

**Effect of integrated nutrient management  
on growth, yield and quality of okra  
[*Abelmoschus esculentus* (L.) Moench]**

**THESIS**

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

BABASAHEB  
BHIMRAO  
AMBEDKAR  
UNIVERSITY



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ESTABLISHED 1996

For the Degree of  
**Doctor of Philosophy**  
In  
**HORTICULTURE**

*Supervisor:* **Dr. M. L. Meena**      *Submitted By:* **Dinesh Chandra Meena**

DEPARTMENT OF APPLIED PLANT SCIENCE (HORTICULTURE)  
SCHOOL FOR BIOSCIENCES AND BIOTECHNOLOGY  
BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY  
(A CENTRAL UNIVERSITY)  
VIDYA VIHAR, RAEBARELI ROAD, LUCKNOW-226 025 (U.P.), INDIA

**2019**

**Enrolment No. 010/12**



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*Dedicated to  
My Beloved Parents*

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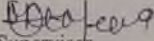
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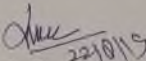
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Date: <sup>22</sup> /08/2019

  
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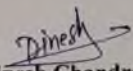
## Declaration

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I **Dinesh Chandra Meena**, (Enrolment No.010/12). I hereby declare that, thesis entitled “**Effect of integrated nutrient management on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]**” submitted the thesis for the fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Horticulture, Department of Applied Plant Science (Horticulture), under the School for Biosciences and Biotechnology, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow-226 025 (U.P.) India, was carried out by me during the experimentation period of 2015-16 and 2016-17 are my own and original work.

Date: 22/08/2019

Place: Lucknow

  
(Dinesh Chandra Meena)  
Research Scholar

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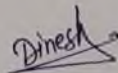
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**Date: 22/08/2019**

**Place: Lucknow**



**(Dinesh Chandra Meena)**

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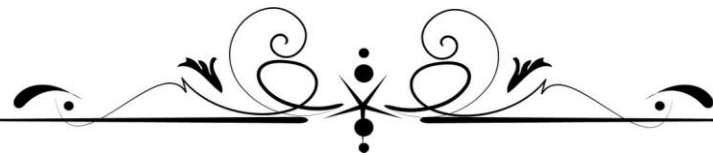
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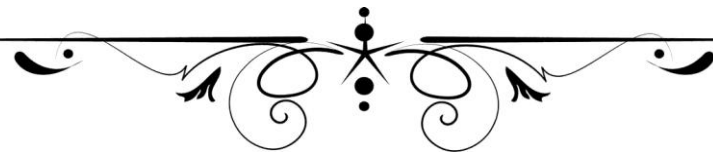
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## List of Abbreviations

%	:	Per cent
@	:	At the rate of
<sup>0</sup> C	:	Degree Centigrade
a.i.	:	Active ingredient
C.D.	:	Critical Difference
Cm	:	Centimeter (s)
cv.	:	Cultivar
DAS	:	Days after Swoing
et al.,	:	et alli (and others)
etc.	:	et cetera (and so on)
Fb	:	followed by
Fig.	:	Figure
G	:	gram (s)
Ha	:	Hectare (s)
i.e.	:	id est (that is)
K	:	Potassium
K <sub>2</sub> O	:	Potash (Potassium oxide)
Kg	:	Kilogram (s)
m.	:	Meter (s)
m <sup>2</sup>	:	Square meter
Max.	:	Maximum
Min.	:	Minimum
Met.	:	Meteorological
Mg	:	Milligram (s)
Mm	:	Millimeter
N	:	Nitrogen
N.S.	:	Non significant
No.	:	Number
P	:	Phosphorus
pH	:	Pussance de hydrogen
Rh	:	Relative humidity
S.E.m.±	:	Standard error
T	:	Tonnes
Viz.	:	Videlicet (namely)



*Chapter 1*  
*Introduction*



## Introduction

---

Okra [*Abelmoschus esculents* (L.) Moench] is one of the most important rainy and summer season vegetable crop, belongs to family Malvaceae with  $2n=8x=72$  or 144 and is polyploidy in nature. It is known by many local names in different parts of the world. It is called lady's finger in England, guino - gombo in Spanish, gumbo in the United States of America, 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 (**Chauhan, 1972**).

It is native of tropical and sub 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 5.07 million hectares with annual production of 58.5 million tonnes and productivity of 11.5 tons per hectare (**Kumawat et al., 2019**).

Okra is cultivated for its green non - fibrous fruits or pods containing round seeds. The fruits are harvested when immature and eaten as a vegetable. Okra fruit can be cooked in a variety of ways. The dried stems and roots of okra are used for clarification of sugarcane juice in gur or jaggery manufacture in India. Its ripe seeds are roasted, ground and used as a substitute for coffee in some countries. Mature fruits and stems containing crude fiber are used in manufacture of paper, card board and fibres. It is also an excellent source of iodine and is useful for the treatment of goiter. Fruit is useful against genito-urinary disorders, spermetorrhoea and chronic dysentery. Fruits are also dried or frozen for use during off-season. It is a good source of vitamins A and B, Protein and minerals. The nutritional value of 100 g of edible okra is characterized 35.0 mg calories, 66.0 mg calcium, 0.35 mg iron, 6.4 g carbohydrates, 103.0 mg potassium, 1.9 g protein, 0.2 g fat, 53.0 mg magnesium, 0.19 mg copper, 1.2 g fiber, 0.01 mg riboflavin, 0.7 g minerals, 0.07 mg thiamine, 56.0 mg phosphorus, 0.06 mg nicotinic acid, 6.9 mg sodium, 13.10 mg Vitamin C, 30.0 mg sulphur and 8.0 mg oxalic acid is present (**Gopalan et al., 2007**). Dried fruit contain 13-22% edible oil and 20-24% protein and used for refined edible oil. Dried seeds are nutritious food.

It contains up to 20% protein and the fiber from okra canes is a possible paper pulp source, while the dried canes are a fuel source (**Lyngdoh *et al.*, 2013**).

Nutrition plays a very important role in growth and productivity of okra. Now days, use of inorganic and organic nutrient sources is playing significant role in horticulture. It plays a major role for producing good quality and high yield per unit area.

Biofertilizers is a substance which contains living micro-organisms which, when applied to seed, plant surfaces or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus and stimulating plant growth through the synthesis of growth-promoting substances. Biofertilizers are able to fix atmospheric nitrogen and they also enhance the availability of nutrients to plants on application to seed (or) soil and offer an eco-friendly, economically viable and socially acceptable means of reducing external input of chemical fertilizers.

The micro-organisms in biofertilizers restore the soil's natural nutrient cycle and build soil organic matter. Through the use of biofertilizers, healthy plants can be grown, while enhancing the sustainability and the health of the soil. Since they play several roles, a preferred scientific term for such beneficial bacteria is "plant-growth promoting rhizobacteria" (PGPR). Therefore, they are extremely advantageous in enriching soil fertility and fulfilling plant nutrient requirements by supplying the organic nutrients through micro-organism and their by products. Hence, biofertilizers do not contain any chemicals which are harmful to the living soil.

The requirements of fertilizers in okra are important for the early growth and total production of fruit yield. Integrated use of organic and inorganic fertilizers can improve crop productivity (**Mal *et al.*, 2013**). The integrated nutrient management is helpful in increasing the yields in crops as well as maintains soil fertility in better condition. The precise information on integrated nutrient management for maximum production and better quality will be of immense value to okra growers. The most important elements present in inorganic fertilizers are phosphorus, potassium and nitrogen 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 (**Sanwal *et al.*, 2007**). A combination of organic and inorganic sources of nutrients might be helpful to obtain a good economic return with good soil health for the subsequent crop yield (**Deshmukh *et al.*, 2010**). Organic fertilizer released all type of micro and macro nutrients that helps to plant elongation. Organic fertilizers improved soil physical properties and supplied of essential plant nutrients for higher growth of plant, protect soil against erosion, supply the cementing substance for desirable aggregate soil formation and loosen the soil. Application of manures sustains cropping system through better nutrient recycling and provides all necessary nutrients, thereby improving the physical and biological properties of soil (**Shahriazzaman *et al.*, 2014**).

Vermicompost means a mixture of worm casting, organic materials, humus, living earthworms, their cocoons and other organisms. Vermicompost is a slow nutrient releasing organic manure which have most of the macro as well as micro nutrients in chelated form and fulfill the nutrient requirement of plant for longer period. Vermicompost is being a stable fine granular organic matter, when added to soil, it loosens the soil and improves the passage to the entry of air. The organic carbon in vermicompost releases the nutrients slowly and steadily into the system and enables the plant to absorb the nutrients. The soil enriched with vermicompost provides additional substances that are not found in chemical fertilizers. It is also an added advantage of the vermicompost. Vermicompost is made up primarily of C, H and O and contains nutrients such as NO<sub>3</sub>, PO<sub>4</sub>, Ca, K, Mg, S and micronutrients which exhibit similar effects on plant growth and yield as inorganic fertilizers applied to soil (**Singh *et al.*, 2008**). Vermicompost an organic source of plant nutrients contains a higher percentage of nutrients necessary for plant growth in readily available forms (**Nagavallema *et al.*, 2004**).

The FYM improves physio-chemical properties of soil and encourages the soil microbial activities that the make the plant- food elements in the soil readily available to crop. Increase in nutrient availability especially of nitrogen and phosphorus is also noted with inoculation of FYM in soil and it is advantageous for its residual value.

Use of organic, inorganic and biofertilizers have played a very important role in determining the yield of the crop in the recent times. The basic concept of integrated nutrient management (INM) is to maintain or adjust the soil fertility and plant nutrient supply in long run to reach the optimum level for sustaining crop production and optimization of the benefits from all possible sources involving inorganic fertilizers, biological sources and organic manures. Fertilizer, even though comparatively a costly input of production is essential for securing higher yield and should be supplied in adequate quantity as it an important input in crop production. Some soil micro-organisms play an important role in improving soil fertility and crop productivity due to their capability to fix atmospheric nitrogen, solubilise insoluble phosphate and decompose farm waste resulting in the release of plant nutrients. When the number and activity of specific micro-organisms called microbial inoculants or biofertilizers is used to hasten biological activity to improve availability of plant nutrient. They are useful in sustainable agriculture. The use of biofertilizers like *Azospirillum*, *Azotobacter* and PSB are recently attempted for improvement of yield of vegetable crops. Use of organic manures to meet the nutrient requirement of crop would be an inevitable practice in the years to come for sustainable agriculture since, organic manures generally improve the soil physical, chemical and biological properties along with conserving the moisture holding capacity of soil and thus resulting in enhanced crop productivity along with maintaining the quality of crop produce (**Maheswarappa et al., 1999**). Although the organic manures contain plant nutrients in small quantities as compared to the fertilizers, the presence of growth promoting principles like enzymes and hormones, besides plant nutrients make them essential for improvement of soil fertility and productivity (**Bhuma, 2001**).

*Azospirillum* is one of the most important symbiotic nitrogen fixing organisms having nitrogen fixing ability. It is type of symbiosis where the bacteria remain in direct contact with plant root and fix nitrogen. These bacteria can not only fix 10-40 kg N ha<sup>-1</sup> but also secrete growth promoting substance which favors better growth of plant. It also saves nitrogenous fertilizers up to 25-30% (**Sharma, 2002**).

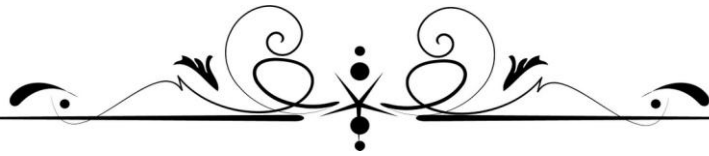
Vesicular Arbuscular Mycorrhiza one of the important type of endo mycorrhizae. VAM plays a great role in inducing plant growth. VAM fungi as a biofertilizer, in terms of cost effectiveness, energy saving and as environment friendly, is a promising perspective. The significance of VAM in augmenting food

production is far and wide; therefore these can be used in sustainable agriculture. *Mycorrhizae* are the root-symbionts which obtain their nutrients from the plant and provide mineral elements like N, P, K, Ca, S and Zn to the host plant. This review is an attempt to explore the suppressing abilities of Arbuscular Mycorrhizal Fungi (AMF) against soil borne pathogens (root feeding nematodes and fungi), infecting various crops. AMF to increase the productivity of vegetable crops (**Abbasi et al., 2015**).

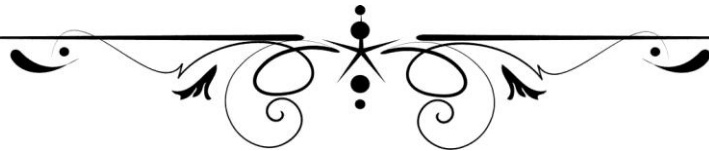
The efficiency of phosphate fertilizer is very low (15-30%) due to its fixation in soil. Besides native soil phosphorus is mostly unavailable to crop because of its low solubility. Phosphate Solubilizing Bacteria (PSB) is another important biofertilizer which has capacity to solubilize the native phosphorus due to secretion of organic acid. It also produces plant growth promoting substances like vitamin B<sub>12</sub> and auxin.

Biological nitrogen fixation depends on the available form of nitrogen. There is good scope to improve crop production involving N-fixing and phosphate solubilizing micro-organism which increases crop yield and nutrient uptake. Biofertilizer secretes certain growth promoting substances. Further, they are harmless, eco-friendly and low cost agro- input supplementary to chemical fertilizers. They increase the soil fertility, improve soil structure, porosity and water holding capacity and also enhance seed germination. Under certain conditions they exhibit anti- fungal activities and thereby protect the plants from pathogenic fungi. Keeping in view the above facts in mind an investigation entitled **“Effect of integrated nutrient management on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]”** was proposed with the following specific objectives:-

- 1) To find out the effect of integrated nutrient management on growth parameters of okra.
- 2) To assess the integrated nutrient management on yield attributes on okra.
- 3) To determine the efficacy of integrated nutrient management on quality of okra.
- 4) To investigate the combined effect of integrated nutrient management on growth, yield and quality traits of okra.



*Chapter 2*  
*Review of Literature*



# REVIEW OF LITERATURE

---

The present research work entitled “**Effect of integrated nutrient management on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]**” was conducted. The review of literature showed that such type of research work was carried out either in different regions or in other vegetable crops. Therefore, there was need to conduct present experiment. The literature pertaining to the topic of study has been reviewed in the present chapter for reference to draw suitable conclusions for the observations recorded:-

### 2.1 Vegetative growth attributes

**Nanthakumar and Veeraraghathatam (1996)** reported that combined application of nutrients through 12.5 t ha<sup>-1</sup> of FYM + 2 kg each of *Azospirillum* and PSB + inorganic fertilizers at 75% of recommended dose of N, P and 100% of K favorably influenced the growth, yield (36.48 t ha<sup>-1</sup>) and quality of brinjal.

**Varu et al., (1997)** observed that an application of FYM (95 t /ha) + NPK (50-25-25 kg/ha) + Dharatidhara (concentrated organic manures) (2 t / ha) reflected in maximum plant height (43.45 cm) and number of leaves per plant (7.05) in onion.

**Sendur et al., (1998)** studied that application of organic manures (FYM, vermicompost, neem cake) combined with recommended dose of inorganic fertilizers showed superior performance in respect of growth and fruit yield of tomato.

**Kumaran et al., (1998)** noted that an application of FYM + 100% NPK (150:100:50) kg ha<sup>-1</sup> with *Azospirillum* and Phosphobacteria in tomato gave the best results in terms of plant height (75.76 cm).

**Terry et al., (2000)** revealed that an inoculation with *Azospirillum* at sowing time increased plant height in tomato and was the best treatment giving a positive effect on growth parameters and yield.

**Nirmala and Vadivel (2000)** obtained significantly highest vine length, no. of leaves/plant, leaf area, minimum number of days and earlier node for first female flower appearance and closest sex ratio in cucumber by the combined application of 30 t FYM and *Azospirillum* + PSB+ VAM bacteria as soil inoculation (2 kg/ha each). It was also reported that these results were significantly superior over recommended dose and control.

**Atiyeh et al., (2000)** found that when 20 % commercial horticultural medium was replaced by vermicompost resulted significantly higher the plant height, root and shoot biomass in tomato crop.

**Barekar (2000)** observed earliness in 50 % flowering in chilli at plants applied with 150:50:50 kg NPK/ha plus 10 t of FYM/ha in combination with PSB biofertilizers.

**Sannigrahi and Borach (2001)** reported that plant height increased with 20 t ha<sup>-1</sup> FYM + NPK 50 % significantly over the control in okra crop.

**Meena (2001)** carried out a field experiment in fenugreek crop grown on loamy sand soils of Jobner reported that application of 75% N through FYM + 25% N through urea significantly increased the plant height, branches per plant and dry matter accumulation per meter row length over rest of the combinations of FYM and urea.

**Bhagvantagoudra and Rokhade (2001)** reported that the treatment with *Azospirillum* through soil application with seedlings dipping recorded the maximum plant spread (46.22cm) plant height (26.44cm) and number of leaves per plant (22.70) in cabbage.

**Krishna and Krishnappa (2002)** revealed that the effect of NPK fertilizer applied with or without organic manures on the yield and quality of tomato cv. Avinash-2 was investigated during rabi 2000-01 in Bangalore, Karnataka, India. In general, NPK at 250:250:250 kg/ha plus Agrimagic at 16.87 t/ha or farm yard manure at 38 t per ha recorded the maximum values for the different yield and quality parameters. These treatments also recorded the longest shelf life and the lowest physiological weight loss of fruit.

**Anburani and Manivannan (2002)** reported that the FYM + poultry manure at 12.5 t/ha each along with 100% NPK + biofertilizers recorded the maximum plant height, number of primary branches and number of leaves per plant, where as FYM at 25 t/ha along with 100 % NPK + biofertilizers recorded the maximum number of secondary branches per plant in brinjal cv. Anamalai.

**Prabu *et al.*, (2002)** reported that 25% recommended dose of fertilizer (RDF @ 90:80:50 NPK kg ha<sup>-1</sup>) + 10 t FYM ha<sup>-1</sup> with biofertilizers (*Azotobacter* + VAM) gave significantly higher plant height and root: shoot ratio of coriander as compared to recommended dose of fertilizer at Prabhani (Maharashtra).

**Naidu *et al.*, (2002)** obtained maximum plant height, fruit girth and 50% flowering of brinjal with 75:35:0 kg per ha N P K along with organic manures.

**Malawadi (2003)** found that the plant height, number of branches, leaf area and total dry matter production in various plant parts of chilli recorded significantly higher values with combined application of NPK +FYM as compared to NPK alone.

**Kumar *et al.*, (2003)** reported that plant height and dry matter accumulation per plant of mung bean improved significantly with application of vermicompost @5 t ha<sup>-1</sup> over control.

**Arancon *et al.*, (2003)** reported that when vermicompost applied @ 5 t ha<sup>-1</sup> or 10 t ha<sup>-1</sup> the shoot weight and leaf area of pepper plant increased in comparison with inorganic fertilizers only.

The application of organic fertilizers viz., FYM, chilli stalks and FYM chilli stalks with inorganic fertilizers significantly influenced growth of chilli and the magnitude of combined effect of organic and inorganic was higher than inorganic fertilizer alone (**Kattimani, 2004**).

**Patil *et al.*, (2004)** noted that growth of cumin including plant height and branches per plant increased significantly due to application of recommended dose of nitrogen in the form of FYM + inorganic fertilizer in ratio of 1:1 over FYM or inorganic fertilizer alone.

**Khoja (2004)** on the basis of results of a field experiment concluded that application of nitrogen through integrated sources i.e. FYM (N30) + urea (N30) + *Azotobacter* significantly increased the plant height, number of branches, dry matter accumulation, leaf area, LAI, CGR and chlorophyll content over rest of the treatment combinations.

**Jat and Ahlawat (2004)** reported that the vermicompost application @3 tonnes ha<sup>-1</sup> significantly increased the growth and yield attribute (pods/plant) and seed straw yield of chick pea over control.

**Kumar and Sharma (2004)** noted that an application of FYM + 150% NPK in tomato and cabbage gave the best results in terms of plant height (178.3 and 30.8 cm) respectively.

A progressive increase in plant height and leaf area index of soya bean was observed with the conjunctive use of 75% N through vermicompost and remaining 25% N through chemical fertilizer and was found at par with 100% N through vermicompost alone. The additive benefit realized from vermicompost application (**Govindan and Thirumurugan, 2005**) might be ascribed to its higher nutrient contents and their availability to crop.

**Ray et al., (2005)** reported that okra seeds treated with *Azospirillum*+ 100% NPK + 15 t FYM showed maximum plant height (42.37, 56.97 and 66.18 cm) days after sowing.

**Powan and Aguziyoh (2005)** reported that combined application of 100 kg P and 20 t FYM ha<sup>-1</sup> gave the maximum plant height in potato as compared to control which resulted in the minimum plant height.

**Yadav et al., (2006)** recorded that an application of FYM and gypsum into cauliflower plant resulted in maximum plant height (59.2 cm in 2001-02 and 57.9 cm in 2002-03), maximum number of leaves per plant observed (14.6 in 2001-02 and 13.6 in 2002-03) in both the years of experimentation.

Application of different organic nitrogen source significantly influenced the tomato growth and yield. Among the different organic source substitution of 100% N as FYM

recorded plant height, number of branches per plant and yield comparable to then of 100 % nitrogen as urea (**Kannan *et al.*, 2006**).

**Rajan and Mahalakshmi (2007)** reported that the number of leaves produced in cowpea and radish seedling were maximum in treatment containing 75% vermicompost. The leaf area, tuber length and wet weight of radish were maximum in 100 % vermicompost applied plots.

**Peyvast *et al.*, (2007)** showed that an addition of vermicompost to soil can increase plant height and number of leaves significantly in spinach.

**Kumar and Sharma (2007)** revealed that tomato seeds were treated with *Azotobacter* + 100% NPK + FYM showed highest plant height (153.20 cm) in both the years of experimentation.

**Bharadiya *et al.*, (2007)** observed that the highest plant height, days required for initiation of flowering, number of fruits per plant, green fruit yield, total yield, weight of individual fruit and fruit length of okra with application of 50% RDF + 50% nitrogen through neem cake over control.

**Vitakar *et al.*, (2007)** reported that treatment with 50 % N through vermicompost and 50 % N through neem cake produced the maximum plant height, primary branches and total yield per hectare compared to RDF in chilli crop.

