentation was recorded inT_{15} (75% RDF + PSB) and minimum average value 76.660 for fruit yield per hectare during both years in T_1 (control).

Table: 4. 13 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on fruit yield per plant (kg), fruit yield per plot (kg) & fruit yield per hectare (q/ ha) during the year 2016-2017 and 2017-2018

	Treatments	**Fruit yield per plant (kg)**			**Fruit yield per plot (kg)**			**Fruit yield per hectare (q/ha)**		
		2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1	**Control**	**0.136**	**0.140**	**0.138**	**2.720**	**2.800**	**2.760**	**75.550**	**77.770**	**76.660**
T_2	**FYM**	0.144	0.147	0.145	2.880	2.940	2.910	79.990	81.660	80.825
T_3	**Vermicompost**	0.147	0.148	0.147	2.940	2.960	2.950	81.660	82.220	81.940
T_4	**Neemcake**	0.140	0.142	0.141	2.800	2.840	2.820	77.770	78.880	78.325
T_5	**50% RDF + FYM**	0.182	0.185	0.184	3.640	3.700	3.670	101.110	102.770	101.940
T_6	**50% RDF+Vermicompost**	0.187	0.190	0.189	3.740	3.800	3.770	103.880	105.550	104.715
T_7	**50% RDF+ Neemcake**	0.159	0.162	0.160	3.180	3.240	3.210	88.330	89.990	89.160
T_8	**75% RDF +FYM**	0.237	0.240	0.238	4.740	4.800	4.770	131.660	133.330	132.495
T_9	**75% RDF+Vermicompost**	0.256	0.259	0.258	5.120	5.180	5.150	142.220	143.880	143.050
T_{10}	**75% RDF+Neemcake**	0.165	0.167	0.166	3.300	3.340	3.320	91.660	92.770	92.215
T_{11}	**50% RDF+Azotobactor**	0.205	0.208	0.207	4.100	4.160	4.130	113.880	115.550	114.715
T_{12}	**50% RDF+PSB**	0.215	0.217	0.216	4.300	4.340	4.320	119.440	120.550	119.995
T_{13}	**50% RDF+VAM**	0.196	0.190	0.193	3.920	3.980	3.950	108.880	110.550	109.715
T_{14}	**75% RDF+Azotobactor**	0.265	0.268	0.266	5.300	5.360	5.330	147.220	148.880	148.050
T_{15}	**75% RDF+PSB**	**0.273**	**0.276**	**0.274**	**5.460**	**5.520**	**5.490**	**151.660**	**153.330**	**152.495**
T_{16}	**75% RDF+VAM**	0.241	0.244	0.242	4.820	4.880	4.850	133.880	135.550	134.715
	SE(m)	0.010	0.010	0.007	0.211	0.225	0.152	2.771	3.337	2.134
	SE(d)	0.014	0.014	0.010	0.298	0.319	0.215	3.919	4.718	3.019
	CD(P=0.05)	0.028	0.030	0.020	0.611	0.649	0.430	8.008	9.641	6.035



4.13: Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on fruit yield per plant (kg), fruit yield per plot (kg) & fruit yield per hectare (q/ ha) during the year 2016-2017 and 2017-2018

4.14 Number of seeds per fruit.

Data gathered on account of number of seeds per fruit under the influence of integrated nutrient management through different sources has been shown in Table 4.14 and graphically presented in Figure 4.14. It is evident from data summarized in Table 4.14 that the number of seeds per fruit significantly showed variations under different doses of treatments combinations of organic inorganic and biofertilizers. T_{15}(75% RDF + PSB) obtained highest number of seeds per fruit 51.12 and 53.50 followed by 50.00 and 52.12 in T_{14}(75% RDF + Azotobactor) and T_1(control) obtained lowest number of seeds per fruit 42.00 and 40.00 followed by 44.25 and 44.80 T_4(Neemcake) during the both successive years of research work respectively.

Table 4.14 also indicate the highest mean value of number of seeds 52.13 per fruit followed by 51.06 was counted in T_{15}(75% RDF + PSB) and the lowest mean value of number of seeds per fruit was 41.00 has been counted in T_1(control).

Table: 4.14 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of seeds per fruit during the year 2016-2017 and 2017-2018

	Treatments	**2016-17**	**2017-18**	**Pooled**
T_1	Control	**42.00**	**40.00**	**41.00**
T_2	FYM	45.00	45.80	45.40
T_3	Vermicompost	45.55	47.10	46.32
T_4	Neemcake	44.25	44.80	44.52
T_5	50% RDF + FYM	46.25	47.12	46.68
T_6	50% RDF+ Vermicompost	46.75	48.12	47.43
T_7	50% RDF+ Neemcake	45.90	50.00	47.95
T_8	75% RDF +FYM	49.10	50.12	49.61
T_9	75% RDF+Vermicompost	49.80	50.15	49.97
T_{10}	75% RDF+Neemcak	46.00	46.90	46.45
T_{11}	50% RDF+Azotobactor	48.21	49.10	48.65
T_{12}	50% RDF+PSB	48.90	49.55	49.22
T_{13}	50% RDF+VAM	47.00	47.90	47.45
T_{14}	75% RDF+Azotobactor	50.00	52.12	51.06
T_{15}	75% RDF+PSB	**51.12**	**53.50**	**52.31**
T_{16}	75% RDF+VAM	49.75	50.75	50.25
SE(m)		1.02	1.19	0.77
SE(d)		1.44	1.69	1.09
CD(P=0.05)		2.96	3.45	2.19

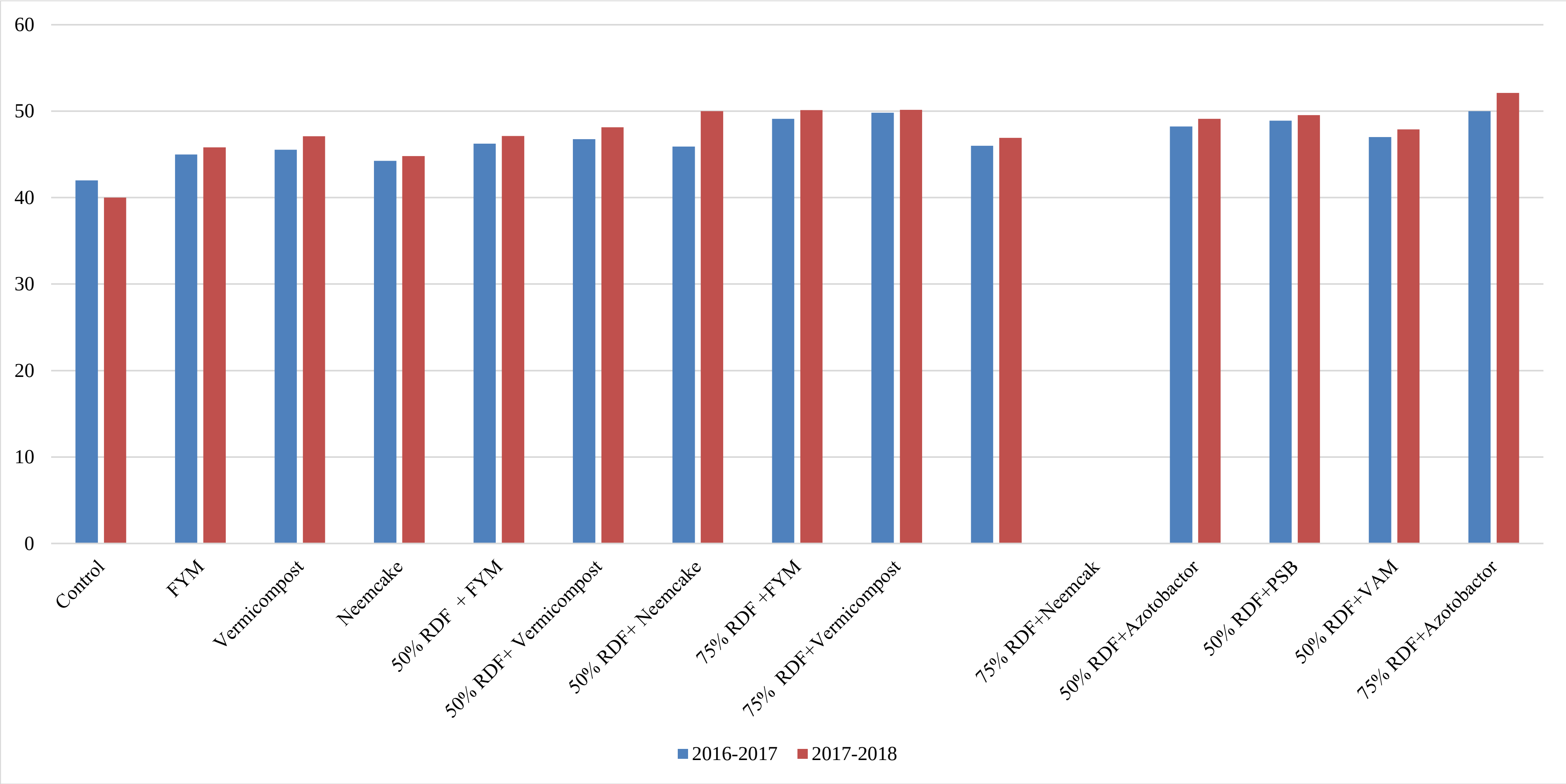


Figure 4.14 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of seeds per fruits during the year 2016-2017 and 2017-2018

4.2 Biochemical Attributes

4.2.1 Total Soluble Solids (^{0}Brix)

Data regarding the total soluble solids as effected by the application of organic, inorganic and biofertilizers have been depicted in Table 4.2.1 and graphically presented in Figure 4.2.1

Total soluble solids were pooled out in the okra plant which were treated with organic, inorganic and biofertilizers. Total soluble solids were found to be higher2.93 and 2.96 in the plants which were harvested from the plot which were supplemented with T_{15}(75% RDF +PSB) and also the second treatment 2.92 and 2.94 which showed good result was T_{14}(75 % RDF + Azotobacter). The third treatment 2.90 and 2.92 which signified good TSS value was shown by T_{9}(75% RDF + Vermicompost) and the total soluble solids were found lower 1.97 and 2.04 in the plants which were harvested from the plot in which no any fertilizer combination is applied during both successive year of experimentation respectively .

The highest mean value 2.94 followed by 2.93 of total soluble solids was recorded in T_{15}(75% RDF +PSB) and lowest average value 2.00 followed by 2.18 was noticed in T_{1}(control) treatment .

Table: 4.2.1 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on T.S.S (^{o} Brix) during the year 2016-2017 and 2017-2018

S.No.	Treatment No.	Treatments	2016-17	2017-18	Pooled
1	T_1	Control	**1.97**	**2.04**	**2.00**
2	T_2	FYM	2.37	2.41	2.39
3	T_3	Vermicompost	2.46	2.5	2.48
4	T_4	Neemcake	2.15	2.22	2.18
5	T_5	50% RDF + FYM	2.66	2.7	2.68
6	T_6	50% RDF+ Vermicompost	2.69	2.72	2.70
7	T_7	50% RDF+ Neemcake	2.51	2.56	2.53
8	T_8	75% RDF +FYM	2.85	2.87	2.86
9	T_9	75%RDF+Vermicompost	2.90	2.92	2.91
10	T_{10}	75% RDF+Neemcak	2.59	2.63	2.61
11	T_{11}	50% RDF+Azotobactor	2.79	2.82	2.80
12	T_{12}	50% RDF+PSB	2.83	2.86	2.84
13	T_{13}	50% RDF+VAM	2.74	2.76	2.75
14	T_{14}	75% RDF+Azotobactor	2.92	2.94	2.93
15	T_{15}	75% RDF+PSB	**2.93**	**2.96**	**2.94**
16	T_{16}	75% RDF+VAM	2.88	2.91	2.89
SE(m)			0.04	0.06	0.03
SE(d)			0.06	0.08	0.05
CD(P=0.05)			0.13	0.18	0.11