**Gowda *et al.*, (2008)** conducted an field experiment on wheat and reported that application of vermicompost @ 3.8 t ha<sup>-1</sup> + poultry manure @ 2.45 t ha<sup>-1</sup> gave significantly higher plant height, number of leaves, number of tillers, test weight, straw and seed yield as well as protein content in seed as compared to control treatment.

**Anchal *et al.*, (2008)** reported that vegetative parameter such as plant height, number of primary branches, dry matter accumulation and yield were found to be superior with 50 % RDF + Biofertilizer +Vermicompost as compare to either alone or other combination treatment in tomato crop.

**Suthar (2009)** observed that the highest range of some plant parameters i.e. root length, shoot length, fresh weight, number of cloves in garlic were in the treatment using 15 t/ha vermicompost + 50 % NPK and with applied vermicompost, FYM showed a comparatively better result of plant production than composted manure. **Abduli et al., (2012)** found that growth of tomato plants significantly rise by increasing ration of vermicompost combined with soil.

Studies conducted by **Premsekhar and Rajashree (2009)** revealed that among the different organic manure treatments, okra showed significantly higher values of growth characters and yield attributes by the application of FYM @ 20 t ha<sup>-1</sup>.

**Mishra et al., (2009)** reported that the significant improvement in all the growth parameters over recommended dose of NPK. The highest plant height, number of branch was recorded with application of vermicompost @ 2-5 t per ha + NPK + PSB + *Azotobacter* over rest of the treatments.

**Kondappa et al., (2009)** studied the effect of INM on growth, yield and economics of chilli cv. Byadgi Dabbi and concluded that use of integrated application of vermicompost with fertilizers remained beneficial.

**Hari et al., (2009)** carried out field studies during 2005-06 and 2006-07 in rabi season to study the effect of organic manures viz. neem cake and vermicompost grown on clayey soil in combination with nitrogenous fertilizer on bulb growth, yield and quality of onion. Significantly higher bulb weight and bulb yield were recorded in the treatment with vermicompost. Similar results were also reported by the same authors in chilli crop.

**Kumar and Gowda (2010)** conducted an experiment on effect of different organic manures and inorganic fertilizers on growth and yield of brinjal (*Solanum melongena* L.). Application of recommended 25 t/ha of FYM, N through vermicompost and green manure (50% each) + recommended NPK (125:100:50 kg/ha) recorded highest plant height, number of leaves and total dry matter of plant. The number of branches was lowest in the treatment of 150% recommended FYM only, Earliness for first 50 % flowering and first harvest was observed with 100% recommended FYM alone.

**Chanda et al., (2011)** studied on the effect of vermicompost and other fertilizers on cultivation of tomato plants using different fertilizers having equal concentration of nutrients to determine their impact on different growth parameters. They found that application of vermicompost + chemical fertilizers showed 73% better yield of fruits than control.

**Sharma and Choudhary (2011)** reported that the application of 100 % Recommended dose of fertilizer and farm yard manure @20 t per ha<sup>-1</sup> significantly increased growth attributes, viz. plant height at harvest, number of branches/plant and leaf area in okra.

**Kumar et al., (2011).** Reported that the highest plant height, number of branches/plant, diameter of fruits, average fruit weight and the earliest flowering were noted in the T<sub>12</sub>, where phosphorus and nitrogen was applied 60 kg and 120 kg/ha, respectively and diameter of main stem showed non significant effect. But the interaction effect on plant height, number of branches/plant, diameter of main stem, days taken to first flowering, diameter of fruit, average fruit weight and yield gave the better performance at the treatment combination I<sub>2</sub>B<sub>2</sub> as compared to other treatments and control.

**Mamta et al., (2012)** study was aimed to understanding the effect of vermicompost on the growth and productivity of brinjal plant. The vermicompost of cow dung, garden waste and kitchen waste in combination were used with brinjal plants under field conditions. The different treatments affected the seed germination of the test crop significantly. Plant height, number of leaves and fruit weight were higher in the vermicompost treated field as compared to control and no disease incidence was observed in the fruits of vermicompost treated plot.

**Bajshya et al., (2013)** suggested that growing of potato cv. Kufri Mega with 75% RD through chemical fertilizers + 25% RD through FYM and 100 % RD through chemical fertilizers proved better growth, greater tuber yield and higher profit from potato in the north eastern hill region of India.

**Bahrampour and Ziveh, (2013)** revealed that addition of vermicompost 15 t /ha significantly increased growth and yield of tomato compared to control. Further EC of

fruit juice and percentage of fruit dry matter increased up to 30 and 24 %, respectively were also observed.

**Laxmi et al., (2015)** found that different combinations of organic manures i.e., FYM, Poultry manure and vermicompost and inorganic fertilizers, (50% RDF + 50% FYM) recorded maximum plant height (133.53 cm), minimum days to first flowering (29.47), maximum number of flower cluster/plant, number of flowers/cluster, number of fruits/cluster, number of fruits/plant followed by (50% RDF + 50% Poultry manure). Among quality parameters TSS content in fruits was found maximum in (50% RDF + 50% FYM) followed by (50% RDF + 50% vermicompost) whereas titratable acidity (1.06%), ascorbic acid content (26.54mg/100 g fruit juice) and shelf life (11.67 days at normal room temperature) were found maximum with application of in (50% RDF + 50% vermicompost) followed by (50% RDF + 50% FYM).

## 2.2 Fruiting and yield

**Jablonska (1976)** studied that an application FYM of (30 tonnes/ha) along with N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O each of 800 kg/ha produced the maximum total yield and commercial yield.

**Subbiah et al., (1982)** found that fruit yield of chilli was the highest (60 t/ha) when plot was applied with 12 t of FYM + 50 % RDF and in control plot yield was (29.7 t/ha) comparatively low.

**Amrithalingam and Balakrishnan (1988)** found that the highest yield in chili crop was obtained with the treatment of *Azospirillum* inoculation to seeds, soil and seedlings + 70 kg N ha<sup>-1</sup> with NAA spray at 5 ppm.

**Subbiah (1990)** revealed that seeds treated with *Azospitillum* along with application of 100 % R.D. of N (120 kg ha<sup>-1</sup>) in tomato resulted in the maximum fruit yield 66.33 t ha<sup>-1</sup>.

**Kropisz (1992)** reported that application of different sources of composts and FYM (@ 25 t ha<sup>-1</sup>) in three year field trials with cabbage, onion and carrot registered higher yield with FYM + NPK in all the three crops as compared to the application of either FYM or inorganic fertilizers individually.

**Paramaguru and Natarajan (1993)** observed that the treatment with *Azospirillum* + 75 % N (56 kg N ha<sup>-1</sup>) recorded the highest mean yield of 24.5 t ha<sup>-1</sup> in chilli.

**Ahmed (1993)** reported that maximum fruit yield of tomato cv. Pusa Ruby was obtained when FYM and coir pith (19 and 17 t/ha respectively) were incorporated, also improved soil condition including strength, bulk density, moisture retention capacity than crop treated with neither FYM or coir pith.

**Nanthakumar and Veeraraghathatam (1996)** reported that combined application of nutrients through 12.5 t ha<sup>-1</sup> of FYM + 2 kg each of *Azospirillum* and PSB + inorganic fertilizers at 75% of recommended dose of N, P and 100% of K favorably influenced the growth, yield (36.48 t ha<sup>-1</sup>) and quality of brinjal.

**Lopes et al., (1996)** reported that an increase in levels of vermicompost up to 10 t per hectare significantly improved dry matter yield of cowpea over the control treatments.

**Jasvir Singh et al., (1997)** revealed that the higher fruit yield per plant in chilli with the application of vermicompost @10 t/ha<sup>-1</sup>, whereas **Patil (1995)** observed that inclusion of vermicompost along with 100 % RDF + FYM resulted in additional dry chilli yield of 1.68 q per ha<sup>-1</sup>.

**Kurup et al., (1997)** indicated that the application of 100 kg N per ha as Neemcake blended with urea produced the maximum yield in okra cv. Kiran.

**Thanunathan et al., (1997)** observed that the yield of onion was increased on the application of soil + mine spoil + vermicompost (1: 1: 1). **Kalembasa and Deska (1998)** stated that the application of vermicompost significantly increased the yield of sweet pepper and radish.

**Kalembasa and Deska, (1998)** reported that the yield of radish and sweet pepper significantly increased with application of vermicompost, Similar **Tomar et al., (1998)** recorded highest yield through vermicompost in brinjal.

**Tomar et al., (1998)** found that maximum yield (97 g and 94.9 g/fruit) in brinjal and carrot respectively was obtained with the application of vermicompost. Similarly, the

yield of radish was proportionally increased with increased with increasing doses of vermicompost (**Buckfield et al., 1999**).

**Vadiraj et al., (1998)** reported that the application of vermicompost at 15 t ha<sup>-1</sup> significantly increased herbage yield of coriander which was comparable to applying chemical fertilizers at 20:20:40, NPK kg ha<sup>-1</sup>. They reported that the herbage yield was maximum (6075.5 kg ha<sup>-1</sup>) at 60th day after sowing in plots treated with 15 t ha<sup>-1</sup> vermicompost. The study also indicated that application of vermicompost @ 15-20 t ha<sup>-1</sup> not only increase herbage and seed yield but also seed weight.

**Sendur et al., (1998)** summarized that application of organic manures (FYM, vermicompost, neem cake) combined with recommended dose of inorganic fertilizers showed superior performance in respect of growth and fruit yield of tomato.

**Nanthakumar and Veeragavathatham (1999)** found that the yield of brinjal was significantly better due to the application of FYM than the inorganic fertilizers alone.

**Kumari et al., (1999)** reported that 12 t/ha vermicompost + full dose of recommend fertilizer (50: 80: 25 kg NPK/ha) produced highest yield and vermicompost as an organic source significantly reduced the cost of okra production.

**Usha Kumari et al., (1999)** reported that 12 t/ha vermicompost + full dose of recommend fertilizer (50:8:25 kg NPK ha<sup>-1</sup>) produced highest yield and vermicompost as an organic source significantly reduced the cost of okra production.

**Shreeniwas et al., (2000)** working with ridge gourd cv. Pusa Nasdar found that the increased rates of vermicompost increased fruit yield. The vermicompost @ 10 t/ha + 50:25:50 kg NPK /ha increased the fruit weight, fruit yield per vine in ridge gourd.

**Terry et al., (2000)** revealed that an inoculation with *Azospirillum* at sowing time increased plant height in tomato and was the best treatment giving a positive effect on growth parameters and yield.

**Aliyo (2000)** reported that the application of FYM + poultry manure at 5 t ha<sup>-1</sup> each, supplemented with 50 kg N ha<sup>-1</sup> resulted in significantly higher fruit compared with other treatment in pepper.

**Sannigrahi and Barah (2000)** conducted field experiments in Assam with tomatoes, French beans and cabbages yield response to the application of organic manures (FYM) or compost with or without NPK fertilizers and root inoculation with mycorrhizas. Tomato yield was highest (17.3 t/ha) with the application of the recommended NPK fertilizer, while the yield of French beans (36.1 t/ha) and cabbage (26.6 t/ha) were highest with 10 t FYM/ha + 15 kg N + 10 kg K<sub>2</sub>O and 10 t compost + inoculation + 40 kg N + 30 kg K<sub>2</sub>O, respectively.

**Rao and Sankar (2001)** found that the effect of organic fertilizer on yield parameters were significantly superior over inorganic fertilizer in brinjal. The maximum fruit yield (12.31 t per ha<sup>-1</sup>) was obtained with the treatment of FYM + Vermicompost.

**Patil and Biradar (2001)** obtained the maximum fruit yield of chilli cv. Byadgikaddi with the application of 200% recommended dose of fertilizer + farm yard manure + Vermicompost. The N, P, K uptake also increased with the increase in nutrient levels. The different levels studied were 100% RDF (150:75:75) kg/ha + farm yard manure 10 t per ha, 100% recommended dose of fertilizer + farm yard manure + vermicompost @ 2.5 t/ha, 150% recommended dose of fertilizer + farm yard manure + Vermicompost, 200% recommended dose of fertilizer + farm yard manure + Vermicompost. While, **Sharu and Meerabai (2001)** recorded highest fruit yield (9.66 t/ha) with 50 % poultry manure + 50% inorganic N.

**Subbarao and Ravisankar (2001)** studied the maximum brinjal fruit yield (12.31 t/ha) by application of FYM + Vermicompost followed by FYM + Neem cake.

**Asha and Geethakumari (2001)** revealed that combined application of FYM and Neem cake (1:1 ratio) along with *Azospirillum* inoculation produced the maximum fruit yield of okra cv. Arka Anamika (166.92 q/ha).

**Samawat et al., (2001)** found that the vermicompost had a significant effect on number of fruits in tomato. In 100 % vermicompost treatment, fruit number was 4 times more than the treatment control.

**Shalini et al., (2002)** observed that an application of 50% (N) (Vermicompost) + 50% (N) (Urea) + *Azospirillum* produced maximum yield of 37.00 tonnes/ha in knol-khol.

**Mohd et al., (2002)** revealed that application of 50% recommended dose of farmyard manure (FYM) @ 12.5 t ha<sup>-1</sup> along with reduced levels of recommended doses of fertilizers (50% of the recommended dose of fertilizers of 100:50:50 NPK kg ha<sup>-1</sup>) resulted in the highest yield with high quality. The study also revealed that the ready made organic manures of commercial companies used in this study were in fervor to traditional organic manures viz., FYM and vermicompost.

**Naidu et al., (2002)** obtained maximum fruit girth, 50% flowering and yield of brinjal cv. JB-64 with 75: 35:0 kg /ha N P K along with organic fertilizer.

The FYM seems to act directly by increase the crop yield either by accelerate the respiratory process through cell permeability or by hormone growth action. It supplies phosphorus, sulphur and nitrogen in available forms to the plants through biological decomposition. Indirectly, it improves the physical properties of soil such as permeability, aeration and water holding capacity (**Chandramohan, 2002**).

**Sengupta et al., (2002)** found that the application of 100 % Nitrogen (120 kg ha<sup>-1</sup>) along with seedlings treatment of *Azospirillum* to tomato plants resulted in the highest fruit diameter 6.75 and 6.45 cm with marketable fruit yield 284.38 and 268.81 q ha<sup>-1</sup> both the respective years.

**Bhagavantagoudra and Rokhade (2002)** found that treatment with *Azospirillum* through soil + seedling dipping gave the maximum values for head diameter (13.33 cm), head surface area (577.31cm<sup>2</sup>), no. of inner leaves per head (41.92) and head weight (687;98 g) in cabbage.

**Harikrishna et al., (2002)** reported that the maximum fruit yield (54.32 t ha<sup>-1</sup>) was recorded under the treatment of FYM 75 % of NPK + *Azospirillum* while the minimum yield 30.31 t ha<sup>-1</sup>) was recorded under the treatment with FYM alone in tomato.

**Rafi et al., (2002)** studied that application of 50% recommended dose of FYM @, 12.5 t/ha along with reduced levels of recommended doses of fertilizers (50% of the recommended doses of fertilizers of 100 : 50:50 NPK kg/ha) resulted in the highest yield with high quality of tomato.

**Krishna and Krishnappa (2002)** studied that the effect of NPK fertilizer applied with or without organic manures (FYM and Agrimagic) on the yield and quality of tomato cv. Avinash-2 was investigated during rabi 2000-01 in Bangalore, Karnataka, India. In general, NPK at 250:250:250 kg/ha plus Agrimagic at 16.87 t/ha or FYM at 38 t/ha recorded the highest values for yield.

**Anburani et al., (2003)** found that application of 25 t ha FYM + 100:50:50 kg NPK ha<sup>-1</sup> + biofertilizer resulted in highest fruit weight and yield of brinjal cv. Annamalai.

**Arancon et al., (2003)** revealed that when vermicompost applied at the rate 5 t ha<sup>-1</sup>, the marketable tomato yield in all vermicompost treated plots were considerably greater than yield from the inorganic fertilized plots.

**Datt et al., (2003)** reported that application of FYM @ 10 t ha<sup>-1</sup> increased the green pod yield of vegetable pea by 16 per cent over control. The higher available N (398.00 kg ha<sup>-1</sup>), P (38.30 kg ha<sup>-1</sup>), K (328.00 kg ha<sup>-1</sup>) and greater organic carbon (7.70 g/kg) content in soil were recorded with combined application of FYM @ 10 t ha<sup>-1</sup> and N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O @20, 26.2, 25 kg ha<sup>-1</sup>, respectively than inorganic alone (362, 30.5, 296 kg ha<sup>-1</sup> N, P, K, respectively and 7.3 g/kg organic carbon). Similarly, higher uptake of NPK was also recorded with combined application of FYM @10 t ha<sup>-1</sup> and N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O than their individual applications.

**Netwal (2003)** reported that application of vermicompost 5 t per ha<sup>-1</sup> significantly increased the pods per plant, seed per pod, harvest index and seed and straw yield of cowpea over control 5 t FYM and 2.5 t vermicompost per ha<sup>-1</sup>.

**Rajkhowa et al., (2003)** observed that application of vermicompost @ 2.5 t ha<sup>-1</sup> being at par with 2.5 FYM t per ha<sup>-1</sup> significantly increased the number of pods per plant, seeds per pod and 1000 grain weight of green gram over control.

The application of organic fertilizers viz., FYM, chilli stalks and FYM chilli stalks with inorganic fertilizers significantly influenced growth of chilli and the magnitude of combined effect of organic and inorganic was higher than inorganic fertilizer alone (**Kattimani, 2004**).

**Jat and Ahlawat (2004)** reported that the vermicompost application @3 tonnes ha<sup>-1</sup> significantly increased the growth and yield attribute (pods/plant) and seed straw yield of chick pea over control.

**Kumhar (2004)** studied an experiment on cauliflower and reported that an application of vermicompost @7.5 t per ha increased the volume of curd significantly. Similarly, **Hashemimajd et al., (2004)** revealed that the treatment vermicompost produced from raw dairy manure (RDM) along with some other composts (sewage sludge + rice hull) gives greatest shoot and root dairy matters (DM) of tomatoes than control treatment.

**Poul et al., (2004)** found that the highest number of fruits per fresh fruit yield per plant of tomato with the application of 50 % recommended dose of N P K along with half does of FYM + cow dung urine slurry.

**Sajitha et al., (2005)** observed that inoculation of biofertilizers along with vermicompost and vermiwash gives better yield in garden bean.

There was increase in the yield (502 kg ha<sup>-1</sup>) in soya bean with the combined application of inorganic fertilizers, FYM and PSB when compared to application of inorganic fertilizers alone (423 kg ha<sup>-1</sup>) (**Deshmukh et al., 2005**).

**Yadav et al., (2006)** found that the application of 90 kg N per ha<sup>-1</sup> through poultry manure, farm yard manure, urea and vermicompost significantly bigger number of fruits, fruit length, girth of fruit and total yield of okra as compared to control.

Application of different organic nitrogen source significantly influenced the tomato growth and yield. Among the different organic source substitution of 100% N as FYM recorded plant height, no. of branches per plant and yield comparable to then of 100 % nitrogen as urea (**Kannan et al., 2006**).

**Vitakar et al., (2007)** reported that treatment with 50 % N through vermicompost and 50 % N through neem cake produced the maximum plant height, primary branches and total yield per hectare compared to RDF in chilli crop.

**Bharadiya et al., (2007)** recorded highest plant height, days required for initiation of flowering, number of fruits per plant, green fruit yield, total yield, weight of individual fruit and fruit length of okra with application of 50% RDF + 50% nitrogen through neem cake over control.

**Sanwal et al., (2007)** reported that among different organic manure treatments significantly higher rhizome yield was recorded with the application of FYM @ 18 t ha<sup>-1</sup> in turmeric which was at par with 10 t ha<sup>-1</sup> poultry manure.

Experiments conducted by **Raghav and Shashi (2007)** revealed that farmyard manure + biofertilizers gave 9.7 % higher green pod yield in cow pea than control (RDF).

**Ghugre et al., (2007)** reported the highest yield in cabbage by application of 50% RDF along with 50% vermicompost at 2.5 t ha<sup>-1</sup>.

**Kalalbandi et al., (2007)** conducted an experiment and observed significantly maximum head yield per plot, head yield per hectare mean TSS of head, mean ascorbic acid, staying capacity of head, keeping quality of head in cabbage cv. Pride of India with 25 per cent recommended NPK rate (RDF) + 75 % FYM.

**Rajan and Mahalakshmi (2007)** reported that the no. of leaves produced in cowpea and radish seedling were maximum in treatment containing 75 % vermicompost. The leaf area, tuber length and wet weight of radish were maximum in 100 % vermicompost applied plots.

**Anchal et al., (2008)** reported that vegetative parameter such as plant height, number of primary branches, dry matter accumulation and yield were found to be superior with 50 % RDF + Biofertilizer +Vermicompost as compare to either alone or other combination treatment in tomato crop.

**Abdullah (2008)** obtained significantly higher average weight of onion bulbs and potato tubers in plots amended with vermicompost and vermiwash.

**Bairwa et al., (2009)** reported that okra produced maximum number of fruits, fruit yield, fruit weight, length of fruits and thickness of fruits with the application of

neemcake 6 q per ha<sup>-1</sup> + vermicompost 10 q per ha<sup>-1</sup> + *Azotobacter* + PSB + 60 per cent RDF of NPK through inorganic fertilizers.

Studies conducted by **Premsekhar and Rajashree (2009)** revealed that among the different organic manure treatments, okra showed significantly higher values of growth characters and yield attributes by the application of FYM @ 20 t ha<sup>-1</sup>.

The response of organic manure and fertilizers on yield and nutrient uptake of ginger was studied by **Dharade et al., (2009)** and reported that the use of 50% N through RD + 25 t FYM t ha<sup>-1</sup> fertilization to crop was beneficial in terms of net returns. The highest uptake of N was recorded due to application of RDF + 50% N through poultry manure, whereas, the uptake of P and K were highest under the treatment having RDF + 25 t FYM ha<sup>-1</sup> followed by the application of 50% N through RDF + 50% N through either poultry manure or vermicompost.

**Gopinath et al., (2009)** observed that integrated crop management (FYM 10 q ha<sup>-1</sup>) and recommended NPK 100:222:41.5 kg ha<sup>-1</sup> has recorded maximum number of bell pepper fruits (23.7) and fruits yield (23.7) and fruits yield (37 kg ha<sup>-1</sup>) as compared to control.

**Kondappa et al., (2009)** studied the effect of INM on yield and economics of chilli cv. Byadgi Dabbi and concluded that use of integrated application of vermicompost with fertilizers remained beneficial.