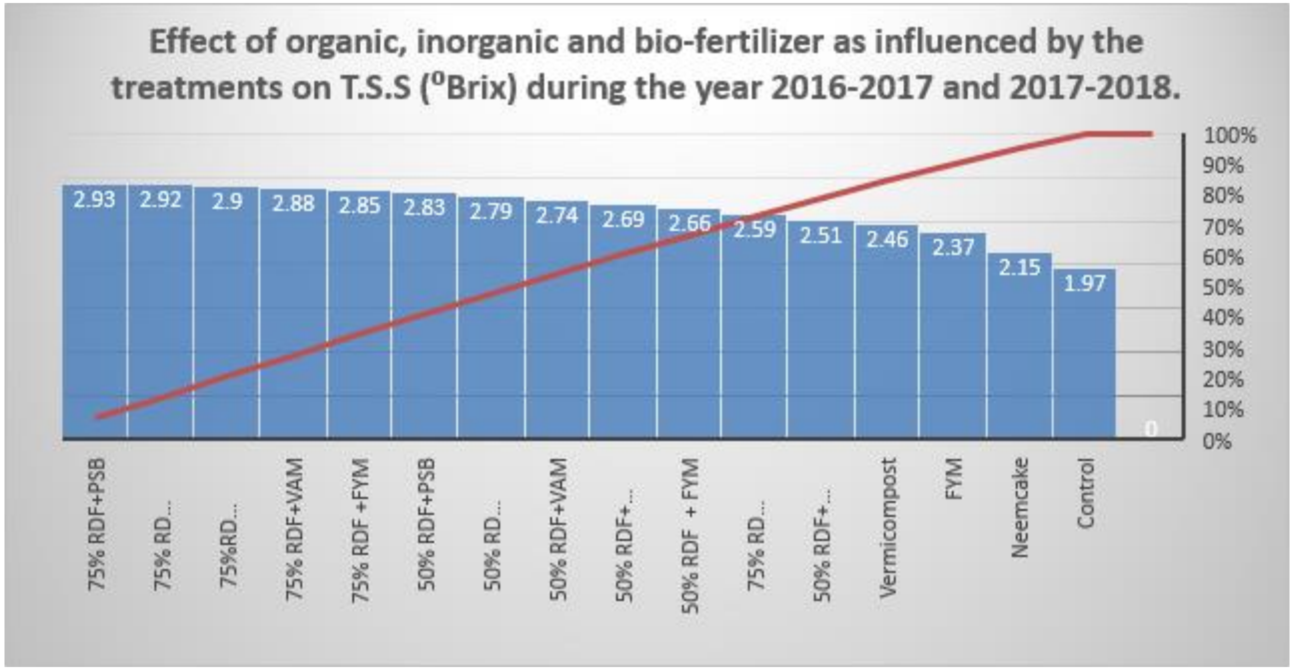


Figure 4.2.1 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on T.S.S (⁰ Brix) during the year 2016-2017 and 2017-2018

4.2.2 Total ascorbic acid content

Data computed regarding total ascorbic acid content in okra due to application of organic, inorganic and biofertilizers at different rates has been clearly presented in Table 4.2.2 and graphically portrayed in Figure 4.2.2

Data regarding the average ascorbic acid content in the crop under the influence of various inorganic, organic inorganic and biofertilizers has been mentioned in Table 4.2.2 and explained in the figure 4.2.2 with the help of comparative graph. The highest ascorbic acid 11.66 and 11.69 content was found to be in T_{15} (75 % RDF and PSB) combination the second best result 10.98 and 11.07 .was given by the combination of 75% RDF and Azotobactor in T_{14} during both of the years of experimentation respectively. And the lowest value 9.24 and 9.26 respectively of ascorbic content was recorded in T_1(control). Average data depicted in table 4.2.2 clearly indicated that maximum ascorbic acid 11.67 was estimated in. T_{15} (75 % RDF and PSB) and minimum 9.25 in T_1 (control).

Table: 4.2.2Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on ascorbic acid (mg/100g) during the year 2016-2017 and 2017-2018.

	Treatments	**2016-17**	**2017-18**	**Pooled**
T_1	Control	9.24	9.26	9.25
T_2	FYM	9.94	9.97	9.55
T_3	Vermicompost	10.06	10.09	10.07
T_4	Neemcake	9.83	9.84	9.83
T_5	50% RDF + FYM	10.28	10.32	10.30
T_6	50% RDF+ Vermicompost	10.32	10.37	10.34
T_7	50% RDF+ Neemcake	10.16	10.18	10.17
T_8	75% RDF +FYM	11.66	11.69	11.67
T_9	75% RDF+Vermicompost	10.69	10.74	10.71
T_{10}	75% RDF+Neemcake	10.20	10.24	10.22
T_{11}	50% RDF+Azotobactor	10.44	10.49	10.46
T_{12}	50% RDF+PSB	10.52	10.61	10.56
T_{13}	50% RDF+VAM	10.39	11.42	10.90
T_{14}	75% RDF+Azotobactor	10.89	10.92	10.90
T_{15}	75% RDF+PSB	10.98	11.07	11.02
T_{16}	75% RDF+VAM	10.77	10.81	10.79
SE(m)		0.10	0.10	0.07
SE(d)		0.14	0.14	0.10
CD(P=0.05)		0.28	0.29	0.19

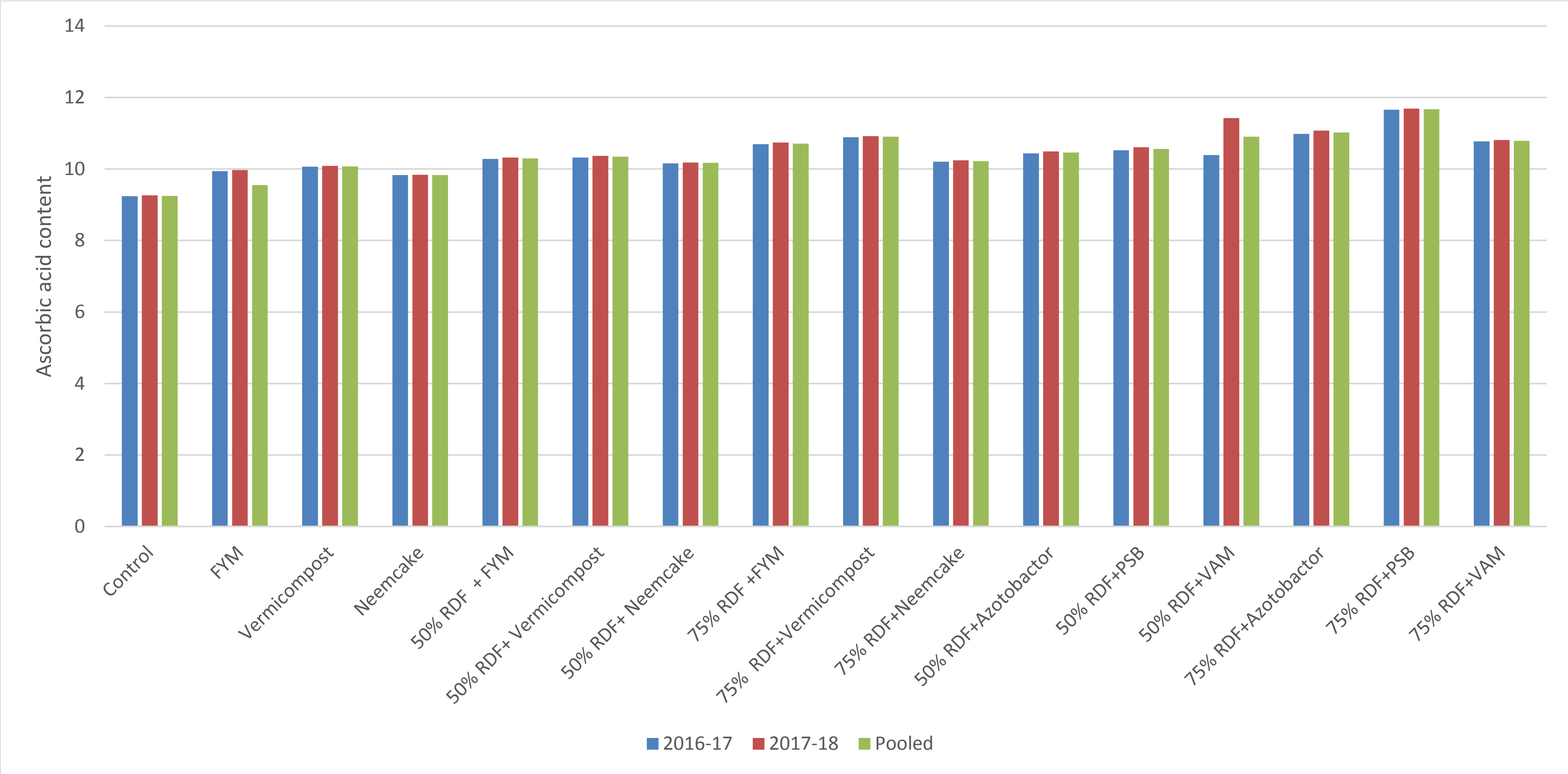


Figure 4.2.2 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on ascorbic acid (mg/100g) during the year 2016-2017 and 2017-2018

4.2.3 Total Sugar (%)

Data collected regarding the total sugar content under the influence of different organic, inorganic and biofertilizers given were interpreted in Table 4.2.4 and graphically depicted in Figure 4.2.4 under the following results.

Total Sugar was found to be highest 3.39and 3.42in the combination of 75 % RDF and PSB in T_{15}(75% RDF + PSB), while the least 1.90 and 1.98 was found to be with the control treatment followed by Neemcake treatment during both of the years of experimentation respectively .The incorporation of organic and inorganic manure as well as biofertilizers majorly affected the sugar content in the okra crop.

Maximum average estimation of total sugars 3.40 of both the years was found in T_{15}(75% RDF + PSB)while minimum 1.94 in T_1(control)

4.2.4 Reducing Sugar (%)

Data pertaining to reducing sugar percentage in okra due to application of different sources of organic, inorganic and biofertilizers nutrients have been portrayed in Table 4.2.4 and graphically presented in Figure 4.2.4

It is interpreted from the data presented in referred table 4.2.4 that there was a significant variation in reducing sugar content in okra. The maximum content of reducing sugar 2.04 and 2.06 has been put down inT_{15}(75% RDF + PSB) followed by T_{14}(75% RDF + Azotobactor) 2.03 and 2.08 in both the consecutive years respectively. The minimum content 1.16 and 1.22 of reducing sugar was estimated in T_1(control) during the years 2016-17 and 2017-18, respectively.

Maximum mean estimation of reducing sugars 2.05 of both consecutive years has been obtained in T_{15}(75% RDF + PSB) while minimum in T_1(control).

4.2.5 Non Reducing Sugar (%)

Data pertaining to non-reducing sugar percentage in okra due to application of various sources of organic, inorganic and biofertilizers nutrients have been depicted in Table 4.2.4 and graphically presented in Figure 4.2.4

It is interpreted from the data presented in referred table 4.2.4 that three was a significant variation in reducing sugar content in okra. The maximum content of non-reducing sugar 1.35and 1.36 has been noticed inT_{15}(75% RDF + PSB) followed by T_{14}(75% RDF + Azotobactor) 1.33 and 1.30 in both the consecutive years respectively. The minimum content 0.74 and 0.76 of non-reducing sugar was estimated in T_1(control) during the years 2016-17 and 2017-18, respectively.

Maximum mean estimation of reducing sugars 1.35 of both consecutive years has been obtained in T_{15}(75% RDF + PSB) while minimum 0.75 in T_1(control).

Table 4.2.3 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on reducing sugar (%), non-reducing sugar (%) & total sugars) during the year 2016-2017 and 2017-2018

	Treatments	**Total sugar (%)**			**Reducing sugar (%)**			**Non Reducing sugar (%)**		
		2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1	**Control**	1.90	1.98	1.94	1.16	1.22	1.19	0.74	0.76	0.75
T_2	**FYM**	2.22	2.28	2.25	1.32	1.38	1.35	0.09	0.09	0.09
T_3	**Vermicompost**	2.38	2.46	2.42	1.38	1.42	1.40	1.00	1.04	1.02
T_4	**Neemcake**	2.05	2.12	2.08	1.26	1.31	1.28	0.79	0.81	0.80
T_5	**50% RDF + FYM**	2.80	2.89	2.84	1.55	1.61	1.58	1.25	1.28	1.26
T_6	**50% RDF+Vermicompost**	2.96	2.99	2.97	1.62	1.67	1.64	1.34	1.32	1.33
T_7	**50% RDF+ Neemcake**	2.60	2.69	2.64	1.42	1.48	1.45	1.18	1.21	1.19
T_8	**75% RDF +FYM**	3.18	3.21	3.19	1.87	1.94	1.90	1.31	1.27	1.29
T_9	**75% RDF+Vermicompost**	3.28	3.31	3.29	2.00	2.03	2.01	1.28	1.28	1.28
T_{10}	**75% RDF+Neemcake**	2.75	2.85	2.80	1.49	1.54	1.51	1.26	1.31	1.28
T_{11}	**50% RDF+Azotobactor**	3.07	3.11	3.09	1.76	1.81	1.78	1.31	1.30	1.30

	Treatments	**Total sugar (%)**			**Reducing sugar (%)**			**Non Reducing sugar (%)**		
T_{12}	**50% RDF+PSB**	3.12	3.17	3.14	1.81	1.85	1.83	1.31	1.32	1.31
T_{13}	**50% RDF+VAM**	3.00	3.04	3.02	1.69	1.74	1.71	1.31	1.30	1.30
T_{14}	**75% RDF+Azotobacter**	3.36	3.38	3.37	2.03	2.08	2.05	1.33	1.30	1.31
T_{15}	**75% RDF+PSB**	3.39	3.42	3.40	2.10	2.13	2.11	1.29	1.29	1.29
T_{16}	**75% RDF+VAM**	3.22	3.26	3.24	1.95	1.99	1.97	1.27	1.27	1.27
	SE(m)	0.10	0.11	0.07	0.05	0.07	0.04	0.07	0.06	0.05
	SE(d)	0.14	0.16	0.10	0.07	0.10	0.06	0.10	0.09	0.07
	CD(P=0.05)	0.28	0.34	0.21	0.15	0.22	0.13	0.21	0.19	0.14