**Sharma et al., (2009)** reported that the highest yield (11.10 and 11.63 t ha<sup>-1</sup>) of okra was recorded under the treatment comprising 100% recommended NPK + vermicompost @10 t ha<sup>-1</sup>, during 2003-2004, respectively. Similarly, maximum yield of (9.83 and 14.67 t ha<sup>-1</sup>) was observed in 2003-04 and 2004-05, respectively. Yield of onion obtained at the application of 12.5 t vermicompost ha<sup>-1</sup> plus 100% NPK (8.38 and 12.56 t ha<sup>-1</sup>) was at par with that under 25 t farm yard manure ha<sup>-1</sup> + 100% NPK (8.86 and 12.08 t/ha<sup>-1</sup>) during 2003-04 and 2004-05. This demonstrated that superiority of vermicompost over farm yard manure in okra onion sequence.

**Hari et al., (2009)** carried out field studies during 2005-06 and 2006-07 in rabi season to study the effect of organic manures viz. neem cake and vermicompost grown on

clayey soil in combination with nitrogenous fertilizer on bulb growth, yield and quality of onion. Significantly higher bulb weight and bulb yield were recorded in the treatment with vermicompost. Similar results were also reported by the same authors in chilli crop.

**Mishra et al., (2009)** reported that the results revealed significant improvement in all the yield parameters over recommended dose of NPK. 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.

Studies conducted by **Premsekhar and Rajashree (2009)** revealed that among the different organic manure treatments, okra showed significantly higher values of growth characters and yield attributes by the application of FYM @ 20 t ha<sup>-1</sup>.

**Yadav and Yadav (2010)** conducted an experiment on okra and found the application of 75 % recommended dose of fertilizer with vermicompost @6.5 t per ha gave significantly maximum marketable fruit yield which was at par with the treatments namely 50% recommended dose of fertilizer with vermicompost @ 6.5 t per ha and 75 per cent recommended dose of fertilizer + Neemcake @3.5 t per ha.

**Sharma et al., (2010)** found that application of 5 t vermicompost ha<sup>-1</sup> recorded significantly maximum values of fruit yield and protein content (18.0%) as well as B:C ratio (2.11) with net returns in okra crop.

**Kumar et al., (2011)** reported that the highest plant height, number of branches/plant, diameter of fruits, average fruit weight and the earliest flowering were noted in the T12, where phosphorus and nitrogen was applied 60 kg and 120 kg/ha, respectively and diameter of main stem showed non significant effect. But the interaction effect on plant height, number of branches/plant, diameter of main stem, days taken to first flowering, diameter of fruit, average fruit weight and yield gave the better performance at the treatment combination I2B2 as compared to other treatments and control.

**Mojtaba et al., (2011)** suggested that use of 150 kg N ha<sup>-1</sup> and vermicompost @ of 12 t ha<sup>-1</sup> gained highest tuber yield and avoidance of environmental pollution in potato crops.

**Chanda et al., (2011)** studied on the effect of vermicompost and other fertilizers on cultivation of tomato plants using different fertilizers having equal concentration of nutrients to determine their impact on different growth parameters. They found that application of vermicompost + chemical fertilizers showed 73% better yield of fruits than control.

**Suchitra and Manivannan, (2012)** revealed that the influence of organic inputs on the yield attributes of brinjal in various seasons. They observed that application of vermicompost @ 5 t/ha and humic acid 0.2 % recorded the no. of fruits plant<sup>-1</sup> (30.11), length of fruit (14.30 cm) and girth of fruit (13.75 cm).

**Mamta et al., (2012)** study was aimed to understanding the effect of vermicompost on the growth and productivity of brinjal plant. The vermicompost of cow dung, garden waste and kitchen waste in combination were used with brinjal plants under field conditions. The different treatments affected the seed germination of the test crop significantly. Fruit weight were higher in the vermicompost treated field as compared to control and no disease incidence was observed in the fruits of vermicompost treated plot.

**Vanmathi and Selvakumari (2012)** reported that the application of vermicompost increased the vegetative growth and yield of *Hibiscus esculentus*.

**Bahrampour and Ziveh, (2013)** determined the effect of vermicompost on growth, yield and fruit quality of tomato (*Lycopersicum esculentum* var. Super Beta) in field condition, the use of different doses of vermicompost (0, 5, 10 and 15 t /ha) were incorporated to in the top 15 cm of soil, its results revealed that addition of vermicompost 15 t /ha significantly increased growth and yield of tomato compared to control. Further EC of fruit juice and percentage of fruit dry matter increased up to 30 and 24 %, respectively were also observed.

**Bajshya et al., (2013)** suggested that growing of potato cv. Kufri Mega with 75% RD through chemical fertilizers + 25% RD through FYM and 100 % RD through chemical fertilizers proved better growth, greater tuber yield and higher profit from potato in the north eastern hill region of India.

**Laxmi et al., (2015)** found that different combinations of organic manures i.e, FYM, Poultry manure and vermicompost and inorganic fertilizers, (50% RDF + 50% FYM) recorded maximum number of fruits per plant, fruit weight, fruit yield/plot, fruit yield/plot and maximum fruit yield followed by (50% RDF + 50% Poultry manure).

### 3.4 Fruit chemicals characters

**Valenzuela and Gallardo, (1997)** studied the effect of different vermicompost and soil properties on tomato cv. Platense and found that use of vermicompost at more than 20% was considered suitable for increasing the available nitrogen, phosphorus, potassium and salts of the substrates.

**Kumaran et al., (1998)** evaluated the effect of application of 15 t/ha of FYM together with recommended dose of NPK (150: 100: 50 kg/ha) as well as combinations with *Azospirillum*, PSB, neem cake and vermicompost on tomato at Coimbatore and concluded that the TSS, Ascorbic acid and Lycopine pigments were comparatively higher in the plants grown organically owing to physiological influence of *Azospirillum* and PSB on the activity of number of enzymes.

**Rajkhowa et al., (2000)** observed that 75 % of recommended dose of nitrogen as urea + 5t/ha as vermicompost application increased the N, P and K per cent in plant of green cv. ML-131. Similarly, **Shreeniwas et al., (2000)** reported that the increased rate of vermicompost up to 10t/ha increased the TSS in ridge gourd cv. Pusa Nasdar.

**Shreeniwas et al., (2000)** working with ridge gourd found that increased rates vermicompost increased fruit quality like TSS. The vermicompost 10 t/ha + 50:25:25 kg NPK /ha increased the total soluble solid in ridge gourd cv. Pusa Nasdar.

**Suresh (2000)** reported that combined application of RDF (100:50:50 kg NPK ha<sup>-1</sup>) + FYM recorded significantly good quality fruits in chilli as compared to RDF alone (11.28 q ha<sup>-1</sup>).

**Prabhu et al., (2002)** observed that vitamin C and dietary fibre decreased and crude protein increased with increasing inorganic fertilizers. Application of FYM and biofertilizers resulted in increase in vitamin C, dietary fibre and crude protein in fruit. They recommended suitability of 66 per cent RDF with 10 t/ha FYM + *Azospirillum* + VAM.

**Rafi et al., (2002)** studies that application of 50% recommended dose of FYM @, 12.5 t/ha along with reduced levels of recommended doses of fertilizers (50% of the recommended doses of fertilizers of 100:50:50 NPK kg/ha) resulted in the high quality of tomato.

**Krishna and Krishnappa (2002)** the effect of NPK fertilizer applied with or without organic manures (FYM and Agrimagic) on the yield and quality of tomato cv. Avinash-2 was investigated during rabi 2000-01 in Bangalore, Karnataka, India. In general, NPK at 250:250:250 kg/ha plus Agrimagic at 16.87 t/ha or FYM at 38 t/ha recorded the highest values for the different quality (pericarp thickness, fruit firmness, total soluble solids and titratable acidity) parameters. These treatments also recorded the longest shelf life and the lowest physiological weight loss of fruit.

**Mohd et al., (2002)** revealed that application of 50% recommended dose of farmyard manure (FYM) @ 12.5 t ha<sup>-1</sup> along with reduced levels of recommended doses of fertilizers (50% of the recommended dose of fertilizers of 100:50:50 NPK kg ha<sup>-1</sup>) resulted in the highest quality. The study also revealed that the ready made organic manures of commercial companies used in this study were in fervor to traditional organic manures viz., FYM and vermicompost.

**Anburani et al., (2003)** conducted an experiment to study integrated nutrient management on quality parameters in brinjal and reported that combined application of FYM + NPK (100: 50: 50) kg ha<sup>-1</sup> + biofertilizers (*Azospirillum* and PSB @ 2kg ha<sup>-1</sup>) was found the best in increasing quality of fruits.

**Rajkhowa et al., (2003)** reported significant increase in uptake of N and P in green gram with application of vermicompost @ 2.5 t ha<sup>-1</sup> along with 100 to 75% fertilizers over control.

**Vasanthi and Subramanian (2004)** reported highest N, P and K concentration and uptake in black gram under the treatment that received vermicompost @ 2 t ha<sup>-1</sup> along with 100 % recommended dose of N, P and K.

**Yadav and Vijyakumari (2004)** found out the experiment to assess the effect of vermicompost vegetable waste on the quality characters of chilli and found that the protein was higher on 60 and 90 DAS. The carbohydrate content was higher in vermicompost treatment on 60 DAS. On 60 DAS, higher chlorophyll b (2.61 mg/g) and total chlorophyll (3.62 mg/g) contents were observed while on 90 days after sowing higher chlorophyll a (1.01 mg/g) and total chlorophyll (1.92 mg/g) content were observed with vermicompost alone.

The application of organic fertilizers viz., farm yard manure, chilli stalks and Farm Yard Manure chilli stalks with inorganic fertilizers (RDF) significantly nutrient uptake and quality of chilli and the magnitude of combined effect of organic fertilizers and inorganic fertilizers was higher than inorganic alone (**Kattimani, 2004**).

**Chaturvedi and Chandel (2005)** found that the highest total uptake of P, K and N under the treatments receiving recommended NPK + FYM @ 10 t per ha<sup>-1</sup> in soybean crop.

**Rajshree et al., (2005)** observed that the application of farm yard manure @ 7.50 t per ha<sup>-1</sup> along with 50 kg ha<sup>-1</sup> N and 30 kg ha<sup>-1</sup> P recorded maximum protein and oil content over control and recommended dose of fertilizer in soybean under soya bean based cropping system.

**Varalakshmi et al., (2005)** observed that application of 100% recommended dose of fertilizer + 7.5 t FYM ha<sup>-1</sup> significantly improved the organic carbon, available N, P and K content of soil.

**Kalalbandi et al., (2007)** conducted an experiment and observed significantly maximum head yield per plot, head yield per hectare mean TSS of head, mean ascorbic acid, staying capacity of head, keeping quality of head in cabbage cv. Pride of India with 25 per cent recommended NPK rate (RDF) + 75 % FYM.

**Gowda *et al.*, (2008)** conducted a field experiment on wheat and reported that application of vermicompost @ 3.8 t ha<sup>-1</sup> + poultry manure @ 2.45 t ha<sup>-1</sup> gave significantly higher protein content in seed as compared to control.

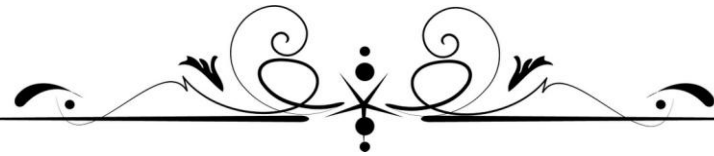
The response of organic manure and fertilizers on yield and nutrient uptake of ginger was studied by **Dharade *et al.*, (2009)** and reported that the use of 50% N through RDF + 25 t FYM t ha<sup>-1</sup> fertilization to crop was beneficial in terms of net returns. The highest uptake of N was recorded due to application of RDF + 50% N through poultry manure, whereas, the uptake of P and K were highest under the treatment having RDF + 25 t FYM ha<sup>-1</sup> followed by the application of 50% N through RDF + 50% N through either poultry manure or vermicompost.

**Premsekher and Rajashree (2009)** observed the crude fibre content of okra fruit under this treatment (FYM 20 t ha<sup>-1</sup>) was less when compared to control.

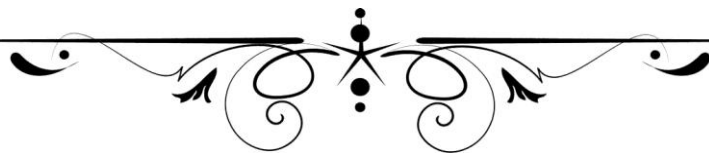
**Sharma *et al.*, (2010)** found that application of 5 t vermicompost ha<sup>-1</sup> recorded significantly maximum values of fruit yield and protein content (18.0%) as well as B:C ratio (2.11) with net returns of Rupees 35614 ha<sup>-1</sup> in okra crop.

**Bahrampour and Ziveh, (2013)** revealed that addition of vermicompost 15 t /ha significantly increased growth and yield of tomato as compared to control. Further EC of fruit juice and percentage of fruit dry matter increased up to 30 and 24 %, respectively were also observed.

**Laxmi *et al.*, (2015)** found that different combinations of organic manures i.e, FYM, Poultry manure and vermicompost and inorganic fertilizers, recorded quality parameters TSS content in fruits was found maximum in (50% RDF + 50% FYM) followed by (50% RDF + 50% vermicompost) whereas titrable acidity (1.06%), ascorbic acid content (26.54mg/100 g fruit juice) and shelf life (11.67 days at normal room temperature) were found maximum with application of in (50% RDF + 50% vermicompost) followed by (50% RDF + 50% FYM) in tomato.



*Chapter 3*  
*Materials and*  
*Methods*



## Materials and Methods

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Present investigation of research work entitled “**Effect of integrated nutrient management on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]**” was carried out at Horticulture Research Farm-II of the Department of Applied Plant Science (Horticulture), School of Biosciences and Biotechnology, Babasaheb Bhimrao Ambedkar University, (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow, (U. P.), India during the year 2015-16 and 2016-17, respectively. The details of the experimental techniques, material used and criteria adopted for the evaluation of treatments during the course of investigation are being presented in this chapter.

### 3.1 Location and weather conditions

Geographically, Babasaheb Bhimrao Ambedkar University, (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow (U. P.), India at 80°55' East longitude and 26°46' North latitude and 111 meter above MSL (mean sea level).

The climate of Lucknow is characterized by Sub-tropical with hot, dry summer and cool winters. This region received an averages annual rainfall of 650-750 mm, which is distributed over a period of more than 100 days with peak period during January-Jun. It also received scattered showers during summer months. In general, the temperature ranges from 5.5<sup>0</sup> to 25<sup>0</sup>. The average relative humidity is 60% in different seasons of the year. The monthly weather conditions prevailing during experimental period is given in Table 3.1. The soil of the experiment site was a saline - alkaline, low in organic matter, nitrogen, phosphorus and potash, respectively.

**Table 3.1.: Average weekly meteorological data during crop season 2015-16 and 2016-17 at Lucknow (U.P.)**

Month	Met. week	Temperature				Relative humidity		Total rainfall(mm)		Sunshine(hours/day)	
		Min.		Max.		15-16	16-17	15-16	16-17	15-16	16-17
		15-16	16-17	15-16	16-17						
Oct.	40	23.4	22.5	31.6	33.5	93	92	11.9	0.00	3.0	3.0
	41	20.4	21.6	32.5	33.6	94	93	0.8	5.60	3.6	1.6
	42	16.7	22.8	31.5	32.7	91	96	0.00	0.00	2.1	5.1
	43	11.8	17.5	30.2	31.9	85	95	0.00	0.00	2.6	4.6
Nov.	44	13.4	14.1	30.8	29.4	87	90	0.60	0.00	0.9	0.9
	45	14.8	15.6	30.1	30.2	89	89	0.00	0.00	0.0	3.0
	46	18.7	16.3	25.8	29.1	90	82	0.00	0.00	0.5	2.5
	47	9.01	14.5	25.2	24.6	84	74	0.00	0.51	0.9	0.4
	48	7.07	11.4	26.3	25.8	96	75	3.14	0.00	0.7	0.9
Dec.	49	7.07	8.9	26.2	25.1	92	90	0.00	9.20	0.9	0.1
	50	10.5	8.6	25.4	24.6	91	86	0.00	0.00	0.7	3.7
	51	8.7	6.4	24.2	23.4	86	75	0.00	0.00	1.9	4.9
	52	5.8	8.9	21.5	24.7	84	71	0.00	0.00	2.7	6.7
Jan.	1	8.2	6.8	15.7	14.6	94	65	9.60	0.00	3.1	7.1
	2	7.6	3.1	15.2	15.4	98	68	0.00	0.00	0.0	2.0
	3	8.8	6.0	16.1	21.2	93	69	3.20	0.00	0.0	3.0
	4	6.3	8.9	18.2	24.1	92	62	0.00	0.00	3.4	3.4
Feb.	5	8.5	7.9	25.6	23.4	90	76	0.00	0.00	3.5	3.5
	6	11.5	9.5	25.3	26.6	76	72	1.20	8.65	5.4	0.4
	7	12.4	12.0	24.2	25.8	82	73	0.00	5.21	2.0	0.0
	8	11.6	9.3	26.6	24.2	76	68	0.00	0.00	3.0	3.0
Mar.	9	15.4	12.1	30.2	27.1	70	92	0.00	0.00	4.1	4.1
	10	14.9	14.4	30.5	29.6	69	92	0.00	0.00	0.0	2.0
	11	14.7	14.6	32.8	31.4	62	96	0.00	0.00	5.3	5.3
	12	18.6	16.1	36.8	34.8	68	86	4.02	3.00	1.3	0.3
	13	20.2	18.1	38.7	33.7	63	80	0.00	0.00	3.3	3.3
Apr.	14	19.6	17.1	39.4	35.6	74	87	0.00	5.01	2.6	0.6
	15	22.3	19.8	41.7	36.1	78	83	0.00	0.00	0.0	2.0
	16	24.8	20.5	42.0	37.6	72	84	0.00	0.00	5.9	5.9
	17	25.0	19.0	40.4	36.7	79	69	3.60	0.00	8.4	8.4
May.	18	24.7	24.6	37.5	39.3	84	68	0.00	6.89	0.0	0.0
	19	25.0	23.9	38.6	40.2	93	62	0.00	2.32	0.0	0.0
	20	26.8	25.9	39.5	39.4	98	74	0.00	0.00	5.6	5.6
	21	25.9	23.6	38.1	37.3	69	79	5.14	2.14	1.0	1.0
	22	24.1	23.8	37.5	36.0	62	72	0.00	0.25	0.3	0.7

## 3.2 Programme of Work

The details of materials used and procedures followed during the course of research work are mentioned below

### 3.2.1 Location

Horticulture Research Farm-II of Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow (U. P.) India -226 025.

### 3.2.2 Cultivars

Okra cultivar Arka Anamika is a selection made at IIHR, Bengaluru and maintained in Horticulture Research Farm-II of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Vidya-Vihar, Rae Bareli Road, Lucknow, (U.P.) India -226 025.

## 3.3 Soil status of the experimental site

Before start of the experiment, the representative soil samples were taken randomly a depth of 15 cm from experimental field and brought to laboratory for physical and chemical analysis. The soil of the field may texturally be classified as sandy loam and slightly alkaline in reaction.

**Table 3.2 Physical property of soil**

S.N	Soil status	Percentage	Method of determination
1	Sandy	34.50	Hydrometer methods (Block, 1965)
2	Silt	50.20	
3	Clay	15.30	
4	Texture class	Sandy loam	Triangular method (Sigmoid,1928)

**Table 3.3 Chemical property of the soil**

S.N	Components	Amounts	Methods determination
1	Available N <sub>2</sub> (kg/ha)	110.50	Kjeldahl's method (A.O.A.C.,1980)
2	Available P <sub>2</sub> O <sub>5</sub> (kg/ha)	40.50	Olsen's method (Jackson,1983)
3	Available K <sub>2</sub> O (kg/ha)	190.40	Flame photometer (Jackson,1983)
4	Organic carbon (%)	0.12	Rapid titration method (Jackson,1983)
5	pH	8.6	Glass electrode, pH meter (Jackson,1983)
6	E.C (1:1)	0.26	Conductivity meter (Jackson,1983)
7	E.S.P	14.80	Conductivity meter (Jackson,1983)

### 3.4 Details of Experiment

The experiment was laid out in the Randomized Block Design with three replications. Each replication comprised of 19 Treatments. The following treatment combinations involving different fertilizer dosages were applied.