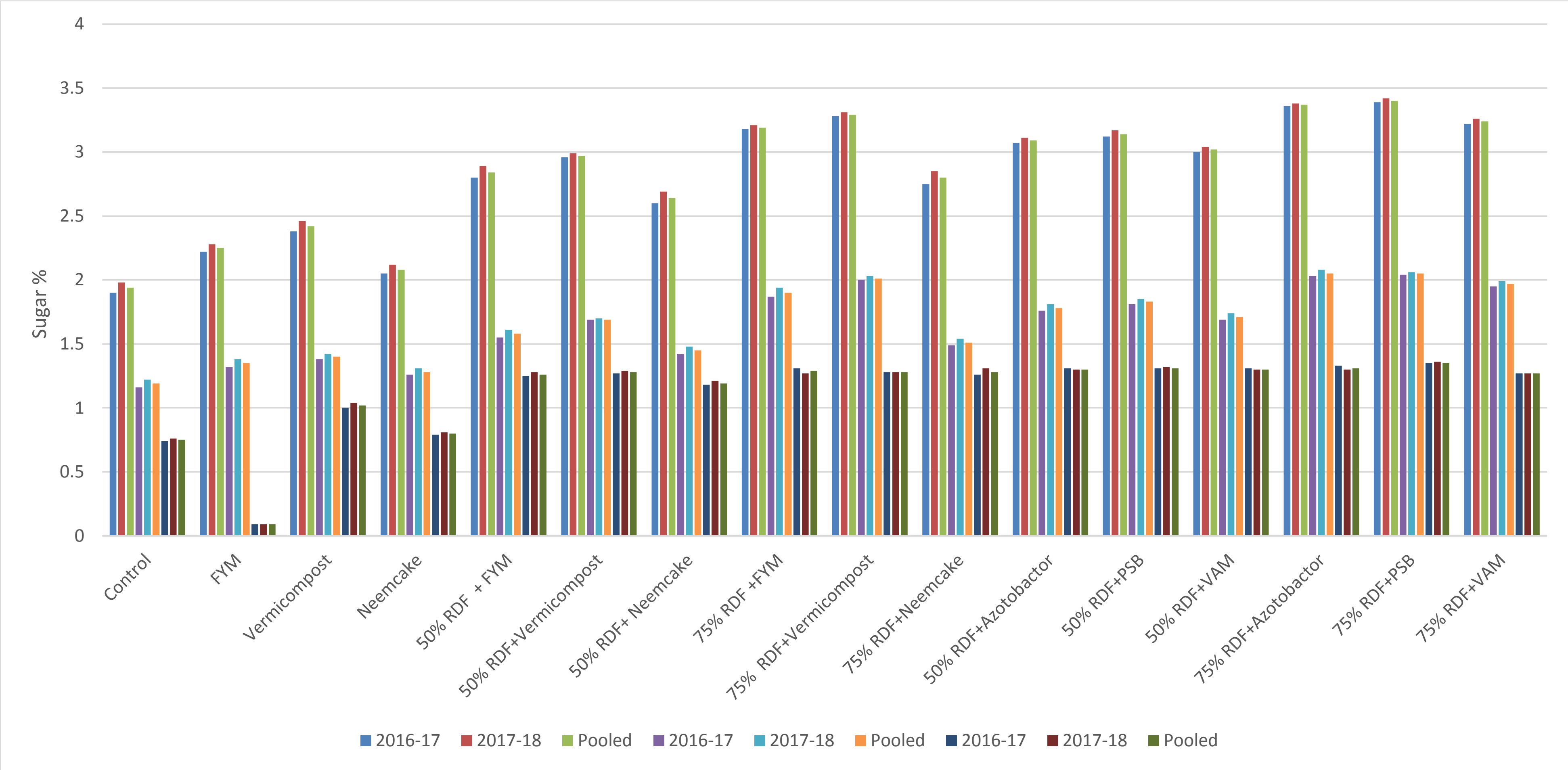


Figure 4.2.4 Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on reducing sugar (%), non-reducing sugar (%) & total sugars) during the year 2016-2017 and 2017-2018

Discussion

"Our goals can only be reached through the vehicle of a plan .There is no other route to success."

Chapter V

Discussion

A field investigation was conducted to study the "Effect of organic, inorganic and biofertilizers on growth, yield and quality traits of okra". The results obtained from the field and laboratory experiments are discussed in this chapter.

The relevant research studies on improvement of production potential in okra are meager and hence, the present investigation is aimed at increasing the seed production potential of okra by the use of organics, inorganic and biofertilizers with treatments combinations at various different doses.

After the green revolution, increase in production was achieved at the cost of soil health. The sustainable crop production at higher levels is possible only by the proper use of agronomic practices like plant nutrients which will help to increase the organic matter content of soils, thus reducing the bulk density and decreasing compaction.

5.1 Growth parameters :-

5.1.1 Plant height :-

The data obtained at the time of maturity of plants, the maximum plant height (100.55 cm) was recorded under the treatment T_{15} (75 % RDF + PSB) followed by T_{14}(75 % RDF + Azotobactor) and T_9 (75 % RDF + Vermicompost) .The minimum plant height (87.90cm) was recorded under T_1(control) followed by T_4(Neemcake). This result is corroborated with the findings of **Meena *et al.* (2018); Singh *et al.*(2018).**

5.1.2 Number of branches / plant :-

T_{15} (75 % RDF + PSB) produced maximum number of branches (5.01) followed by T_{14}(75 % RDF + Azotobactor) 4.91 and T_9 (75 % RDF + Vermicompost). This corroborated the result of **Kumar V., Saikia J.Barik N.,(2017)** who studied on " Influence of organic, inorganic and biofertilizers on growth, yield quality and economics of okra ". The results indicated that application of RDF recorded the highest branches per plant . **Bhusan A. BhatK.L. and Sharma J.P., (2013)** study supported that the effect of Azotobacter and inorganic fertilizers on growth, fruit and seed yield of okra cv. Hisar unnat.

5.1.3 Number of leaves / plant :-

The data obtained at 90 DAS, the maximum number of leaves per plant was recorded in T_{15} (75 % RDF + PSB) 48.12 followed by T_{14}(75 % RDF + Azotobactor) , however the minimum plant leaves were recorded under T_1(control) 33.05 followed by T_4(neemcake) similar nodules were obtained by **Bhagavantagoudra and Rokhade (2001).**

5.1.4 Diameter of stem (cm) :-

The data collected at 90 DAS, the maximum diameter of stem was recorded under the treatmentT_{15} (75 % RDF + PSB) 2.51 cm followed by T_{14}(75 % RDF + Azotobactor) 2.48 cmand T_9(75 % RDF + Vermicompost) 2.46 cm, and the minimum stem diameter of plant was noticed under T_1(control) . Parvatham *et al* (1989) agreed that inoculation of Bhindi cv. Pusa sawani, which increased the plant height, plant girth, number of leaves, root length and root volume significantly. In bhindi application of 25 t / ha FYM alone was ineffective when compared to FYM at 25 t /ha in combination with Azospirillum (2 kg /ha), phosphobacteria (2 kg /ha) and inorganic fertilizers (40: 50:30 kg NPK /ha) which exihibited the highest plant height, number of leaves and number of branches further this result is supported with the findings of **Rajasekhar *et al*., 1995.**

5.1.5 Number of days taken to first flowering :-

Least number of days taken to first flowering was reported under T_{15} (75 % RDF + PSB) 40.50 followed by T_{14}(75 % RDF +Azotobacter)40.67 days . The late flowering was recorded with T_1(control) 50.62 days . **Singh (1979)** who studied the effect of application and levels of N (0, 75 and 150kg / ha) and phosphorous and potash (0, 60, 120 kg/ ha) on pusa sawani variety in summer season at Varanasi, U.P. It was noticed that the application of only N and P respectively @ 75 and 60 kg / ha showed maximum value of yield and plant height, number of branches, number of days taken to first flowering, pod and size of pods per plant . The levels of K did not show any effect.

5.1.6 Number of fruits per plant:-

Highest number of fruits per plant were recorded underT_{15} (75 % RDF + PSB) 18.39 followed by T_{14}(75 % RDF +Azotobacter) 18.15 . Similarly the result was conformity by **Mal *et al.* (2014)** assessed the effect of diazotrophs (biofertilizers – Azotobacter, Azospirillum, Phosphate Solubilizing Bacteria) and chemical fertilizers that themaximum number of fruits per plant was recorded with FYM @ 10 t per ha + 75 % NPK + vermicompiost.

5.1.7Weight of fruit (g)

The highest fruit weight was recorded inT_{15} (75 % RDF + PSB) **14.96 followed by** T_{14}(75 % RDF +Azotobacter) and the lowest fruit weight was recorded in T_1(control)11.00 g .Similar result was also reported by **Bhushan A. Bhat K.L. and Sharma J.P., (2013)** who reported that the effect of Azotobacter and inorganic fertilizers on growth, fruit and seed yield of okra cv Hisar unnat.

5.1.8 Length of fruit (cm)

The highest fruit length of fruit 13.63 cm was observed under T_{15} (75 % RDF + PSB) followed by T_{14}(75 % RDF +Azotobacter) 13.59 cm . The lowest length of fruit was noted with T_1(control) 8.13 cm .Similar results are reported by Balasubramani (1988) that application Azospririllum to seed + oil with 30 kg N per ha recorded the highest fruit length, fruit girsth, fruit weight and number of fruits per plant in bhindi cv Pusa sawani . Inoculation of Azospirillum in soil significantly increased the total number of fruits, fruit length, girth and volume as well as the yield in bhindi cv. Pusa sawani **Parvatham and Vijayan, (1989).**

5.1.9 Diameter of fruit (cm)

T_{15}(75 % RDF + PSB) recorded maximum diameter of fruit 2.23 cm followed by T_{14}(75 % RDF +Azotobacter. The minimum girth was recorded in T_1(control) 1.98cm . This result conformity with the findings of **Kumar *et al.*(2017).**

5.1.10 Fruit yield per plant (g)

The highest fruit yield per plant was noted down inT_{15}(75 % RDF + PSB) 0.270 g followed by T_{14}(75 % RDF +Azotobacter.) 0.260 g and the lowest fruit yield per plant was recorded in T_1(control) 0.130 g **this result is quite close to the report of Bhusan *et al*; (2013)**study quite close to the report that the effect of Azotobacter and inorganic fertilizers on growth, fruit and seed yield of okra cv. Hisar unnat.

5.1.11 Fruit yield per hectare (q)

T_{15}(75 % RDF + PSB) 152.49 q produced the highest yield of okra at 90 days after sowing .This result supports the finding obtained by by **Bambal *et al*. (1968)**reported that application of Azotobactor + A zospirillum + 100% RDF significantly increased yield., This finding is in agreement with the findings of **Dhawale*et al*.(2010).**Who reported that significantly maximum plant height of the plant (215.46 cm) and number of branches (3.97) were recorded at 100 DAS .The treatment T_5 produced significantly maximum fruit yield per plant (0.124 kg) and fruit yield per ha (26.99 tones).

Various organic manures like farmyard manure, compost, green manure etc., that are added to the soil from time to time further add to the store of organic matter (**Palaniappan and Annadurai, 1999**). The application of FYM can help in improving yield levels in most of the crops under different agro - ecological regions, through correction of deficiencies of secondary nutrients, micronutrients. It also improves the soil physical properties which provide healthy and favourable soil conditions to enhance nutrient use efficiency.

Utilization of vermicompost in crop production is gaining much importance in the recent years under the concept of sustainable agriculture because vermicompost is known to contain plant nutrients, growth promoter substances and beneficial micro flora. With this background, an attempt was made to know the effect of organic manures, inorganic fertilizers and biofertilizers on crop growth, seed yield and quality parameters in okra. The results obtained in the present investigation has been discussed here under in light of the work done by others on okra and other related crops.

The results obtained during the course of investigation has been discussed in the light of literature available on okra as well as other vegetable crops to make the findings of the present investigation logical and meaningful. In this chapter there will be a specified and broad discussion on the results obtained during the course of the research in order to justify the also current research program. After keenly examining the data we have reached the conclusion that there are various factors which require references to various findings with clarifications of objectives. Results obtained after keeping the okra crop under the effect of organic manures, inorganic fertilizers and biofertilizers on growth, yield and quality traits of okra.

- Plant height, Branches, nodes and leaves are the manifestation of morphological, physiological, biochemical and growth parameters and are considered to be resulted from the trapping and conversion of solar energy efficiency.
- The maximum plant height at 30 DAS, 60 DAS and 90 DAS(43.75 cm, 73.90 cm and 100.55 cm) was observed under T_{15}, while, minimum plant height was (cm) recorded under control. These findings clearly indicated that vermicompost and Azotobacter played a significant role in enhancing the growth of okra. The beneficial effect of vermicompost on plant growth might be attributed to the fact that the earthworms mineralize macro and micronutrients during vermicompost and made available to crop plants for longer period. The results are in close conformity with the findings of in okra **Peyvast *et al.* (2007).**
- Application of vermicompost @ 5 t ha-1 + Azotobacter alone or in combination had influenced the plant height significantly at 30 DAS, 60 DAS and at 90 DAS over control.
- The data discussed in chapter 4 revealed that application of bio-organics had influenced the number of branches per plant,. The maximum branches per plant (5.01), were recorded under treatment T_{15} Application by bio-organics i.e. vermicompost @ 5t ha-1 + PSB in combination also resulted in the highest number of branches . Vermicompost has solubilizing effect on some mineral compounds present in the soil and brings about the conversion of a

number of chemical elements into available form to plants. In addition, they also improve the structure, aeration and water holding capacity of soil. The results are in close conformity with the findings **Vanmasthi *et al.(*2014).**

- The induction of early flowering due to the application of PSB and azotobacter was mainly described to the process of bio regulators, which have an influence on early flower initiation. These results are in line with the findings of **Nirmala and Vadivel (1999)** in bitter gourd. Another probable reason may be due to better nutritional status of the plants. which was favored by the treatments. Increased production of leaves might help to elaborate more photosynthates and induced flowering which stimulated, early initiation of flower bud and increased seed setting.