**Plate No. 1 A general view of layout of experiment field**



**Plate No. 2 A general view of experimental field**



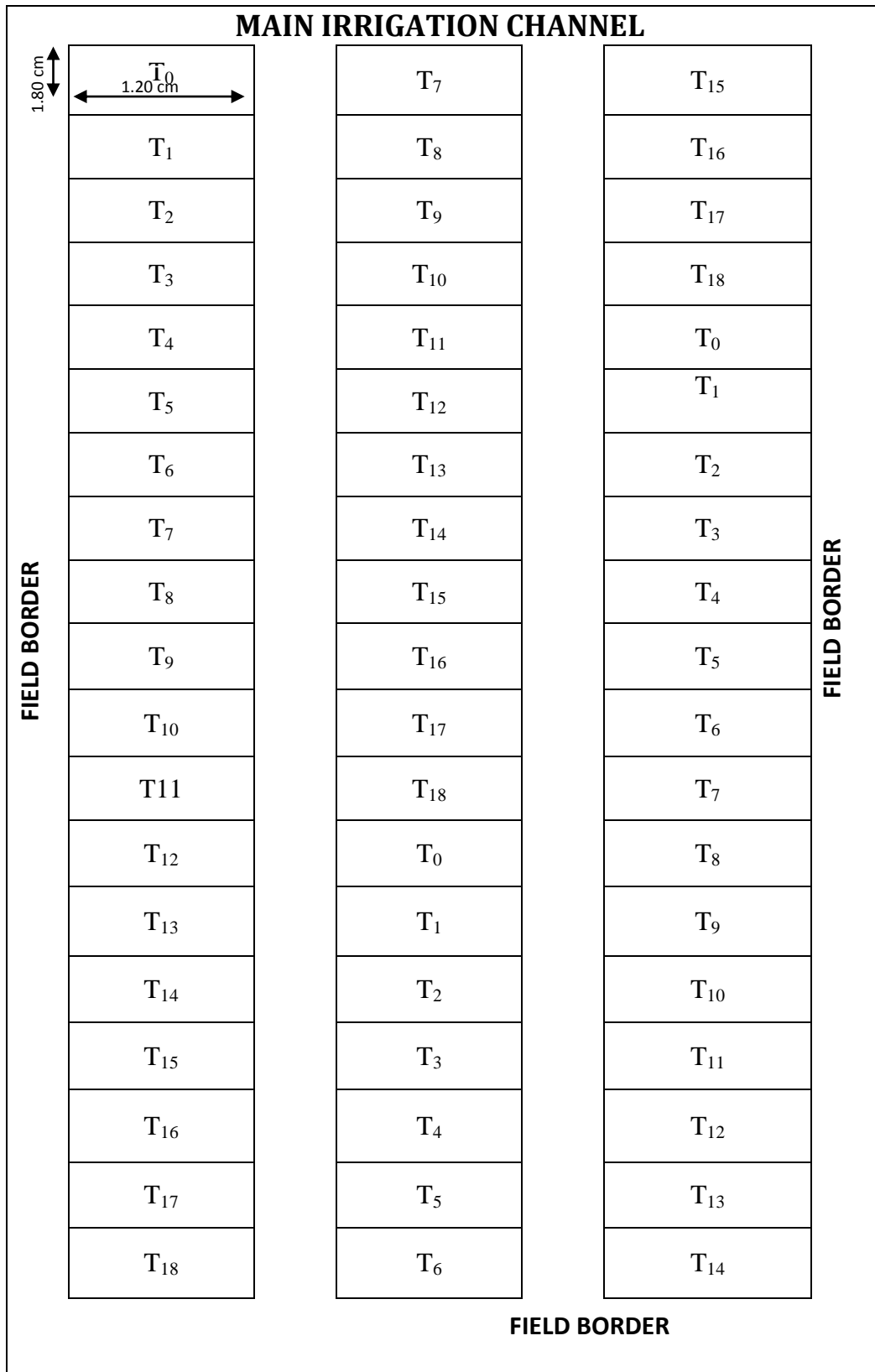
Table 3.4 Treatment detail

Sl. No	Treatments combination	Symbol
1	Control (without fertilizers)	T <sub>0</sub>
2	RDF (Recommended dose of fertilizer)	T <sub>1</sub>
3	FYM (Farm yard manure)	T <sub>2</sub>
4	Neem Cake	T <sub>3</sub>
5	Karanj Cake	T <sub>4</sub>
6	Bone Meal	T <sub>5</sub>
7	Vermi compost	T <sub>6</sub>
8	Fish gyano	T <sub>7</sub>
9	Mahua Cake	T <sub>8</sub>
10	RDF + FYM	T <sub>9</sub>
11	RDF + Neem Cake	T <sub>10</sub>
12	RDF +Karanj Cake	T <sub>11</sub>
13	RDF + Bone Meal	T <sub>12</sub>
14	RDF + Vermicompost	T <sub>13</sub>
15	RDF + Fish gyano	T <sub>14</sub>
16	RDF + Mahua Cake	T <sub>15</sub>
17	RDF + <i>Azospirillum</i>	T <sub>16</sub>
18	RDF + VAM ( <i>Vesicular - Arbuscular Mycorrhiza</i> )	T <sub>17</sub>
19	RDF + PSB ( <i>Phosphate Solubilizing Bacteria</i> )	T <sub>18</sub>

### 3.5 Design and layout of the experiment:

The experiment was laid out in Randomized Block design with three replications. The treatments were allocated in layout plan randomly which depicted diagrammatically

Layout plan



**Table 3.5 Details of Layout**

Experimental design	-	Randomized Block Design
No. of treatments	-	19
No. of replications	-	3
Total no. of plots	-	19 x 3 =57
Main irrigation channel	-	1 m
Sub irrigation channel	-	0.5 m
Field border	-	0.5 m
Bund	-	0.25 m
Spacing of crop	-	45 x 30 cm <sup>2</sup>
Total no. of plant per plot	-	16
Total area of the experimental plot	-	280 m <sup>2</sup>
Cultivar	-	Arka Anamika

### 3.6 Cultural Operation

The required cultural operations were carried out as and when required. The plot was kept free of diseases and pest by spraying the insecticides and pesticides as per the advice of the experts. The plots were kept weed free by hand weeding as and when required.

### 3.7 Land Preparation

The experimental field was deeply ploughed with a tractor drawn cultivator followed by one cross harrowing by tractor drawn harrow to obtain good tilth and it was made free from weeds. Finally the field was leveled with the help of leveler after leveling the experimental layout was made and field /plots are prepared.

### **3.8 Application of organic manures**

Full dose of FYM, neem cake, karanj cake, bone meal, vermicompost, fish gyano and mahua cake were applied and well mixed with the soils of respective plots before the sowing of seeds.

### **3.9 Application of inorganic fertilizers**

The recommended dose of NPK were applied through urea, DAP and MOP, respectively. The recommended dose of NPK for okra crop was 100:60:50 kg ha<sup>-1</sup>, respectively. For each fertilizer treatment combination, the NPK dose were calculated and applied timely.

### **3.10 Application of bio fertilizers**

The sealed packet of *Azospirillum*, PSB and VAM was obtained from the Biotech Park. The bio fertilizers was applied @100 gm/kg seeds of okra.

### **3.11 Seed Sowing**

Healthy seeds of equal size were dibbled 2 cm deep at the rate of two seeds per hill on the ridges, at the distance of 45 cm within seeds and 30 cm within rows. Irrigation was given immediately after sowing.

### **3.12 Irrigation**

First light irrigation was given immediately after seed sowing and then in initial stage of crop was irrigated twice a week. The irrigation interval was expended up to 6-7 days in the later stages, depending upon soil moisture condition and stage of crop growth.

### **3.13 Intercultural operations**

In order to keep the field clean and also free from weeds the weeding was done twice once at 30 day after seed sowing and other at 45 days after seed sowing.

**Plate No. 3 A view of experimental field after irrigation**



**Plate No. 4 A view of experiment at flowering stage**



### **3.14 Plant protection**

To control the pest and disease, necessary plant protection measures were taken up as per the recommended package of practices for the trial crop.

### **3.15 Harvesting**

The tender young fruit, 7-10 cm long was harvested every alternate day. Frequent picking promoted fruit development and yield. The time of harvesting for the production of maximum edible fruits was 7-8 days after pollination. Fruits were harvested 6-8 days after fruit set for getting maximum crop yield and nutritive values.

### **3.16 Observations recorded**

Five competitive plants from each net plot were selected randomly for recording observations for following different characters and averages were used in the statistical analysis.

#### **3.16.1 Vegetative growth attributes**

##### **3.16.1.1 Plant height (cm)**

The heights of five randomly selected plants from the ground level to the growing point was taken for five plants and the mean was calculated and expressed in centimeters at 30, 60 and 90 days after sowing.

##### **3.16.1.2 Number of branch per plant**

The numbers of branches was counted from five randomly selected plants from each of the treatments were counted and the average number of branches per plant from the central rows and then mean was calculated at the final harvest.

Plate No.5 A view of experiment in lab condition



### **3.16.1.3 Stem diameter (mm)**

The stem girth was recorded above the ground level ten tagged plant and expressed with the help of digital Vernier calliper in millimeters and averages calculated.

### **3.16.1.4 Number of flower buds**

Number of flowers buds appeared on individual plants in a plot was recorded and average was calculated over selected plants.

### **3.16.1.5 Leaf area**

The five tagged plants were used for leaf area measurement. The leaf area was measured with the help of leaf area meter. The average leaf area in cm<sup>2</sup> was recorded as mean value to calculate total leaf area per plant.

### **3.16.1.6 Days to 50% flowering**

It was recorded as the number of days from plant emergence to when 50% of the plants in a plot produce flower.

## **3.16.2 Fruiting and yield**

### **3.16.2.1 Number of fruit per plant**

Total numbers of okra fruits harvested in all the picking from randomly selected five plants were recorded and average number of fruits per plant was counted.

### **3.16.2.2 Fruit yield per plant (Kg)**

The fruits were harvested from selected plants and weighted, accordingly after taking fruit weight the average fruit weight was multiplied by total number of fruits per plant to get fruit yield per plant.

### **3.16.2.3 Fruit yield per plot (Kg)**

Fruit weight was taken plant wise and calculated the fruit yield per plant was multiplied by the number of plants per plot to get yield per plot.

#### **3.16.2.4 Fruit yield per ha (t)**

The total yield per hectare was calculated by multiplying hectare factor to total yield per plot.

#### **3.16.3 Fruit physical characters**

##### **3.16.3.1 Fruit length (cm)**

Fruit length of randomly selected five okra fruits was measured from the base of the fruits to the tip in centimeters.

##### **3.16.3.2 Fruit diameter (cm)**

At the time of harvest ten fruits were randomly selected from each treatment and their diameters measured transversely with the help of digital Vernier calliper in centimetres and averages calculated.

##### **3.16.3.3 Fruit fresh weight (g)**

Randomly selected ten fruits in each treatment during harvesting were weighed with the help of single pan balance and mean weight of fruit was calculated.

##### **3.16.3.4 Fruit dry weight (g)**

The ten physiological dried fruit randomly selected from observation plants, mean value of fruit taken average dry fruit weight in expressed in grams.

#### **3.16.4 Fruit chemicals characters**

##### **3.16.4.1 Titratable Acidity (%)**

The fruits were randomly taken from each treatment and likewise from all the three replication. The fruits were then cut into small pieces and mixed to make one composite sample. The official method (**A.O.A.C.-1995**) was followed in determining the content of fruits which was represented as percent acidity.

Acidity was determined by the simple acid-base titration method as described by Miller (1950). 10 ml okra juice was measured with the help of pipette and transferred to a 250 ml flask and volume made up to mark with distilled water and then filtered through cotton. 10 ml of an aliquot was titrated against N/10 NaOH (standard) solution using few drops of 1% phenolphthalein solution as an indicator, till a light pink colour, was obtained which persists for at least 30 seconds. NaOH solution was standardized with N/10 oxalic acid solution using phenolphthalein as an indicator. Calculation was done by simple mathematical process using formula of acid base titration. Acidity was estimated in terms of citric acid:

Factor: - 1 ml of N/10 NaOH = 0.0064 gm of citric acid

$$\% \text{ Acidity (as citric acid)} = \frac{\text{Titre} \times \text{Normality of NaOH} \times \text{Factor} \times 100}{\text{Weight of volume of Sample}}$$

#### **3.16.4.2 Total Soluble Solids (TSS <sup>0</sup>Brix)**

The T.S.S. content of fresh sample of fruit juice of okra selected from variety was determined by digital hand refractometer.

#### **3.16.4.3 Ascorbic acid (Vitamin C) (mg/100g)**

It was estimated with using 2, 6-dichlorophenol indophenol dye as per **A.O.A.C. (1995)** method. It was expressed in mg/100 g sample.

##### **1. Extraction of solution**

Fifteen grams of Meta phosphoric acid pallets were dissolved in 40 ml glacial acetic acid and 200ml of water and the volume was made up to 500ml with distilled water. The solution was filtered rapidly through filter paper and stored in refrigerator.

##### **2. Ascorbic acid standard solution**

100 milligrams analytical grade ascorbic acid (Reference standard) was accurately weighed on electronic balance and dissolved in a few ml of extraction solution. The content was transferred to a 100ml volumetric flask and volume was made 100ml

Plate No. 6 A general view of treatment combinations of okra



with extraction solution. The stock solution was diluted up to 20 times before use with Meta phosphoric acid, so that it would consume less dye.

### 3. Indophenol standard dye solution

50 mg of 2, 6-Di-chlorophenol indophenols salt that was stored in desiccators over soda lime was dissolved in 50 ml distilled water in a beaker containing 42mg of sodium bicarbonate. The content was shaken vigorously and when dye dissolved diluted 20ml with distilled water and water filtered and stored in dark coloured in a refrigerator.

### 4. Procedure

20 gram of fruit pulp was homogenized in metaphoric acid (extraction solution) and the volume was made to 100ml in a volumetric flask and was titrated against dye. The reading was noted and content of ascorbic acid were expressed in milligrams (mg/100g juice) was calculated by the following:

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Dye factor} \times \text{Titre reading} \times \text{volume made}}{\text{weight of fruit taken} \times \text{volume taken for estimation}} \times 100$$

#### 3.16.4.4 Reducing sugar

Reducing sugar (%) in fruit was determined by the method of Miller (1959). One ml sugar extract was mixed with 3 ml dinitro Salicylic acid (DNS) reagent and kept on boiling water both for 10 minutes. The test tube was cooled at room temperature and the intensity of colour was measured as 575 nm on spectronic 20. The calculation was done with the help of standard curve and results were expressed in % of reducing sugar.

#### 3.16.4.5 Non reducing sugar

Non reducing sugar was obtained by subtraction of reducing sugar from total sugar.

$$\text{Non reducing} = (\text{Total sugar} - \text{reducing sugar}) \times 0.95$$

### 3.16.4.6 Total sugar (%)

The total sugar percentage was determined by the method of Dubois *et al.*, (1956) using Phenol reagent. The sugar extract 0.1 ml was taken in test tube and volume made up to 1 ml with distilled water. Then 0.1 ml 80 % phenol reagent was added and 4 ml conc. H<sub>2</sub>SO<sub>4</sub> was added by the side of test tube and cooled at room temperature. The intensity of colour was recorded at 480 nm on spectronic- 20. The calculating was done with the help of standard curve and results were expressed in % on the basis of 100 g fruit sample.

### 3.16.4.7 Proteins

The seeds were weighed and powdered. Total nitrogen in powdered sample was determined by employing the method described by Jackson (1973). Percentage of total protein was obtained by multiplying the per cent N by 6.25, the factor.

Calculation- calculate percentage of nitrogen (N) as follows:

$$N(\%) = \frac{T[\text{ml HCl used in ml HCl used determination in blank}] \times \text{Normality of HCl} \times 14.00 \times 100}{\text{Sample (mg)}}$$

$$\text{Protein (\%)} = N (\%) \times 6.25$$

### 3.16.4.8 Phosphorus (mg/100g)

To 5 ml of ash solution obtained by dry ashing, add 5 ml of molybdate reagent and mix. Add 2 ml of amino naphthol sulphonic acid solution, mix, and make up the volume to 50 ml. prepare similarly blank using water in place of sample. Allow to stand for 10 minute and measure the colour at 650nm setting the blank at 100% transmission.

Standard curve: Dilute 10 ml standard potassium phosphate solution to 50 ml with water (1ml= 0.02mg P). Pipette aliquots of this solution from 5 to 40 ml into 50 ml volumetric flask. Add 5 ml of molybdate reagent and mix. Then add ml of amino naphthol sulphonic acid reagent, mix, makeup the volume of 50 ml and measure the

colour as in sample. Plot concentration against absorbance. Values were computed using the following formula.

$$\text{Phosphorus (mg/100g)} = \frac{\text{mg of P in the aliquot of ash solution taken X Total volume of ash solution x 100 for estimation}}{\text{ml of ash solution taken for estimation X wt. of sample taken for ashing}}$$

#### 3.16.4.9 Calcium (mg/100g)

Pipette an aliquot (20 to 100 ml) of ash solution obtained by dry ashing to 250 ml beaker. Add 25 to 50 ml of water, if necessary. Add 10 ml of saturated ammonium oxalate solution and 2 drop methyl red indicator. Make the solution slightly alkaline by the addition of dilute ammonia and then slightly acid with a few drop of acetic acid until the colour is faint pink (pH 5.0). Heat the solution to boiling point. Filter through Whatman no. 42 paper and wash with water, till the filtrate is oxalate free. Break the point of the filter paper with platinum wire or pointed glass rod. Wash the precipitate first using hot dilute  $\text{H}_2\text{SO}_4$  (1+4), from wash bottle into the beaker in which the calcium was precipitated. Then wash with hot water and titrate while still hot, (temperature 70 to 80 °C) with 0.01 N  $\text{KMnO}_4$  to the first permanent pink colour. Finally, add filter paper to solution and complete the titration. Values were computed using the following formula:

$$\text{Calcium (mg/100g)} = \frac{\text{Titre X 0.2 X total volume of ash solution X 100}}{\text{Volume taken for estimation X wt. of sample taken for ashing}}$$

#### 3.16.4.10 Magnesium (mg/100g)

The combined mg filtrate and washing from calcium determination, add 2 ml of citric acid, 100 ml of ammonia and 50 ml of alcohol and then add with constant stirring 25 ml of 10% ammonium phosphate solution. Let it stand overnight. Filter the solution into original beaker; make the volume to 100-150 ml. To this solution in the original beaker, add 10-15 ml of ammonia and 2 drops of ammonium phosphate solution. Stand for 3 hours or longer, filter through a good crucible and wash with ammonia. Moisten filter paper with saturated ammoniacal solution of ammonium nitrate. Ignite the precipitate and weigh as  $\text{Mg}_2\text{P}_2\text{O}_7$ .

Weight of Mg = weight of  $Mg_2P_2O_7 \times 0.2162$

### 3.17 Statistical analysis:

#### ANOVA

The data on the growth and yield were statistically analysed according to the method suggested by **Fisher and Yates (1959)**.

Source of variation	D.F.	S.S.	M.S.S.	Variation ratio	Table F Cal.	Table value of F at	
						5%	1%
<b>Block</b>	r-1			$V_B$			
<b>Treatments</b>	n-1			$V_T$	$V_T/V_E$		
<b>Error</b>	(n-1) (r-1)			$V_E$			
<b>Total</b>	nr-1						

Hence, the total number of observation in nr, the total degree of freedom will be nr-1, as the block and treatments are represented by “r” and “n” respectively their corresponding degree of freedom will be (r-1) and (n-1) standard error (S.E.) due to treatment =  $\sqrt{V_E/r}$

#### Standard Error (S.E.) and critical difference (C.D.):-

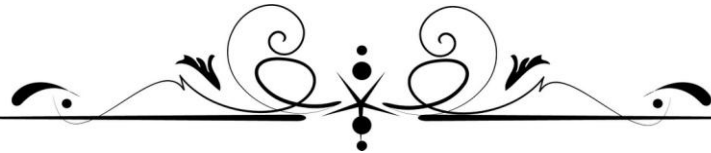
The standard error of the mean based on “r” replication was estimated

By relation:-

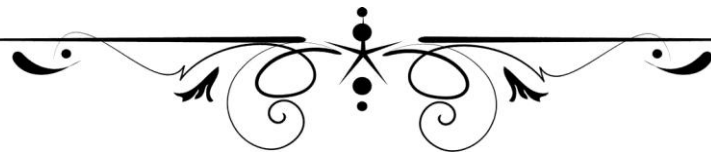
$$(S.E.) \text{ Mean} = \sqrt{V_E/r}$$

Critical difference (C.D.) at 5% level of significance = (SE) diff  $\times t_5\%$  for error degree of freedom.

The results significant at 5% levels of significance were marked with one asterisk and those significant at 1% levels of significance were marked with two asterisks.



*Chapter 4*  
*Experimental*  
*Findings*



# EXPERIMENTAL FINDINGS

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In this chapter, the experimental findings obtained during the investigation entitled “**Effect of integrated nutrient management on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]**” conducted during two consecutive years (2015-16 and 2016-17) were described in this chapter data pertaining to various criteria used for evaluation of the treatments were statistically analyzed and analysis of variance has been furnished in Appendices. Interpretation of data had been made on pooled basis, highlighting the significant effect of treatments. The chapter as affected by different treatments has been categorized in following sub heads:-

4.1 Vegetative growth attributes

4.2 Fruiting and yield

4.3 Fruit characters

4.4 Fruit biochemical characters.

### **4.1 Vegetative growth attributes**

#### **4.1.1 Plant height (cm)**

##### **4.1.1.1 Plant height (cm) at 30 DAS**

The data on plant height of okra at 30 days after sowing has been presented in Table 4.1 and depicted through Fig. 4.1. The corresponding analysis of variance has been appended in Appendix I. During the first year (2015-16) significant difference in the plant height was recorded due to application of different combinations of organic, inorganic fertilizer and biofertilizers. The maximum plant height at 30 DAS (43.40 cm) was recorded from T<sub>13</sub> treatment (RDF + vermicompost) followed by T<sub>9</sub> – RDF + FYM (42.33 cm) and T<sub>17</sub>- RDF + VAM (41.50) while the minimum plant height at 30 DAS (27.43 cm) was recorded from T<sub>0</sub> control which was statistically similar with T<sub>8</sub> - Mahua Cake (29.25 cm).

During the second year (2016-17) significant difference in the plant height was recorded due to application of different combinations of organic, inorganic fertilizer and biofertilizers. The maximum plant height at 30 DAS (46.13 cm) was recorded from T<sub>13</sub> treatment (RDF + Vermicompost) followed by T<sub>9</sub> (44.93 cm) and T<sub>17</sub>- RDF + VAM (43.60) while the minimum plant height at 30 DAS (27.77 cm) was recorded from T<sub>0</sub> control which was statistically similar with T<sub>8</sub> - Mahua Cake (31.01 cm).

The mean value of both years clearly revealed that the maximum plant height was recorded in treatment T<sub>13</sub>- RDF + vermicompost (44.77cm) followed by T<sub>9</sub>- RDF+ FYM ( 43.63 cm) while, the minimum plant height at 30 DAS was recorded in T<sub>0</sub>- control (without fertilizers) (28.60 cm) in okra.

#### **4.1.1.2 Plant height (cm) at 60 DAS**

The data recorded on height of plant at 60 days after sowing as been displayed in Table 4.1 and graphically represented in Figure 4.2. The analysis of variance of data on this attribute has been mentioned in Appendix II. Critical analysis of data presented in above table revealed the expressive differences in plant height at 60 DAS due to various treatment of organic, inorganic fertilizers and biofertilizers. The maximum plant height i.e. 92.50 cm and 95.33 cm were noted by the application of T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 90.87 cm and 93.57 cm and T<sub>17</sub>- RDF + VAM i.e. 88.96 cm and 91.45 cm during 2015-16 and 2016-17, respectively and this improvement was significantly highest then rest of the treatment, however, minimum values i.e. 66.68 cm and 69.18 cm were in control where plots were deprived off by the use of any organic, inorganic fertilizers and biofertilizers in both the years.

During both the years, mean to plant height at 60 DAS was noticed to be maximum (93.92 cm) in the treatment T<sub>13</sub> followed by T<sub>9</sub> and T<sub>17</sub> and minimum (67.93 cm) was reported in T<sub>0</sub> (control).