- In the present study, days to 50 per cent flowering was not significantly influenced by combined application of inorganic and organic manures. The application of recommended dose of fertilizer + Phosphate solubilizing bacteria recorded less number of days to 50 per cent flowering (45.15) followed by 75 % RDF + Azotobacter (45.20) which was on par with 75 % RDF + VC (45.28). Whereas T_1(control) and treatment T_4(Neemcake) took more number of days (50.62) and 49.49 respectively to 50 per cent flowering.

- Yield is polygenic in nature and is influenced by several factors (internal and external) throughout the crop growth period. The number of fruits per plant and the branches, number of nodes per fruit are the major yield components that determine the fruit yield. Among the nutrient treatments, 75 % RDF + PSB, recorded highest number of fruits per plant similar results have also been reported by **Subbarao and Ravishankar (200**1) in brinjal and **Patil (1995)** in tomato.

- Increase in number of fruits per plant is due to production of more number of flowers, higher per percentage of fruit set and reduced shedding of flowers and fruits and resulted in increased fruit. Increase in the levels of fertilizers along with organic manure and biofertilizers (phosphate solubilizing bacteria) influenced significantly fruit yield and its components.

- Application of 100 kg N ha-1 resulted in the maximum and significantly more values of yield and yield attributes viz., number of fruits per plant (18.39), fruit length (14.01 cm), fruit weight (14.93 g), fruit yield per plot (**5.490)** and fruit yield ha-1 in quintal per hectare (**152.495**) as compared to control, 60 and 80 kg N ha-1, whereas, all the above mentioned parameters remained statistically at par with 120 and 140 kg N ha-1. It is relevant to mention here that adequate supply of nitrogen to plants not only promotes the synthesis of food but also its subsequent partitioning in sink. The application of nitrogen favored the metabolic and auxin activities in plant and ultimately resulted in increased fruit size, number of fruits per plant, fruit weight and yield ha-1. These findings are similar of those reported by in okra crop **Garwal *et al.*(2007).**

Effect of organic, inorganic manure on Biofertilizers on Biochemical parameters

Ascorbic acid content 11.67 was recorded with the treatment T_{15} (75% RDF +PSB). It means that combined application of different biofertilizers specially phsoahate solubilizing Bacteria helped in the maximum yield in Ascorbic acid content Total soluble solids (2.94 ^{0}Brix) was recorded in treatment T_{15}(75% RDF +PSB) **Mishra *et al.*(2014**) in knolkhol, reported that the TSS content was increased with the increase in the nutrient level in the soil.

Summary and Conclusion

"Great things are not done by impulse, but a series of small things brought together"

Chapter VI

Summary and Conclusion

The present investigation entitled " Effect of organic, inorganic and biofertilizers on growth, yield and quality traits of okra [*Abelmoschus esculentus* (l.) Moench.] was carried out at the Horticulture Research Farm-II of the Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Vidya Vihar Rae Bareli Road, Lucknow. The results obtained from the investigations are summarized in this chapter. The field experiment consisted of 16 treatment combinations viz., control, Farmyard manure, Vermicopost,Neemcake, 50%RDF+Farmyard manure , 50%RDF+Vermicompost, 50 % RDF + Neemcake, 75 %RDF +Farmyard manure,75%RDF +Vermicompost, 75% RDF+Neemcake, 50%RDF+Azotobacter, 50%RDF+PSB, 50% RDF +VAM, 75%RDF+Azotobacter., 75%RDF+ PSB, 75 %RDF+VAM, and was laid out in RBD with randomized block design having three replications with single standard of okra cultivar. The salient findings of the investigations are summarized below:

- To find out the effect of organic fertilizers on growth, yield and quality traits of okra.
- To investigate the effect of inorganic fertilizers on growth, yield and quality traits of okra.
- To assess the effect of biofertilizers on growth, yield and quality traits of Okra.
- To study the combined effect of organic, inorganic and biofertilizers on growth yield and quality traits of okra.

The days taken days to germination of fruit initiation to half grown in each selected plants of plots were recorded from the date of sowing and expressed as days to germination 50%.For only PSB it took around 5.40 days to give 50 % of germination in both the years of germination 2016-2017 and 2017-2018 .When no any treatments combinations were used i.e. in control treatment accordingly poor results were obtained 7.05 days were required by the Okra to grow. The second combination which gave the best result 75% RDF and azotobactor . 100 % germination was observed around 10-11 days of sowing, with the T_{15} (75 % RDF + PSB)100 % germination was observed earlier after T14(75 % RDF + azotobactor) in both the years 2016-2017 and 2017-18 .minimum number of days were used by 75%RDF+PSB, optimum days for 100 % germination of Okra was found to be 13.05 days it was achieved by control treatment having no combination of fertilizer followed by neemcake took this optimum time for growth. The duration of 100% germination was much better in integrated use of inorganic, organic and biofertilizers. When compared to the control the results of experiments were much better in T_{15} (75 % RDF + PSB took minimum 10.20 days for 100% germination.

After 60 days also the result was quite similar to the result of 30 days to sowing 75% additionally with PSB gave the height nearly double to 30 days in both the years when the average value was pooled out. This plant height was accompanied by the height of plant of the plot which was provided treatment with 75% RDF and PSB. No changes were observed from the earlier results 75% RDF and PSB combination was found to be the best one at last day of reading. To plant height the weakest result was shown by the control treatment .

Stem diameter is also a significant parameter, From each plot five plants were chosen for the calculation of the girth the strongest girth was found to be 2.51 cm it was again obtained by the combination of 75%RDF and PSB, 75%RDF and Azotobactor showed sort of equivalent results. The weakest result was given by the control treatment

Branches on plants have indicated the number of fruits to be more .The data on number of branches per plant at 30, 60,and 90 DAS as influenced by application of organics, inorganic and biofertilizers are presented in Table 4.5 At 30 days after sowing (DAS) The number of leaves per plant at 30 days after sowing in okra did not vary significantly due to application of organic, inorganic and biofertilizers. However, plants applied with 75 %RDF + PSB treatment recorded numerically more number of branches (2.27) at 30 DAS . whereas; less number of branches (1.47) per plant at 30 DAS was recorded with plants treated with control treatment during the experimentation. In general the highest mean number of branches per plant recorded was 3.29. At 90 days after sowing Non-significant differences were observed in number of branches per plant at 60 days after sowing in okra due to application of organic, inorganic and biofertilizers.