#### 4.1.1.3 Plant height (cm) at 90 DAS

The data assembled on height of plant at 90 days after sowing due to influence of various levels of organic, inorganic fertilizers and bio fertilizers have been displayed in Table 4.1 and graphically represented in Figure 4.3. The analysis of variance of data on this attribute has been mentioned in Appendix III. Critical analysis of data presented in above table revealed the expressive differences in plant height at 90 DAS due to various treatment of organic, inorganic fertilizers and biofertilizers. The maximum plant height i.e. 148.83 cm and 150.63 cm were noted by the application of T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 145.82 cm and 147.82 cm and T<sub>17</sub>- RDF + VAM i.e. 143.57 cm and 145.67 cm during 2015-16 and 2016-17, respectively and this improvement was significantly highest than rest of the treatment, however, minimum values i.e. 117.65 cm and 119.55 cm were in control where plots were deprived off by the use of any organic, inorganic fertilizers and biofertilizers in both the years.

During both the years, mean plant height at 90 DAS was noticed to be maximum (149.73 cm) in the treatment T<sub>13</sub> followed by T<sub>9</sub> and T<sub>17</sub> and minimum (118.60 cm) was reported in T<sub>0</sub> (control).

Table 4.1: Effect of organic, inorganic fertilizers and biofertilizers on plant height of okra at 30 DAS, 60 DAS and 90 DAS

Treatment	Plant height 30 DAS			Plant height 60 DAS			Plant height 90 DAS		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	27.43	29.77	28.60	66.68	69.18	67.93	117.65	119.55	118.60
T <sub>1</sub> -RDF	36.53	39.07	37.80	81.45	83.25	82.35	136.55	138.05	137.30
T <sub>2</sub> -FYM	37.63	39.95	38.79	82.37	84.87	83.62	137.65	139.45	138.55
T <sub>3</sub> -Neem Cake	30.47	32.47	31.47	69.33	71.23	70.28	121.25	122.75	122.00
T <sub>4</sub> -Karanj Cake	32.65	34.89	33.77	73.15	75.65	74.40	124.82	126.42	125.62
T <sub>5</sub> -Bone Meal	31.17	33.65	32.41	70.56	72.96	71.76	122.43	123.63	123.03
T <sub>6</sub> -Vermi compost	38.48	40.48	39.48	83.85	86.75	85.30	138.37	139.87	139.12
T <sub>7</sub> -Fish gyano	31.85	34.21	33.03	72.02	74.22	73.12	123.54	124.94	124.24
T <sub>8</sub> -Mahua Cake	29.25	31.01	30.13	67.96	70.76	69.36	119.54	121.04	120.29
T <sub>9</sub> -RDF + FYM	42.33	44.93	43.63	90.87	93.57	92.22	145.82	147.82	146.82
T <sub>10</sub> -RDF + Neem Cake	35.96	38.71	37.34	79.90	81.90	80.90	135.65	137.25	136.45
T <sub>11</sub> -RDF +Karanj Cake	33.57	35.82	34.70	74.68	77.58	76.13	125.25	126.75	126.00
T <sub>12</sub> -RDF + Bone Meal	35.33	37.67	36.50	78.21	80.71	79.46	133.72	135.12	134.42
T <sub>13</sub> -RDF + Vermicompost	43.40	46.13	44.77	92.50	95.33	93.92	148.83	150.63	149.73
T <sub>14</sub> -RDF + Fish gyano	34.10	36.64	35.37	75.80	78.30	77.05	127.67	129.67	128.67
T <sub>15</sub> -RDF + Mahua Cake	34.78	37.08	35.93	76.67	79.07	77.87	129.84	132.34	131.09
T <sub>16</sub> -RDF + Azospirillum	39.00	41.00	40.00	85.00	87.60	86.30	140.67	143.07	141.87
T <sub>17</sub> -RDF + VAM	41.50	43.60	42.55	88.96	91.45	90.21	143.57	145.67	144.62
T <sub>18</sub> -RDF + PSB	40.63	42.13	41.38	86.78	88.78	87.78	142.57	144.57	143.57
CD (P = 0.05)	4.477	2.273	3.334	2.039	1.974	1.972	2.220	3.653	2.875
SEm±	1.555	0.789	1.158	0.708	0.686	0.685	0.771	1.269	0.998

Fig. 4.1: Effect of organic, inorganic fertilizers and biofertilizers on plant height of okra at 30 DAS

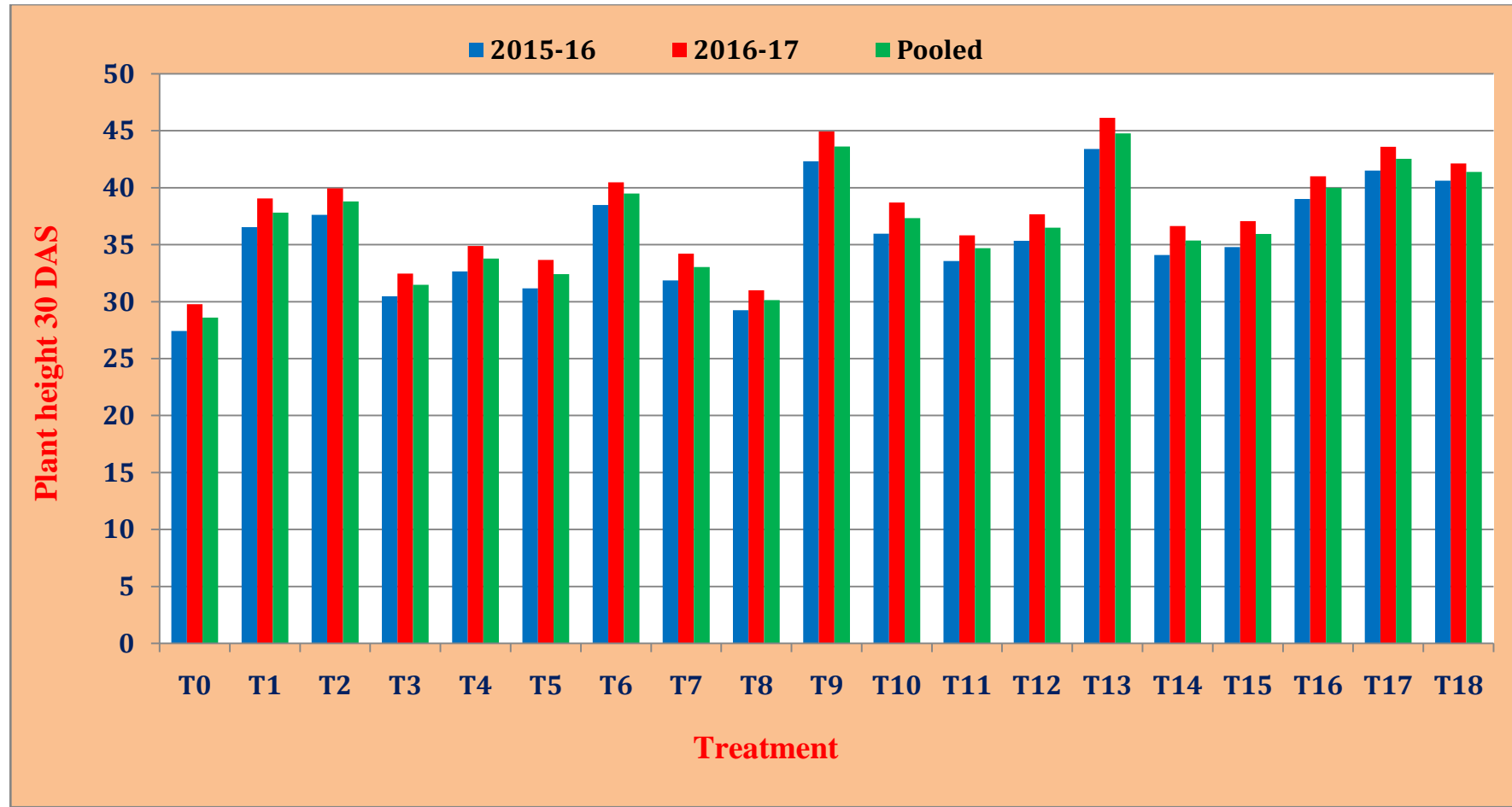


Fig. 4.2: Effect of organic, inorganic fertilizers and biofertilizers on plant height of okra at 60 DAS

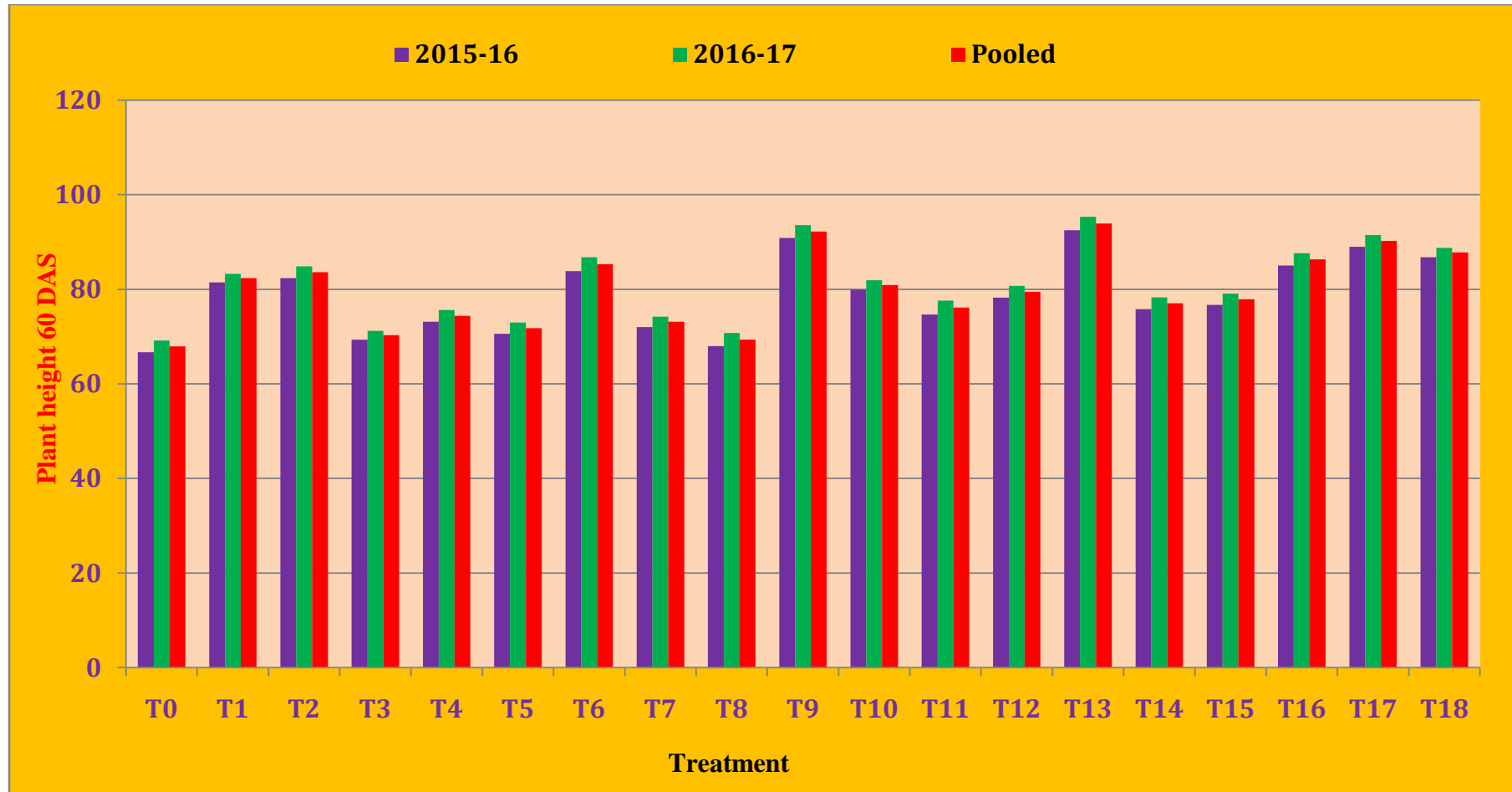
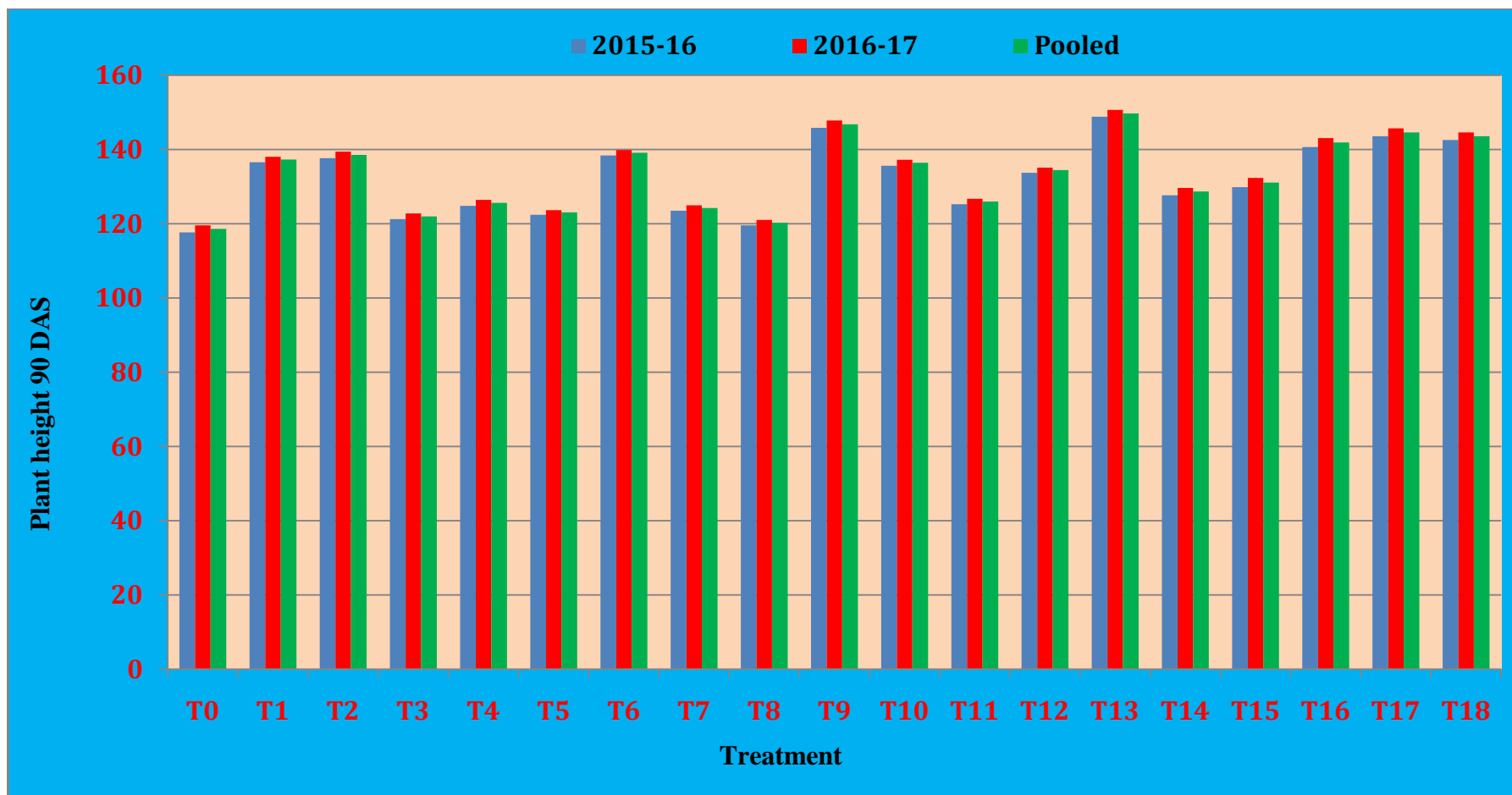


Fig. 4.3: Effect of organic, inorganic fertilizers and biofertilizers on plant height of okra at 90 DAS



### 4.1.2 Number of branch per plant

The data pertaining to number of branch per plant due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been displayed in Table 4.2 and graphically represented in Figure 4.4. The analysis of variance of data on this parameter has been mentioned in Appendix IV. Critical analysis of data revealed that various treatments significantly enhanced the number of branch per plant at all stages of growth except at 100 days after sowing and maximum number of branch per plant i.e. 4.73 and 5.33 were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 4.60 and 5.15 and T<sub>17</sub>- RDF +VAM i.e. 4.53 and 5.01 while lowest number of branch per plant 3.12 and 3.31 were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

During both the years, mean number of branch per plant was noticed to be maximum (5.03) in the treatment T<sub>13</sub> followed by T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub> and minimum (3.22) was reported in T<sub>0</sub> (control).

### 4.1.3 Stem diameter

The data accumulated on stem diameter due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been displayed in Table 4.3 and graphically represented in Figure 4.5. The analysis of variance of data on this parameter has been mentioned in Appendix V. Critical analysis of data revealed that various treatments significantly enhanced the stem diameter at all stages of growth except at 100 days after sowing and maximum stem diameter i.e. 29.67 mm and 30.10 mm were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 28.33 mm and 29.25 mm and T<sub>17</sub>- RDF +VAM i.e. 27.78 mm and 28.45 mm while minimum stem diameter 16.96 mm and 17.75 mm were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

During both the years, mean stem diameter per plant was noticed to be maximum (29.89) in the treatment T<sub>13</sub> followed by T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub> and minimum (17.36) was reported in T<sub>0</sub> (control).

Table 4.2: Effect of organic, inorganic fertilizers and biofertilizers on number of branch per plant of okra.

Treatment	Number of Branch per plant		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	3.12	3.31	3.22
T <sub>1</sub> -RDF	4.15	4.45	4.30
T <sub>2</sub> -FYM	4.22	4.59	4.41
T <sub>3</sub> -Neem Cake	3.33	3.50	3.42
T <sub>4</sub> -Karanj Cake	3.65	3.85	3.75
T <sub>5</sub> -Bone Meal	3.43	3.62	3.53
T <sub>6</sub> -Vermi compost	4.28	4.67	4.48
T <sub>7</sub> -Fish gyano	3.57	3.78	3.68
T <sub>8</sub> -Mahua Cake	3.25	3.45	3.35
T <sub>9</sub> -RDF + FYM	4.60	5.15	4.88
T <sub>10</sub> -RDF + Neem Cake	4.05	4.33	4.19
T <sub>11</sub> -RDF +Karanj Cake	3.70	3.88	3.79
T <sub>12</sub> -RDF + Bone Meal	3.95	4.20	4.08
T <sub>13</sub> -RDF + Vermicompost	4.73	5.33	5.03
T <sub>14</sub> -RDF + Fish gyano	3.76	3.97	3.87
T <sub>15</sub> -RDF + Mahua Cake	3.87	4.10	3.99
T <sub>16</sub> -RDF + <i>Azospirillum</i>	4.33	4.75	4.54
T <sub>17</sub> -RDF + VAM	4.53	5.01	4.77
T <sub>18</sub> -RDF + PSB	4.45	4.89	4.67
CD (P = 0.05)	0.292	0.292	0.292
SEm±	0.101	0.101	0.101

Fig. 4.4: Effect of organic, inorganic fertilizers and biofertilizers on number of branch per plant of okra

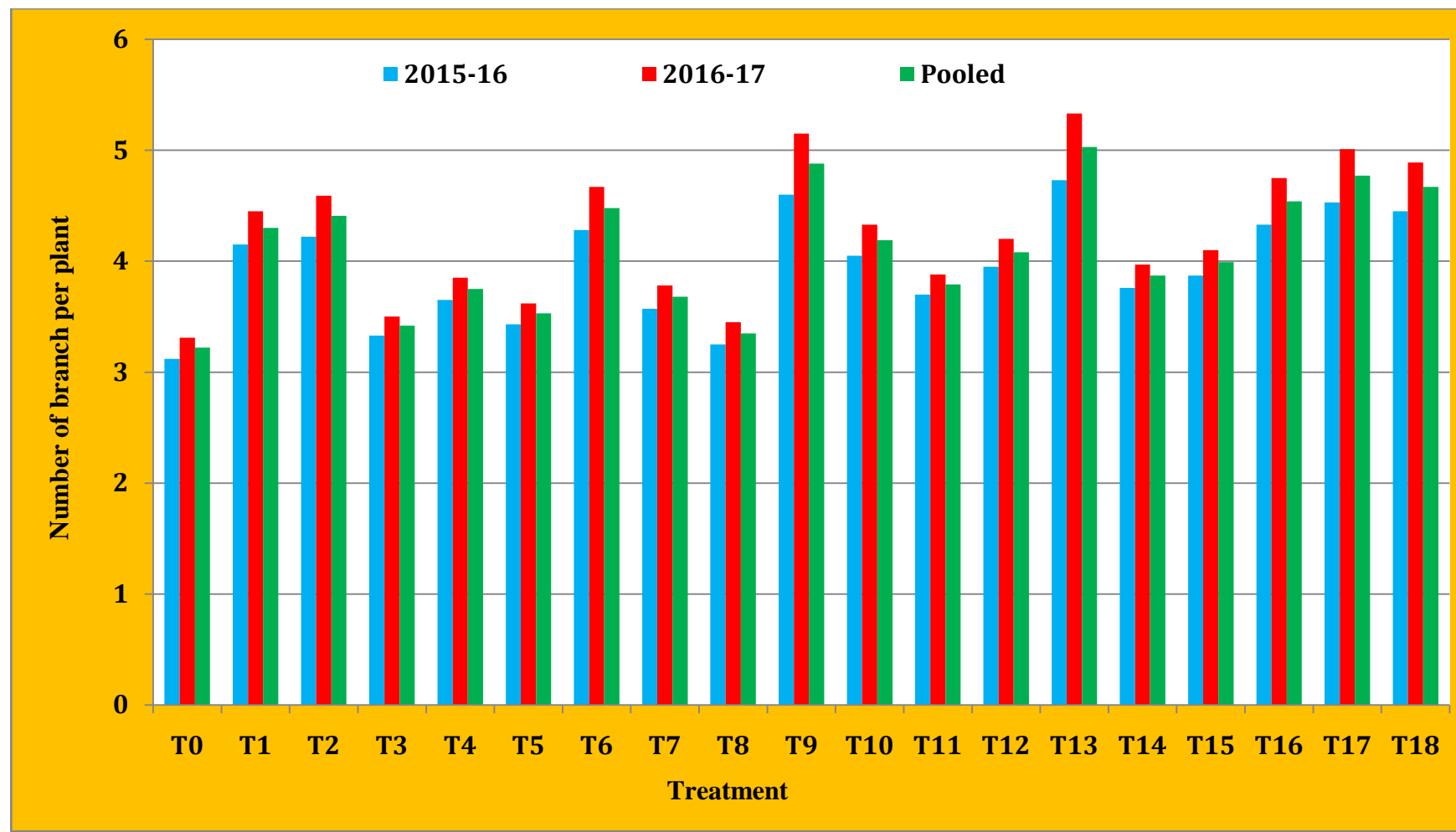
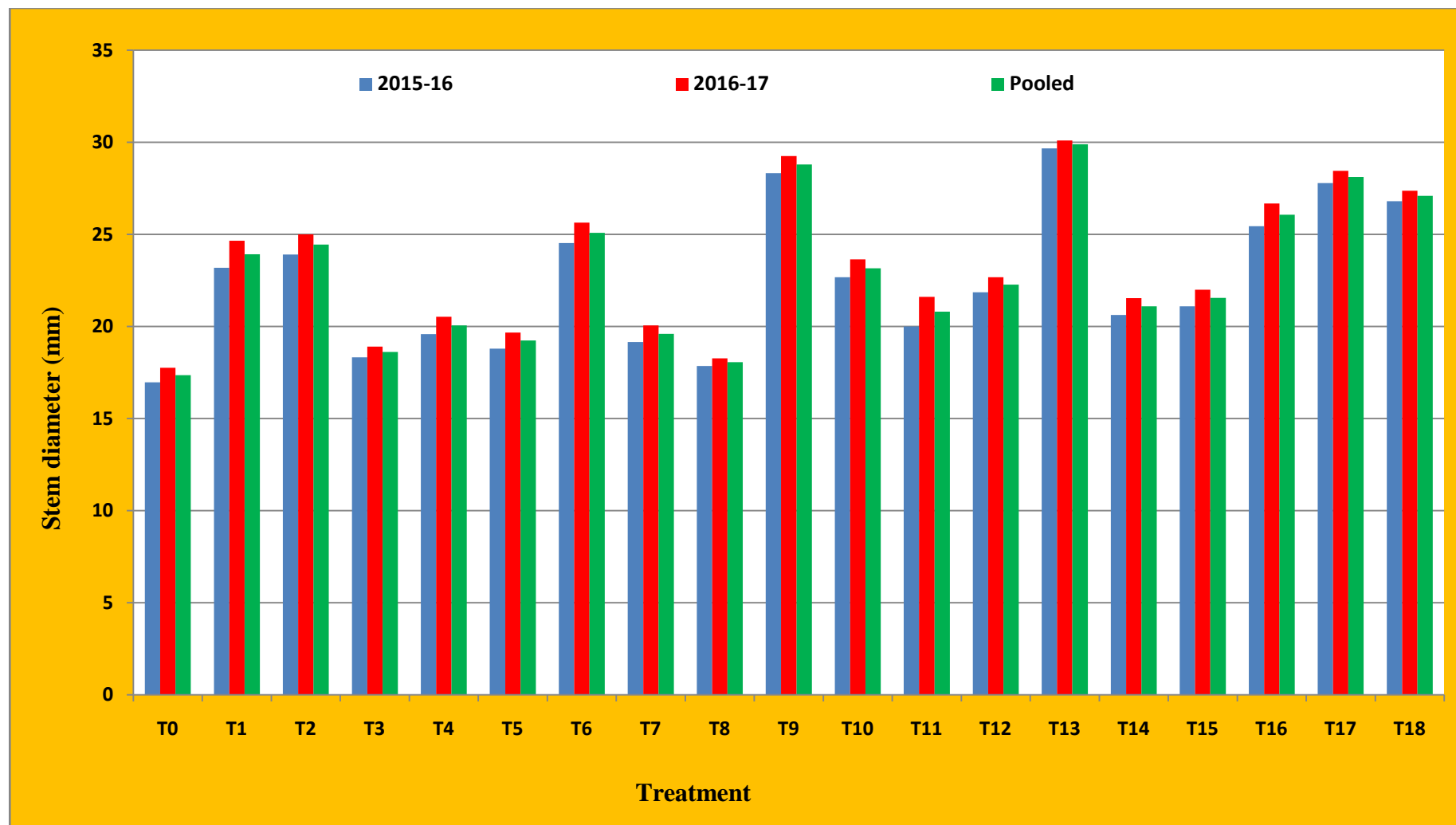


Table 4.3: Effect of organic, inorganic fertilizers and biofertilizers on stem diameter of okra.

Treatment	Stem diameter (mm)		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	16.96	17.75	17.36
T <sub>1</sub> -RDF	23.18	24.65	23.92
T <sub>2</sub> -FYM	23.90	25.00	24.45
T <sub>3</sub> -Neem Cake	18.33	18.90	18.62
T <sub>4</sub> -Karanj Cake	19.58	20.53	20.06
T <sub>5</sub> -Bone Meal	18.80	19.67	19.24
T <sub>6</sub> -Vermi compost	24.53	25.64	25.09
T <sub>7</sub> -Fish gyano	19.15	20.05	19.60
T <sub>8</sub> -Mahua Cake	17.85	18.27	18.06
T <sub>9</sub> -RDF + FYM	28.33	29.25	28.79
T <sub>10</sub> -RDF + Neem Cake	22.68	23.64	23.16
T <sub>11</sub> -RDF +Karanj Cake	20.00	21.60	20.80
T <sub>12</sub> -RDF + Bone Meal	21.85	22.68	22.27
T <sub>13</sub> -RDF + Vermicompost	29.67	30.10	29.89
T <sub>14</sub> -RDF + Fish gyano	20.63	21.54	21.09
T <sub>15</sub> -RDF + Mahua Cake	21.10	22.00	21.55
T <sub>16</sub> -RDF + <i>Azospirillum</i>	25.45	26.68	26.07
T <sub>17</sub> -RDF + VAM	27.78	28.45	28.12
T <sub>18</sub> -RDF + PSB	26.80	27.37	27.09
CD (P = 0.05)	4.247	3.611	2.971
SEm±	1.475	1.254	1.032

Fig. 4.5: Effect of organic, inorganic fertilizers and biofertilizers on stem diameter (mm) of okra.



#### 4.1.4 Number of flower buds

Data recorded towards number of flower buds due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been displayed in Table 4.6, graphically represented in Figure 4.6 and analysis of variance of data on this parameter has been mentioned in Appendix VI. Critical analysis of data revealed that various treatments significantly enhanced the number of flower buds due to various treatments of organic, inorganic fertilizers and biofertilizers. The maximum number of flower buds i.e. 19.30 and 18.82 were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 18.68 and 18.43 and T<sub>17</sub>- RDF +VAM i.e. 18.08 and 18.15 while minimum number of flower buds 12.98 and 13.68 were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

The mean number of flower buds per plant over two years, irrespective of treatments was obtained maximum (19.06) under the treatment T<sub>13</sub> while, minimum (13.33) mean number of flower buds was obtained under the treatment T<sub>0</sub> (control)

#### 4.1.5 Leaf area

The data accumulated on leaf area due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been displayed in Table 4.7 and graphically represented in Figure 4.7. The analysis of variance of data on this parameter has been mentioned in Appendix VII. Critical analysis of data revealed that various treatments significantly enhanced the leaf area at all stages of growth except at 100 days after sowing and maximum leaf area i.e. 881.25 cm<sup>2</sup> and 891.52 cm<sup>2</sup> were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 856.50 cm<sup>2</sup> and 866.74 cm<sup>2</sup> and T<sub>17</sub>- RDF +VAM i.e. 823.25 cm<sup>2</sup> and 832.47 cm<sup>2</sup> while minimum leaf area 578.56 cm<sup>2</sup> and 584.04 cm<sup>2</sup> were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

During both the years, mean leaf area was noticed to be maximum (886.39 cm<sup>2</sup>) in the treatment T<sub>13</sub> followed by T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub> and minimum (581.30 cm<sup>2</sup>) was reported in T<sub>0</sub> (control).

Table 4.4: Effect of organic, inorganic fertilizers and biofertilizers on number of flower per plant of okra.

Treatment	Number of flower buds		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	12.98	13.68	13.33
T <sub>1</sub> -RDF	15.83	16.91	16.37
T <sub>2</sub> -FYM	16.18	17.10	16.64
T <sub>3</sub> -Neem Cake	13.56	14.28	13.92
T <sub>4</sub> -Karanj Cake	14.15	15.30	14.73
T <sub>5</sub> -Bone Meal	13.65	14.61	14.13
T <sub>6</sub> -Vermi compost	16.50	17.32	16.91
T <sub>7</sub> -Fish gyano	13.82	15.02	14.42
T <sub>8</sub> -Mahua Cake	13.31	14.08	13.69
T <sub>9</sub> -RDF + FYM	18.68	18.43	18.56
T <sub>10</sub> -RDF + Neem Cake	15.51	16.56	16.03
T <sub>11</sub> -RDF +Karanj Cake	14.41	15.76	15.09
T <sub>12</sub> -RDF + Bone Meal	15.28	16.41	15.85
T <sub>13</sub> -RDF + Vermicompost	19.30	18.82	19.06
T <sub>14</sub> -RDF + Fish gyano	14.70	15.84	15.27
T <sub>15</sub> -RDF + Mahua Cake	14.96	16.16	15.56
T <sub>16</sub> -RDF + <i>Azospirillum</i>	16.97	17.67	17.32
T <sub>17</sub> -RDF + VAM	18.08	18.15	18.12
T <sub>18</sub> -RDF + PSB	17.55	17.96	17.76
CD (P = 0.05)	1.477	1.403	0.847
SEm±	0.513	0.487	0.294

Fig.4.6: Effect of organic, inorganic fertilizers and biofertilizers on number of flower per plant of okra.

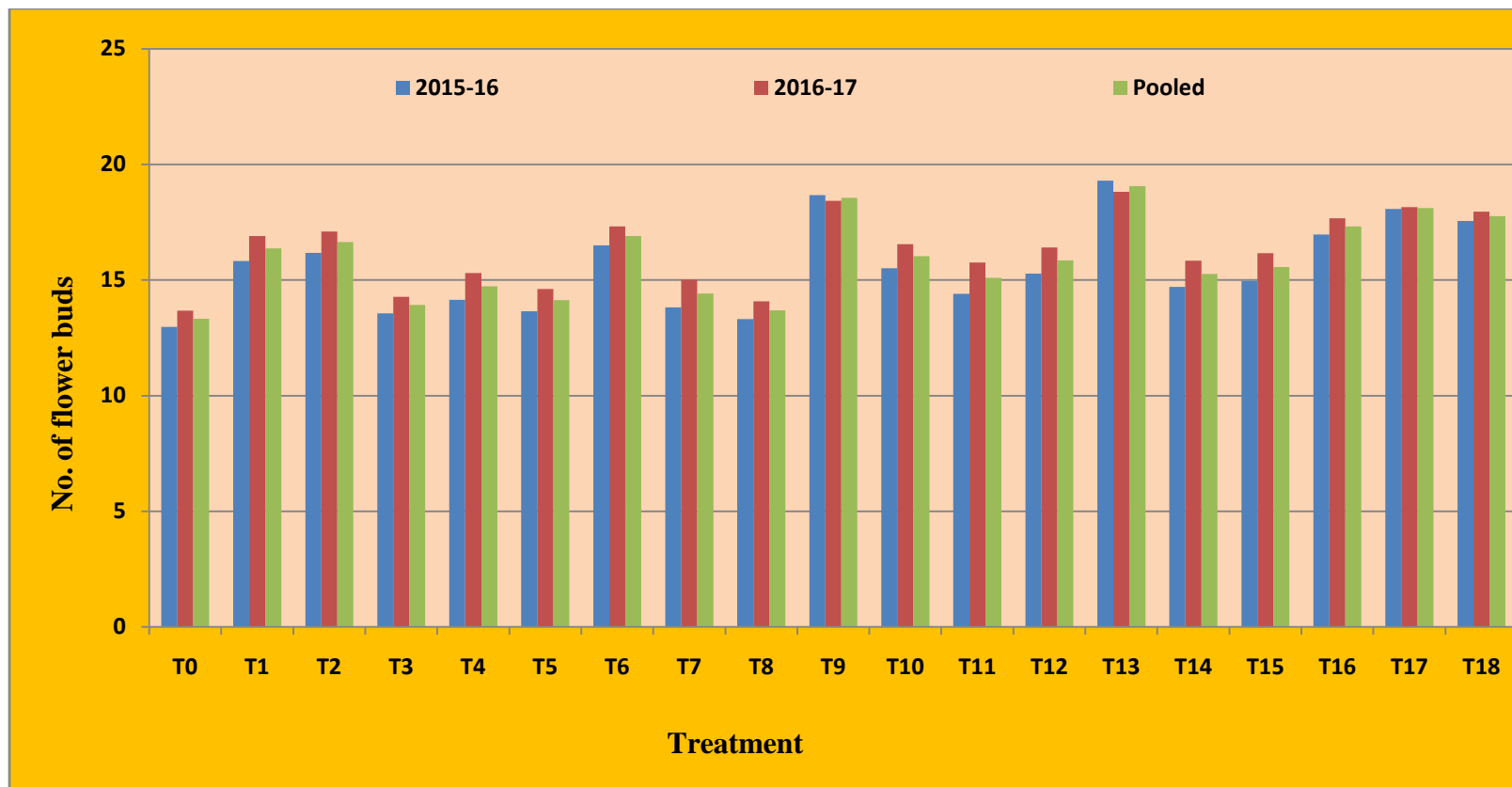
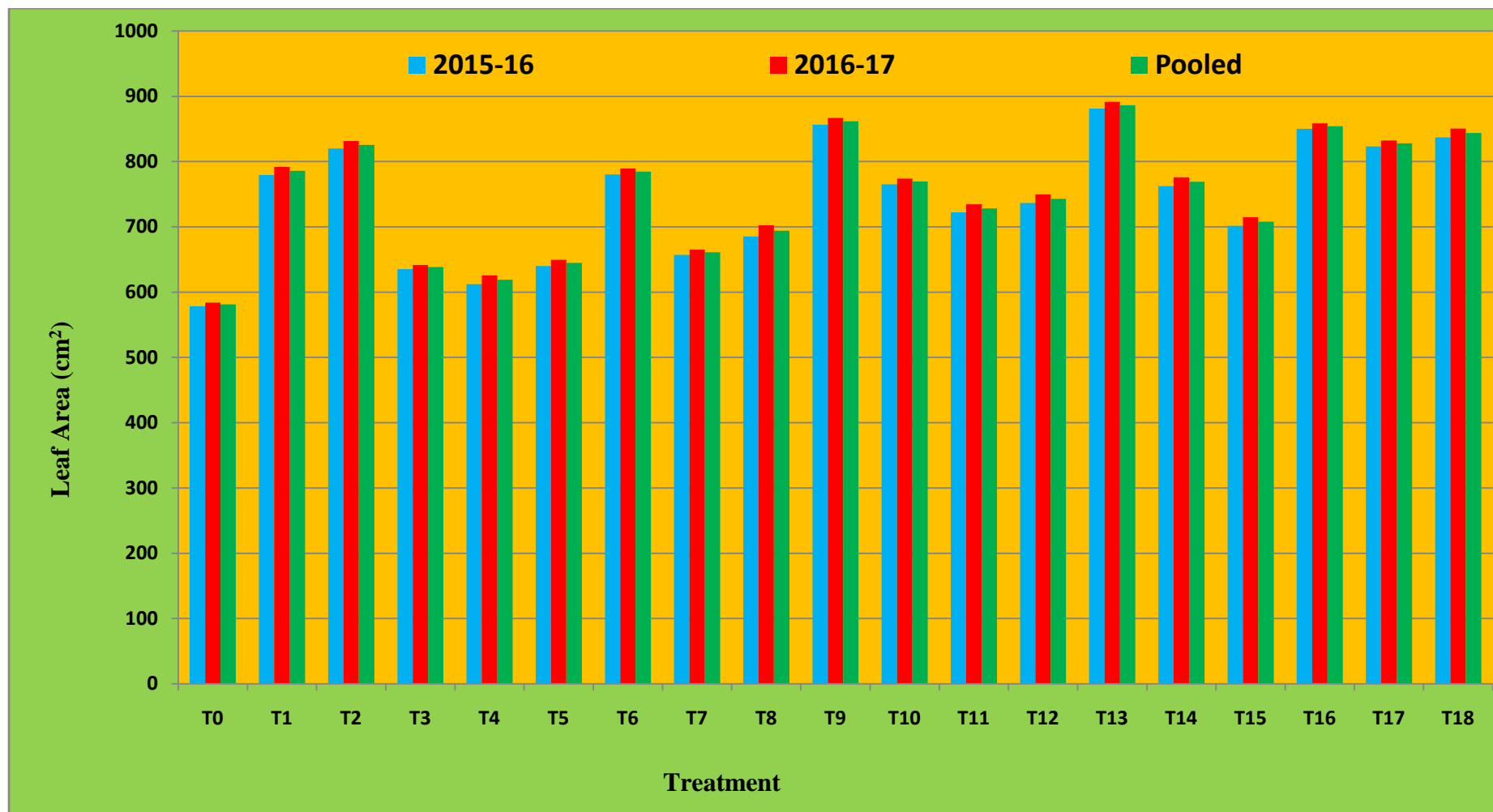


Table 4.5: Effect of organic, inorganic fertilizers and biofertilizers on leaf area of okra.

Treatment	Leaf Area (cm) <sup>2</sup>		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	578.56	584.04	581.30
T <sub>1</sub> -RDF	779.54	791.78	785.66
T <sub>2</sub> -FYM	820.10	831.36	825.73
T <sub>3</sub> -Neem Cake	635.25	641.60	638.43
T <sub>4</sub> -Karanj Cake	612.35	625.60	618.98
T <sub>5</sub> -Bone Meal	640.23	649.44	644.84
T <sub>6</sub> -Vermi compost	780.12	789.37	784.75
T <sub>7</sub> -Fish gyano	657.00	665.25	661.13
T <sub>8</sub> -Mahua Cake	685.48	702.48	693.98
T <sub>9</sub> -RDF + FYM	856.50	866.74	861.62
T <sub>10</sub> -RDF + Neem Cake	765.25	774.05	769.65
T <sub>11</sub> -RDF +Karanj Cake	722.20	734.46	728.33
T <sub>12</sub> -RDF + Bone Meal	736.40	749.75	743.08
T <sub>13</sub> -RDF + Vermicompost	881.25	891.52	886.39
T <sub>14</sub> -RDF + Fish gyano	762.50	775.75	769.13
T <sub>15</sub> -RDF + Mahua Cake	701.54	714.79	708.17
T <sub>16</sub> -RDF + <i>Azospirillum</i>	850.25	858.48	854.37
T <sub>17</sub> -RDF + VAM	823.25	832.47	827.86
T <sub>18</sub> -RDF + PSB	837.22	850.43	843.83
CD (P = 0.05)	6.991	6.592	6.749
SEm±	2.428	2.289	2.344

Fig. 4.7: Effect of organic, inorganic fertilizers and biofertilizers on leaf area of okra.



#### 4.1.6 Days to 50% flowering

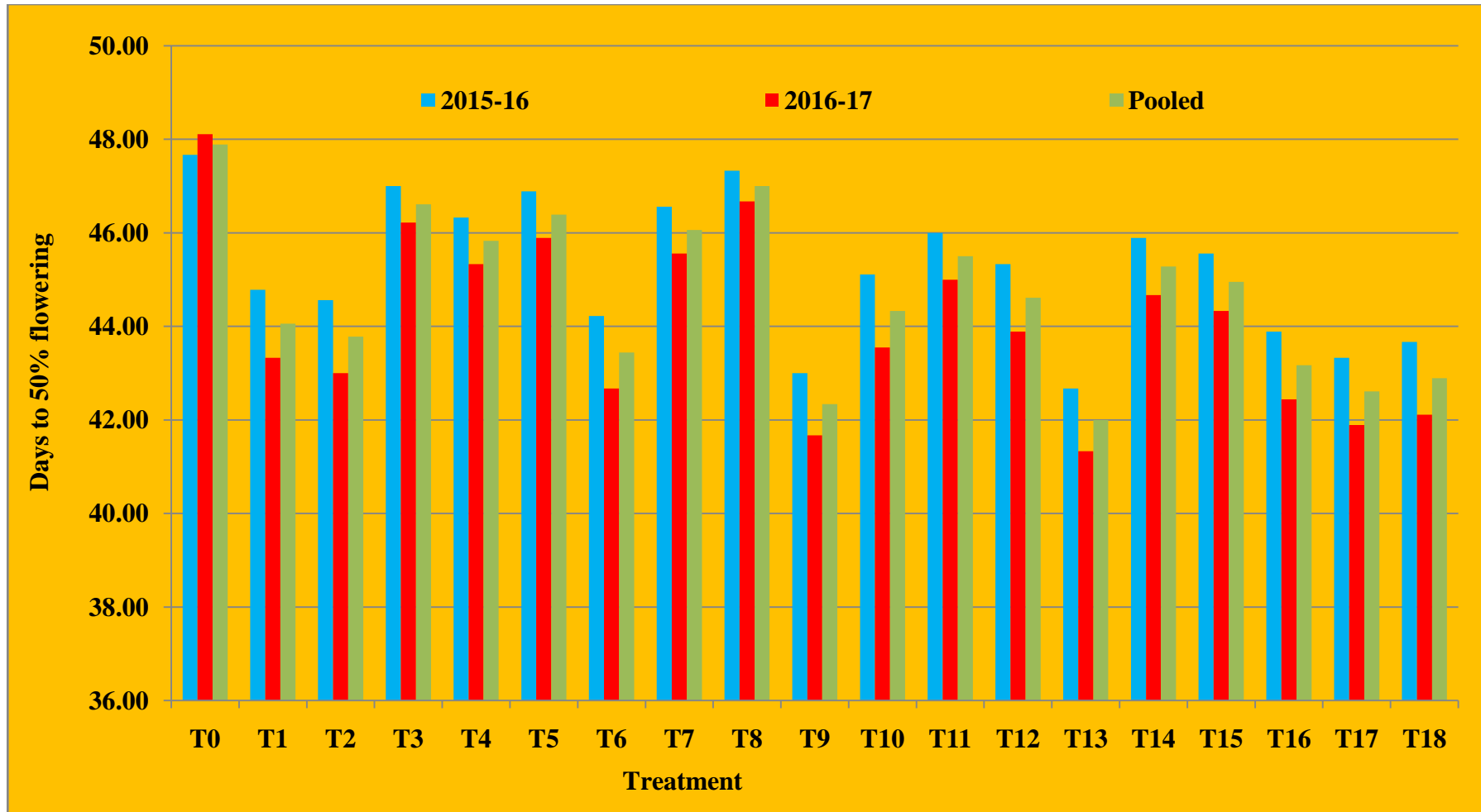
Data recorded towards days to 50% flowering due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been displayed in Table 4.8, graphically represented in Figure 4.8 and analysis of variance of data on this parameter has been mentioned in Appendix VIII. Data presented in above table clearly marked out that different treatment caused significant response on days to 50% flowering. The minimum days to 50% flowering i.e. 42.67 and 41.33 were recorded during 2015-16 and 2016-17, respectively, with the application of T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 43.00 and 41.67 and T<sub>17</sub>- RDF +VAM i.e. 43.33 and 41.89. The maximum (47.67 and 48.11) days to 50% flowering was found under the treatment T<sub>0</sub> (control).