The data on number of leaves per plant as influenced by application of organic, inorganic and biofertilizers are presented in Table 4.6 and Fig.4.6. Number of leaves per plant differed significantly due to application of organic, inorganic nutrients and biofertilizers. Plants supplied with 75 %RDF + PSB($T_{15)}$recorded significantly higher number of leaves per plant (48.12) at 90 DAS and was followed by T_{14} (75 % RDF+ Azotobacter). Effect of organic, inorganic and bio-fertilizer as influenced by the treatments on number of nodes at 30 DAS (Days after sowing), 60 DAS, 90 DAS. During the year 2016-2017 and 2017-2018.The data on number of nodes per plant as influenced by application of organics, inorganic and biofertilizers are presented in Table 4.7. The data on number of nodes as influenced by organic, inorganic nutrients and biofertilizers exhibited non-significant difference. However, T_1(control) treatment followed by T_4(Neemcake) recorded least number of nodes 12.82 and 12.95 respectively at 90 DAS . Compared to all other treatments Highest number of nodes were found to be given by the combination of 75 % RDF and PSB, which proved out to be the best combination that came out.

The internodal length was calculated with the help of the scale and the distance between the two consecutive nodes were calculated .Like other experimentation in this also significant results were found in 75 %RDF with PSB which was found to be 7.76 the best of the result was attained by the combination of 50 %v RDF and PSB .

The number of days to first flowering and 50 % flowering in Okra plant by incorporation of organic inorganic and biofertilizers were best studied at T_{15}(75 % RDF and PSB) the second best combination proved out to be T_{14}(75 % RDF and Azotobactor) . Out of all these the least number of result was given by control treatment and Neemcake treatment . The best result was as much least as 45.15 with 75 % of RDF and PSB, one noticeable result was given by T_1(control) which actually took longer number days.

The number of fruits harvested from the okra plants 75%RDF and PSB (T_{15}) gave the result as 18.39 number of fruits and 18.15 was the result obtained by 75 % RDF and Azotobactor while the average least number of fruit per plants (12.60) has been recorded under control. The maximum fruit weight was obtained with the combination of 75 %RDF and PSB while the second best combination was achieved by 75% RDF and Azotobacter.. Similar results were obtained in the case of fruit diameter and fruit length.

The days to first picking has been mentioned in the table 4.12 and all together there were 16 treatments and all the treatments were compared in accordance to days to first picking.75 % RDF and PSB gave the significant result with an average of 63.90 and the second best result was given by the 75 % RDF and Azotobactor . The least were shown by control .

Fruit yield per plant, fruit yield per plot, fruit yield per hectare were the three parameters which were compared in this experiment. The highest fruit yield was obtained during both the year 2016-2017 and 2017 -18 was from treatment combination (75 %RDF and PSB)although this is an average workout 75 % RDF and Azotobacter also showed a good result. The least of all results were found to be in control.

Number of seeds per plants were found to be more in 75 % RDF and PSB with 52.31, the second best result was given by 75 % RDF + Azotobacter .

Total soluble solids were pooled out in the okra plant which were treated with organic, inorganic and biofertilizers, total soluble solids were found to be higher in the plants which were harvested from the plot which were supplemented with 75% RDF +PSB and also the second treatment which showed good result was 75 % RDF + Azotobacter. Data regarding the average ascorbic acid content in the crop under the influence of various inorganic, organic and biofertilizers has been mentioned in table 4.17 and explained in the figure 4.17 with the help of comparative graph. The highest ascorbic acid content was found to be in 75 % RDF and PSB combination the second best result was given by the combination of 75% RDF and Azotobacter.

Data collected under the influence of different organic, inorganic and biofertilizers given were interpreted under the following results. Total sugar, Reducing Sugar and Non reducing Sugar was found to be highest in the combination of 75 % RDF and PSB, while the least was found in control treatment . The incorporation of organic and inorganic manure as well as biofertilizers majorly affected the sugar content in the okra crop.

Conclusion

Based on the field experiment carried out during the course of investigation of both the years 2016-2017 and 2017-2018 respectively.

1. Application of RDF + Phosphate solubilizing bacteria was found beneficial for obtaining higher seed yield as well as better quality seeds in okra cultivar Kashi Pragati.

2. Application of 120:60:60 kg NPK/ha + PSB recorded the highest fruit yield and quality seeds under Lucknow conditions.

3. Combined application of 75% RDF + Azotobacter and 75% RDF + Vermicompost to okra crop is found next best nutrient combination for getting higher seed yield and seed quality.

It can be revealed from the present investigation that the best results with respect to vegetative, flowering, fruiting and yield parameters as well as with respect to chemical aspects has been recorded in the treatment -15 ($T_{15,}$ 75% RDF + PSB) followed by T_{14}(75 % RDF + Azotobactor) and T_9(75% RDF + Vermicompost) also showed nearly the similar good results during the entire course of experimentation work.

It is very clearly visible from the tables and figures depicted in experimental findings chapter IV that days to germination 50 %, days to germination 100 %, plant height, stem diameter, number of branches, number of leaves, number of nodes, intermodal length, days to first flowering, days to 50 % flowering, number of fruits per plant, fruit weight, fruit length, fruit diameter, days taken to first picking, number of seeds per fruit, T.S.S., ascorbic acid, total sugars, reducing sugar, non-reducing sugar, all these parameters resulted best when the experimental plots were treated with 75% RDF in combination with PSB followed by 75 % RDF + Azotobactor and 75 % RDF + Vermicompost also showed nearly good result . The control treatment that is not treated with any kind of treatment combination showed lower results followed by the neemcake treatment when neemcake was given separately during the course of experimentation work .

Future Line of work

In continuation of the present investigation, the following future line of work can be taken up for producing higher quality seed in okra.

1. Studies are to be initiated to find out the appropriate strains, rates and time of inoculation of N_2 fixers and P-solubilizers under diverse agro - climatic conditions for promoting fruit yield and quality potentality of okra.

2. Long - term studies on Biofertilizers and other sources of nutrients need to be initiated to develop integrated nutrient management schedule for higher fruit yield and seed quality in okra.

3. Studies on varying doses and time of application of micronutrients are to be taken up for further investigation.

4. Research on residual effect of various organic sources under different environments and management practices need to be initiated.

5. Biofertilizer technology needs to be refined to it make more acceptable by seed producers. Microbial strains which can compete with indigenous ones and work efficiently over a wide range of soil climatic conditions are to be identified and investigated for seed yield and quality.

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"when you achieve the goal, Let's remember the formers role"

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