The mean days to 50% flowering over two years, irrespective of treatments, was obtained minimum (42.00) under the treatment T<sub>13</sub> while, maximum (47.89) mean days to 50% flowering was obtained under the treatment T<sub>0</sub> (control).

Table 4.6: Effect of organic, inorganic fertilizers and biofertilizers on days to 50% flowering of okra.

Treatment	Days to 50% flowering		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	47.67	48.11	47.89
T <sub>1</sub> -RDF	44.78	43.33	44.06
T <sub>2</sub> -FYM	44.56	43.00	43.78
T <sub>3</sub> -Neem Cake	47.00	46.22	46.61
T <sub>4</sub> -Karanj Cake	46.33	45.33	45.83
T <sub>5</sub> -Bone Meal	46.89	45.89	46.39
T <sub>6</sub> -Vermi compost	44.22	42.67	43.44
T <sub>7</sub> -Fish gyano	46.56	45.56	46.06
T <sub>8</sub> -Mahua Cake	47.33	46.67	47.00
T <sub>9</sub> -RDF + FYM	43.00	41.67	42.34
T <sub>10</sub> -RDF + Neem Cake	45.11	43.55	44.33
T <sub>11</sub> -RDF +Karanj Cake	46.00	45.00	45.50
T <sub>12</sub> -RDF + Bone Meal	45.33	43.89	44.61
T <sub>13</sub> -RDF + Vermicompost	42.67	41.33	42.00
T <sub>14</sub> -RDF + Fish gyano	45.89	44.67	45.28
T <sub>15</sub> -RDF + Mahua Cake	45.56	44.33	44.95
T <sub>16</sub> -RDF + <i>Azospirillum</i>	43.89	42.44	43.17
T <sub>17</sub> -RDF + VAM	43.33	41.89	42.61
T <sub>18</sub> -RDF + PSB	43.67	42.11	42.89
CD (P = 0.05)	0.781	1.748	1.049
SEm±	0.271	0.607	0.364

Fig 4.8: Effect of organic, inorganic fertilizers and biofertilizers on days to 50% flowering of okra.



## 4.2 Fruiting and yield

### 4.2.1 Number of fruit per plant

The data accumulated on number of fruit per plant due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been displayed in Table 4.9 and graphically represented in Figure 4.9. The analysis of variance computed for this character given in Appendix IX. The data presented in above table clearly indicated that the maximum number of fruit per plant was noticed under treatment T<sub>13</sub>- RDF + vermicompost i.e. 18.11 and 17.63. The values recorded by T<sub>9</sub>- RDF + FYM i.e. 17.50 and 17.25 being at par with T<sub>13</sub> and it was significantly superior over remaining treatments, however, minimum values i.e. 11.78 and 12.48 were in control where plots were deprived off by the use of organic, inorganic fertilizer and biofertilizers in both the years.

A perusal of data for mean over two years reveal that mean number of fruit per plant was maximum (17.87) in treatment T<sub>13</sub> followed by T<sub>9</sub>, and T<sub>17</sub> and minimum (12.13) was reported in T<sub>0</sub> (control).

### 4.2.2 Fruit yield per plant (kg)

The data accumulated on fruit yield per plant due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been displayed in Table 4.10 and graphically represented in Figure 4.10. The analysis of variance computed for this character given in Appendix X. The data presented in above table clearly indicated that the maximum fruit yield per plant was recorded under treatment T<sub>13</sub>- RDF + vermicompost i.e. 0.242 kg and 0.264 kg. The values recorded by T<sub>9</sub>- RDF + FYM i.e. 0.233 kg and 0.251 kg being at par with T<sub>13</sub> and it was significantly superior over remaining treatments, however, minimum values i.e. 0.134 kg and 0.150 kg were in control where plots were deprived off by the use of organic, inorganic fertilizer and biofertilizers in both the years.

A perusal of data for mean over two years reveal that mean fruit yield per plant was maximum (0.253 kg) in treatment T<sub>13</sub> followed by T<sub>9</sub>, and T<sub>17</sub> and minimum (0.142 kg) was reported in T<sub>0</sub> (control).

Table 4.7: Effect of organic, inorganic fertilizers and biofertilizers on number of fruit per plant of okra.

Treatment	Number of fruit per plant		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	11.78	12.48	12.13
T <sub>1</sub> -RDF	14.60	15.68	15.14
T <sub>2</sub> -FYM	14.98	15.90	15.44
T <sub>3</sub> -Neem Cake	12.33	13.05	12.69
T <sub>4</sub> -Karanj Cake	12.95	14.10	13.53
T <sub>5</sub> -Bone Meal	12.47	13.43	12.95
T <sub>6</sub> -Vermi compost	15.30	16.12	15.71
T <sub>7</sub> -Fish gyano	12.65	13.85	13.25
T <sub>8</sub> -Mahua Cake	12.10	12.87	12.49
T <sub>9</sub> -RDF + FYM	17.50	17.25	17.38
T <sub>10</sub> -RDF + Neem Cake	14.33	15.38	14.86
T <sub>11</sub> -RDF +Karanj Cake	13.23	14.58	13.91
T <sub>12</sub> -RDF + Bone Meal	14.10	15.23	14.67
T <sub>13</sub> -RDF + Vermicompost	18.11	17.63	17.87
T <sub>14</sub> -RDF + Fish gyano	13.53	14.67	14.10
T <sub>15</sub> -RDF + Mahua Cake	13.78	14.98	14.38
T <sub>16</sub> -RDF + <i>Azospirillum</i>	15.78	16.48	16.13
T <sub>17</sub> -RDF + VAM	16.90	16.97	16.94
T <sub>18</sub> -RDF + PSB	16.37	16.78	16.58
CD (P = 0.05)	1.449	1.411	0.830
SEm±	0.503	0.490	0.288

Fig. 4.9: Effect of organic, inorganic fertilizers and biofertilizers on number of fruit per plant of okra.

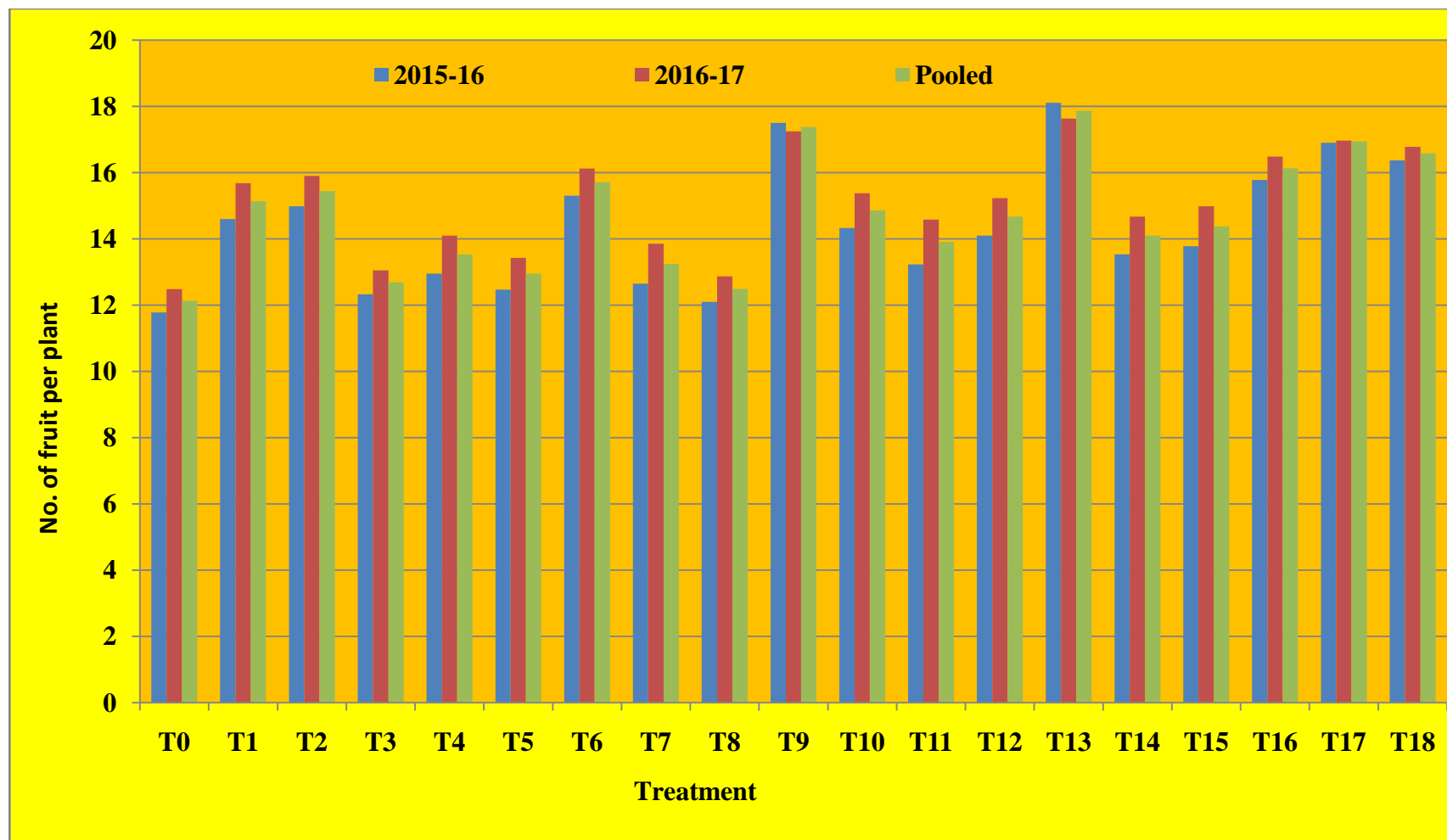
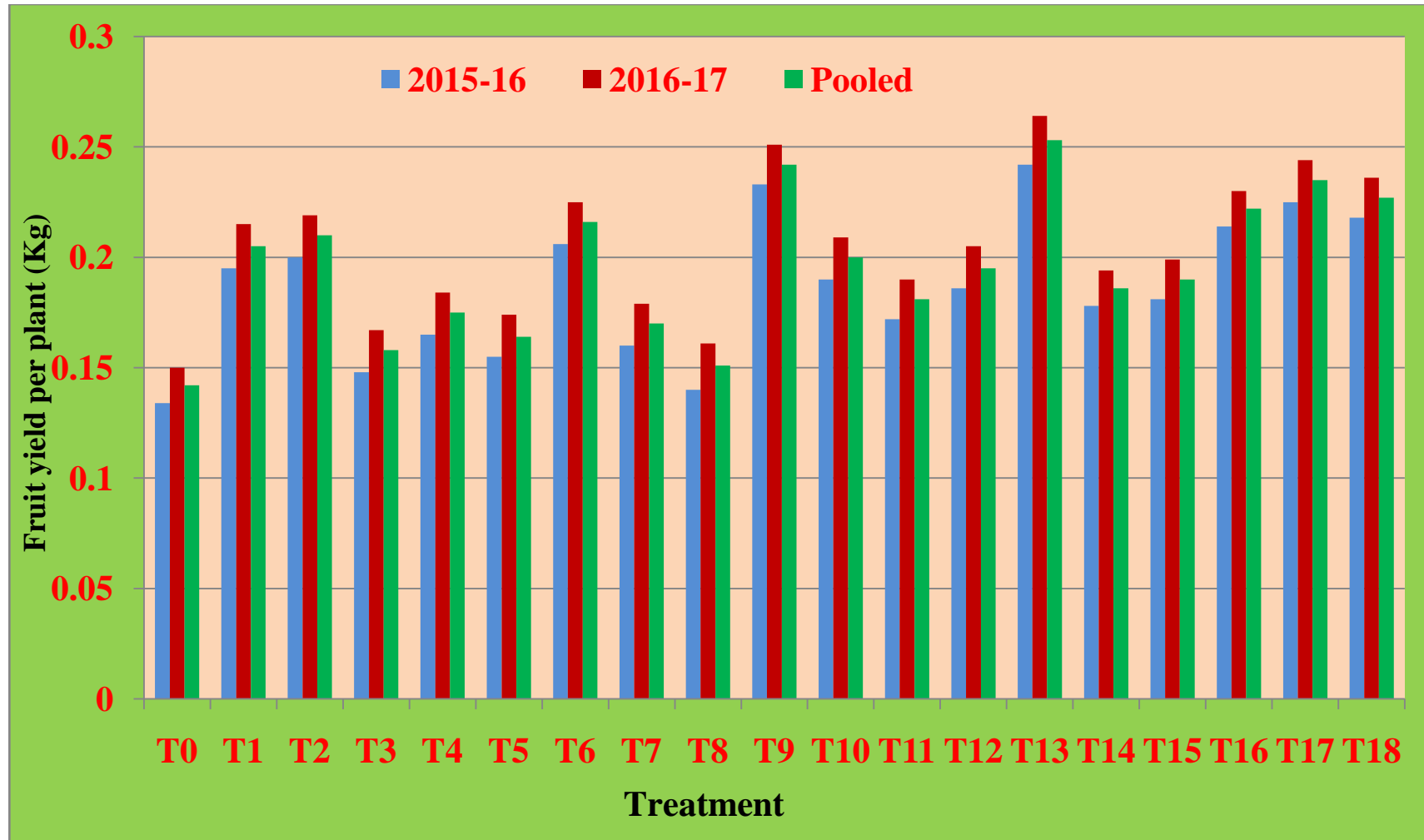


Table 4.8: Effect of organic, inorganic fertilizers and biofertilizers on fruit yield per plant (kg) of okra.

Treatment	Fruit yield per plant (Kg)		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	0.134	0.150	0.142
T <sub>1</sub> -RDF	0.195	0.215	0.205
T <sub>2</sub> -FYM	0.200	0.219	0.210
T <sub>3</sub> -Neem Cake	0.148	0.167	0.158
T <sub>4</sub> -Karanj Cake	0.165	0.184	0.175
T <sub>5</sub> -Bone Meal	0.155	0.174	0.164
T <sub>6</sub> -Vermi compost	0.206	0.225	0.216
T <sub>7</sub> -Fish gyano	0.160	0.179	0.170
T <sub>8</sub> -Mahua Cake	0.140	0.161	0.151
T <sub>9</sub> -RDF + FYM	0.233	0.251	0.242
T <sub>10</sub> -RDF + Neem Cake	0.190	0.209	0.200
T <sub>11</sub> -RDF + Karanj Cake	0.172	0.190	0.181
T <sub>12</sub> -RDF + Bone Meal	0.186	0.205	0.195
T <sub>13</sub> -RDF + Vermicompost	0.242	0.264	0.253
T <sub>14</sub> -RDF + Fish gyano	0.178	0.194	0.186
T <sub>15</sub> -RDF + Mahua Cake	0.181	0.199	0.190
T <sub>16</sub> -RDF + <i>Azospirillum</i>	0.214	0.230	0.222
T <sub>17</sub> -RDF + VAM	0.225	0.244	0.235
T <sub>18</sub> -RDF + PSB	0.218	0.236	0.227
CD (P = 0.05)	0.019	0.032	0.018
SEm±	0.007	0.011	0.006

Fig. 4.10: Effect of organic, inorganic fertilizers and biofertilizers on fruit yield per plant (kg) of okra.



### 4.2.3 Fruit yield per plot (kg)

Data assembled on account of fruit yield per plot as influenced by the use of various levels of organic, inorganic fertilizers and biofertilizers have been tabulated in Table 4.11 and graphically represented in Figure 4.11 and analysis of variance computed for this character given in Appendix XI. Data presented in above table clearly marked out that different treatment caused significant response on fruit yield per plot. The more fruit yield per plot (3.877 kg and 4.224 kg) was recorded under the treatment T<sub>13</sub>- RDF + vermicompost during 2015-16 and 2016-17, respectively. The values recorded by T<sub>9</sub> – RDF +FYM i.e. 3.728 kg and 4.016 kg being at par with T<sub>13</sub> and it was significantly superior over remaining treatments. The lower (2.149 kg and 2.400 kg) fruit yield per plot were observed in T<sub>0</sub> (control) treatment during both the year of experimentation.

A perusal of data for mean over two years reveal that mean fruit yield per plant was maximum (4.051 kg) in treatment T<sub>13</sub> followed by T<sub>9</sub> and minimum (2.275 kg) was observed in T<sub>0</sub> (control).

### 4.2.4 Fruit yield per ha (t)

Data assembled on account of fruit yield per hectare as influenced by the use of various levels of organic, inorganic fertilizers and biofertilizers have been tabulated in Table 4.12 and graphically represented in Figure 4.12 and analysis of variance computed for this character given in Appendix XII. Data presented in above table clearly marked out that different treatment caused significant response on fruit yield per hectare. The maximum fruit yield per hectare (17.95 t/ha and 19.55 t/ha) was recorded under the treatment T<sub>13</sub>- RDF + vermicompost during 2015-16 and 2016-17, respectively. The values recorded by T<sub>9</sub> – RDF +FYM i.e. 17.26 t/ha and 18.59 t/ha being at par with T<sub>13</sub> and it was significantly superior over remaining treatments. The minimum fruit yield per hectare (9.95 t/ha and 11.11 t/ha) were recorded in T<sub>0</sub> (control) treatment during both the year of experimentation.

A perusal of data for mean over two years reveal that mean fruit yield per hectare was highest (18.75 t/h) in treatment T<sub>13</sub> followed by T<sub>9</sub> and minimum (10.53 t/ha) was observed in T<sub>0</sub> (control).

Table 4.9: Effect of organic, inorganic fertilizers and biofertilizers on fruit yield per plot (kg) and fruit yield per ha (t) of okra.

Treatment	Fruit yield per plot (Kg)			Fruit yield per ha (t)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	2.149	2.400	2.275	9.95	11.11	10.53
T <sub>1</sub> -RDF	3.120	3.440	3.280	14.44	15.92	15.18
T <sub>2</sub> -FYM	3.200	3.504	3.352	14.81	16.22	15.51
T <sub>3</sub> -Neem Cake	2.373	2.672	2.523	10.99	12.37	11.67
T <sub>4</sub> -Karanj Cake	2.645	2.944	2.795	12.25	13.63	12.93
T <sub>5</sub> -Bone Meal	2.475	2.784	2.629	11.46	12.88	12.17
T <sub>6</sub> -Vermi compost	3.296	3.600	3.448	15.26	16.66	15.96
T <sub>7</sub> -Fish gyano	2.560	2.864	2.712	11.85	13.25	12.55
T <sub>8</sub> -Mahua Cake	2.240	2.576	2.408	10.37	11.92	11.14
T <sub>9</sub> -RDF + FYM	3.728	4.016	3.872	17.26	18.59	17.92
T <sub>10</sub> -RDF + Neem Cake	3.040	3.344	3.192	14.07	15.48	14.77
T <sub>11</sub> -RDF +Karanj Cake	2.747	3.040	2.893	12.72	14.07	13.39
T <sub>12</sub> -RDF + Bone Meal	2.971	3.280	3.125	13.75	15.18	14.46
T <sub>13</sub> -RDF + Vermicompost	3.877	4.224	4.051	17.95	19.55	18.75
T <sub>14</sub> -RDF + Fish gyano	2.843	3.104	2.973	13.16	14.37	13.76
T <sub>15</sub> -RDF + Mahua Cake	2.891	3.184	3.037	13.38	14.74	14.06
T <sub>16</sub> -RDF + <i>Azospirillum</i>	3.419	3.680	3.549	15.83	17.03	16.43
T <sub>17</sub> -RDF + VAM	3.600	3.904	3.752	16.67	18.07	17.37
T <sub>18</sub> -RDF + PSB	3.483	3.776	3.629	16.12	17.48	16.80
CD (P = 0.05)	0.309	0.517	0.503	1.429	2.393	1.314
SEm±	0.107	0.180	0.175	0.496	0.831	0.456

Fig. 4.11: Effect of organic, inorganic fertilizers and biofertilizers on fruit yield per plot (kg) of okra.

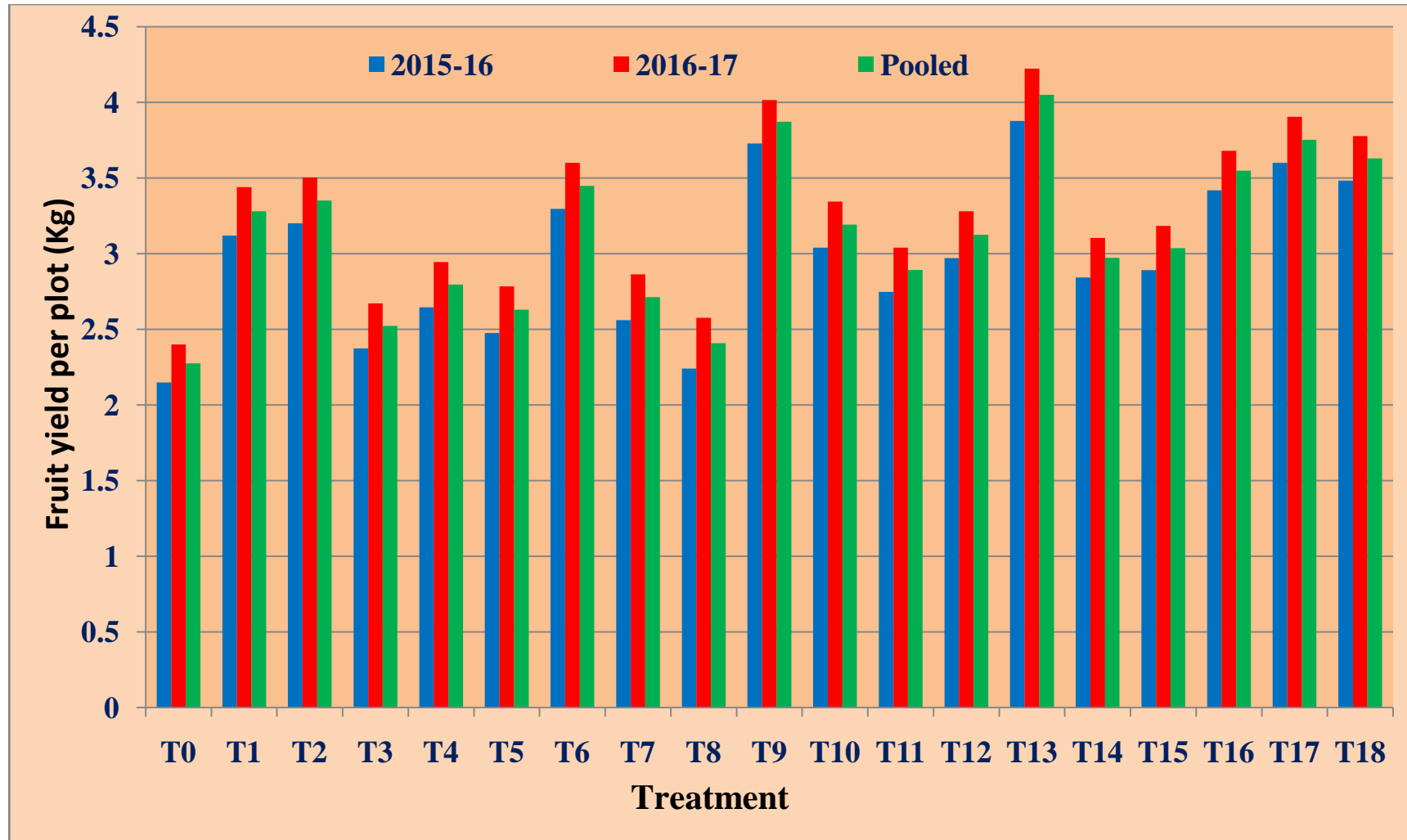
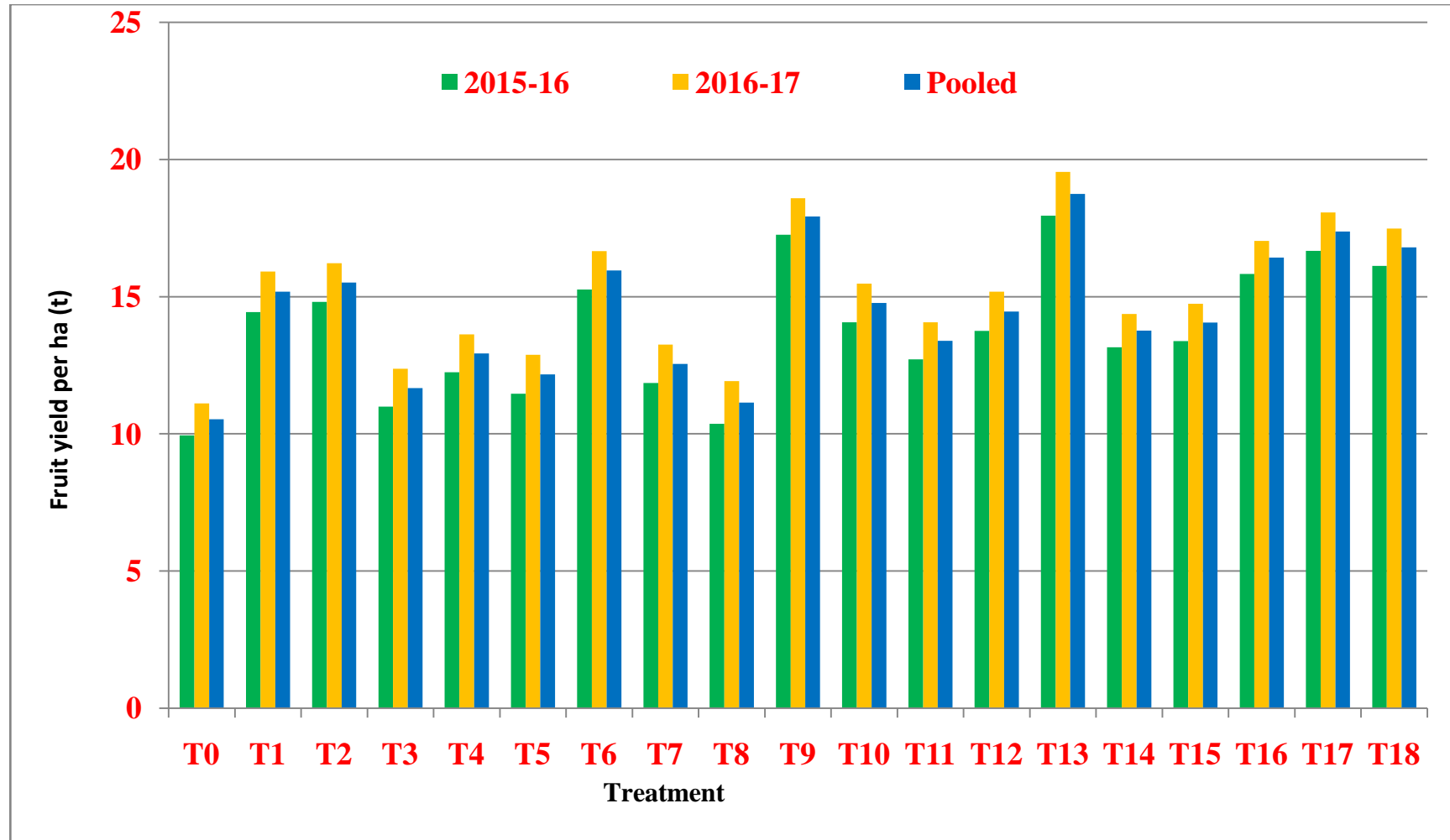


Fig. 4.12: Effect of organic, inorganic fertilizers and biofertilizers on fruit yield per ha (t) of okra.



### 4.3 Fruit characters

#### 4.3.1 Fruit length (cm)

The Data collected in connection with fruit length of okra due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been summarized in Table 4.13 and graphically represented in Figure 4.13 and analysis of variance computed for this character given in Appendix XIII.

Data presented in above table clearly indicated that the maximum fruit length was recorded under the treatment T<sub>9</sub> – RDF +FYM i.e. 14.89 cm and 16.24 cm during 2015-16 and 2016-17, respectively. The values recorded by T<sub>13</sub>- RDF + vermicompost i.e. 14.15 cm and 15.50 cm being at par with T<sub>9</sub> and it was significantly superior over remaining treatments. The minimum values (8.47 cm and 9.87 cm) fruit length were recorded in T<sub>0</sub> (control) treatment during both the year of experimentation.

During both the years, mean fruit length was noticed to be maximum (15.57 cm) in the treatment T<sub>9</sub> followed by T<sub>13</sub>, T<sub>18</sub> and T<sub>17</sub> and minimum value (9.17 cm) was reported in T<sub>0</sub> (control).

#### 4.3.2 Fruit diameter (cm)

Data collected in connection with fruit diameter of okra due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been summarized in Table 4.14 and graphically represented in Figure 4.14 and analysis of variance computed for the data depicted in Appendix XIV.

The data presented in above table clearly indicated that the fruit diameter was recorded under treatment T<sub>9</sub>- RDF + FYM i.e. 3.63 cm and 3.83 cm. The values recorded by T<sub>13</sub>- RDF + vermicompost i.e. 3.50 cm and 3.65 cm being at par with T<sub>9</sub> and it was significantly superior over remaining treatments, however, minimum values i.e. 1.98 cm and 2.07 were in Treatment T<sub>0</sub> (control) where plots were deprived off by the use of organic, inorganic fertilizer and biofertilizers in both the years.

A perusal of data for mean over two years reveal that mean fruit diameter was maximum (3.73 cm) in treatment T<sub>9</sub> followed by T<sub>13</sub>, and T<sub>18</sub> and minimum (2.03 cm) was reported in T<sub>0</sub> (control).

Table 4.10: Effect of organic, inorganic fertilizers and biofertilizers on fruit length (cm) and fruit diameter (cm) of okra.

Treatment	Fruit length (cm)			Fruit Diameter (cm)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	8.47	9.87	9.17	1.98	2.07	2.03
T <sub>1</sub> -RDF	10.05	11.60	10.83	2.25	2.36	2.31
T <sub>2</sub> -FYM	12.27	13.72	13.00	3.11	3.16	3.14
T <sub>3</sub> -Neem Cake	9.73	11.23	10.48	2.37	2.45	2.41
T <sub>4</sub> -Karanj Cake	10.23	11.49	10.86	2.20	2.30	2.25
T <sub>5</sub> -Bone Meal	9.33	10.63	9.98	2.18	2.24	2.21
T <sub>6</sub> -Vermi compost	12.58	14.08	13.33	3.16	3.25	3.21
T <sub>7</sub> -Fish gyano	11.96	13.26	12.61	2.95	3.02	2.99
T <sub>8</sub> -Mahua Cake	9.00	10.40	9.70	2.10	2.15	2.13
T <sub>9</sub> -RDF + FYM	14.89	16.24	15.57	3.63	3.83	3.73
T <sub>10</sub> -RDF + Neem Cake	11.78	13.04	12.41	2.83	2.90	2.87
T <sub>11</sub> -RDF +Karanj Cake	10.43	11.67	11.05	2.45	2.54	2.50
T <sub>12</sub> -RDF + Bone Meal	11.40	12.85	12.13	2.70	2.80	2.75
T <sub>13</sub> -RDF + Vermicompost	14.15	15.50	14.83	3.50	3.65	3.58
T <sub>14</sub> -RDF + Fish gyano	10.75	12.25	11.50	2.60	2.63	2.62
T <sub>15</sub> -RDF + Mahua Cake	11.12	12.42	11.77	2.63	2.71	2.67
T <sub>16</sub> -RDF + <i>Azospirillum</i>	13.00	14.40	13.70	3.25	3.33	3.29
T <sub>17</sub> -RDF + VAM	13.35	14.78	14.07	3.30	3.41	3.36
T <sub>18</sub> -RDF + PSB	13.80	15.21	14.51	3.43	3.50	3.47
CD (P = 0.05)	0.155	0.111	0.107	0.507	0.481	0.491
SEm±	0.054	0.038	0.037	0.176	0.167	0.170

Fig 4.13: Effect of organic, inorganic fertilizers and biofertilizers on fruit length (cm) of okra.

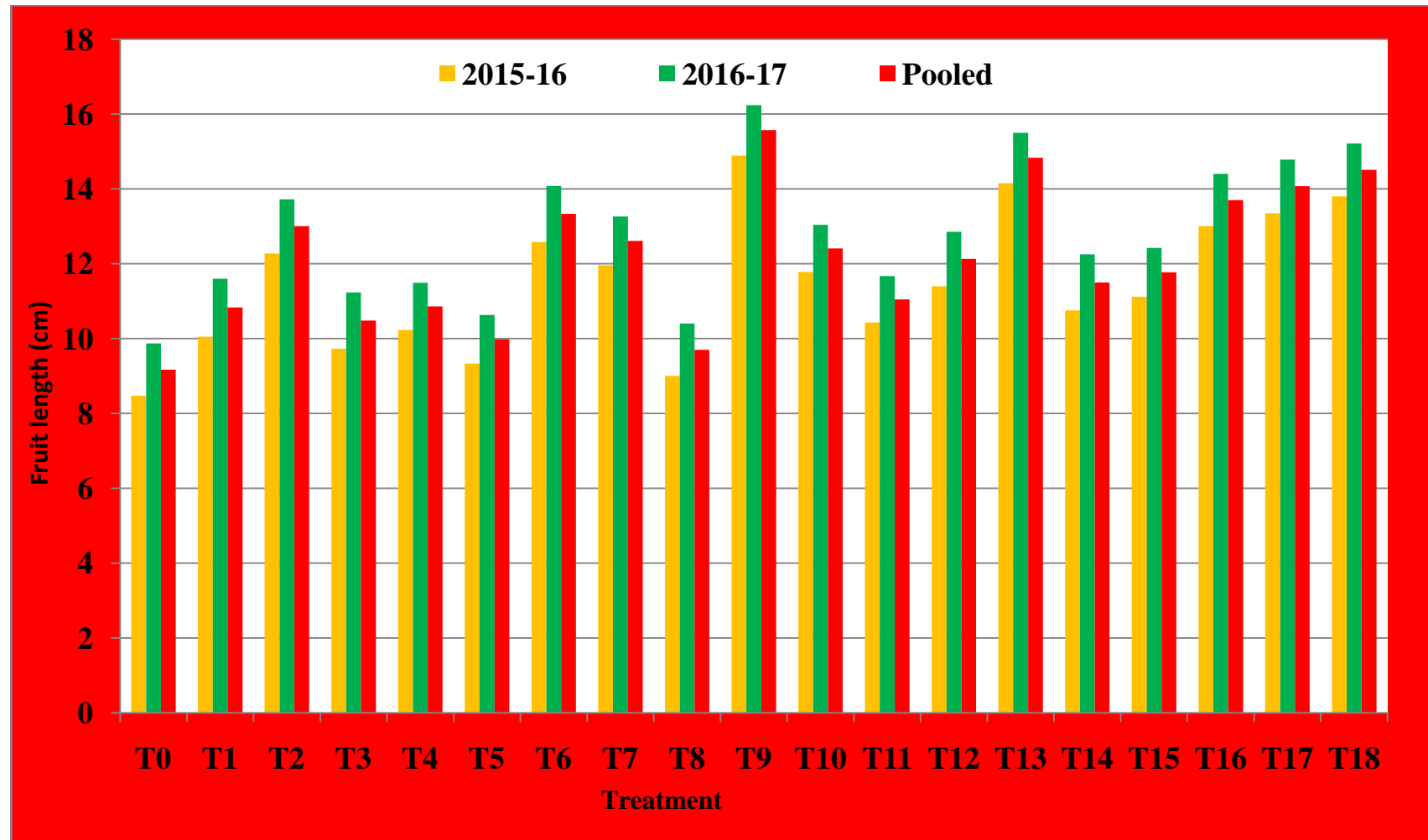
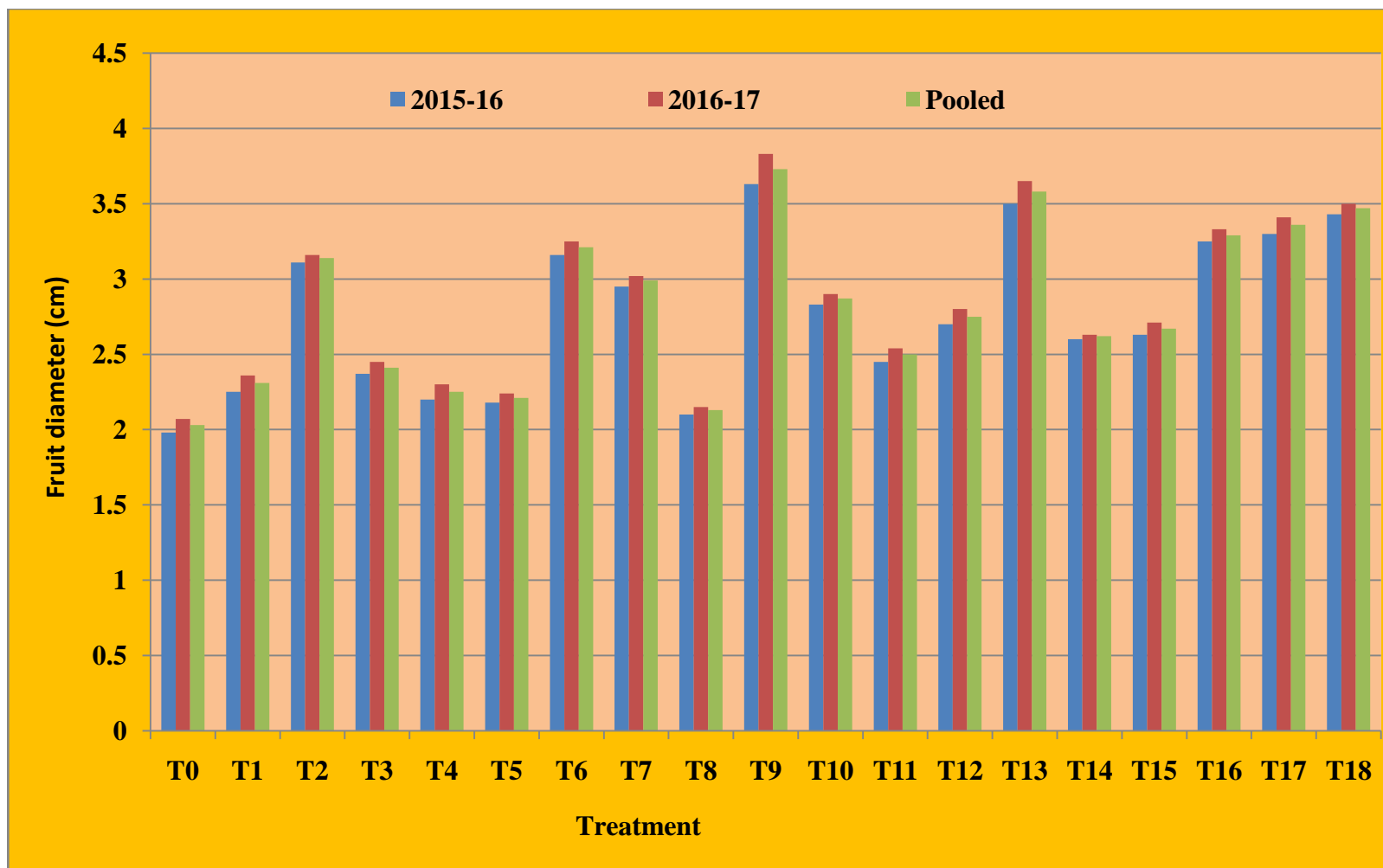


Fig. 4.14: Effect of organic, inorganic fertilizers and biofertilizers on fruit diameter (cm) of okra.



### 4.3.3 Fruit fresh weight (g)

The Data collected in connection with fruit fresh weight of okra due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been summarized in Table 4.15 and graphically represented in Figure 4.15 and analysis of variance computed for this character given in Appendix XV. Data presented in above table clearly indicated that the maximum fruit fresh weight was recorded under the treatment  $T_{13}$  – RDF + vermicompost i.e 14.85 gm and 15.53 gm during 2015-16 and 2016-17, respectively. The values recorded by  $T_9$ - RDF + FYM i.e. 14.60 gm and 15.17 gm being at par with  $T_{13}$  and it was significantly superior over remaining treatments. The minimum values (11.76 gm and 12.25 gm) fruit fresh weight were recorded in  $T_0$  (control) treatment during both the year of experimentation.

During both the years, mean fruit fresh weight was noticed to be maximum (15.19 gm) in the treatment  $T_{13}$  followed by  $T_9$ ,  $T_{17}$  and  $T_{18}$  and minimum value (12.01 gm) was reported in  $T_0$  (control).

### 4.3.4 Fruit Dry weight (g)

The data accumulated on fruit dry weight due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been displayed in Table 4.16 and graphically represented in Figure 4.16. The analysis of variance of data on this parameter has been mentioned in Appendix XVI. Data presented in above table clearly marked out that different treatment caused significant response on fruit dry weight. The maximum fruit dry weight (5.40 gm and 5.67 gm) was recorded under the treatment  $T_{13}$ - RDF + vermicompost during 2015-16 and 2016-17, respectively. The values recorded by  $T_9$  – RDF +FYM i.e. 5.23 gm and 5.45 gm being at par with  $T_{13}$  and it was significantly superior over remaining treatments. The minimum fruit dry weight (4.05 gm and 5.15 gm) were recorded in  $T_0$  (control) treatment during both the year of experimentation.

During both the years, mean fruit dry weight was noticed to be maximum (5.54 gm) in the treatment  $T_{13}$  followed by  $T_9$ ,  $T_{17}$  and  $T_{18}$  and minimum (4.10 gm) was reported in  $T_0$  (control).

Table 4.11: Effect of organic, inorganic fertilizers and biofertilizers on fruit fresh weight (g) and fruit dry weight (gm) of okra.

Treatment	Fruit fresh weight (gm)			Fruit dry weight (gm)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	11.76	12.25	12.01	4.05	4.15	4.10
T <sub>1</sub> -RDF	13.65	14.07	13.86	4.85	4.93	4.89
T <sub>2</sub> -FYM	13.77	14.30	14.04	4.90	5.05	4.98
T <sub>3</sub> -Neem Cake	12.15	12.62	12.39	4.21	4.25	4.23
T <sub>4</sub> -Karanj Cake	12.50	13.17	12.84	4.35	4.45	4.40
T <sub>5</sub> -Bone Meal	12.21	12.87	12.54	4.25	4.31	4.28
T <sub>6</sub> -Vermi compost	13.85	14.41	14.13	5.00	5.17	5.09
T <sub>7</sub> -Fish gyano	12.34	13.00	12.67	4.28	4.37	4.33
T <sub>8</sub> -Mahua Cake	12.00	12.46	12.23	4.15	4.17	4.16
T <sub>9</sub> -RDF + FYM	14.60	15.17	14.89	5.23	5.45	5.34
T <sub>10</sub> -RDF + Neem Cake	13.48	13.80	13.64	4.73	4.85	4.79
T <sub>11</sub> -RDF +Karanj Cake	12.76	13.29	13.03	4.43	4.53	4.48
T <sub>12</sub> -RDF + Bone Meal	13.30	13.67	13.49	4.67	4.80	4.74
T <sub>13</sub> -RDF + Vermicompost	14.85	15.53	15.19	5.40	5.67	5.54
T <sub>14</sub> -RDF + Fish gyano	12.88	13.43	13.16	4.45	4.65	4.55
T <sub>15</sub> -RDF + Mahua Cake	13.16	13.55	13.36	4.60	4.73	4.67
T <sub>16</sub> -RDF + <i>Azospirillum</i>	14.01	14.58	14.30	5.10	5.22	5.16
T <sub>17</sub> -RDF + VAM	14.37	14.86	14.62	5.16	5.33	5.25
T <sub>18</sub> -RDF + PSB	14.21	14.70	14.46	5.12	5.27	5.20
CD (P = 0.05)	1.190	0.754	0.954	0.335	0.252	0.287
SEm±	0.413	0.262	0.331	0.116	0.088	0.100

Fig. 4.15: Effect of organic, inorganic fertilizers and biofertilizers on fruit fresh weight (g) of okra.

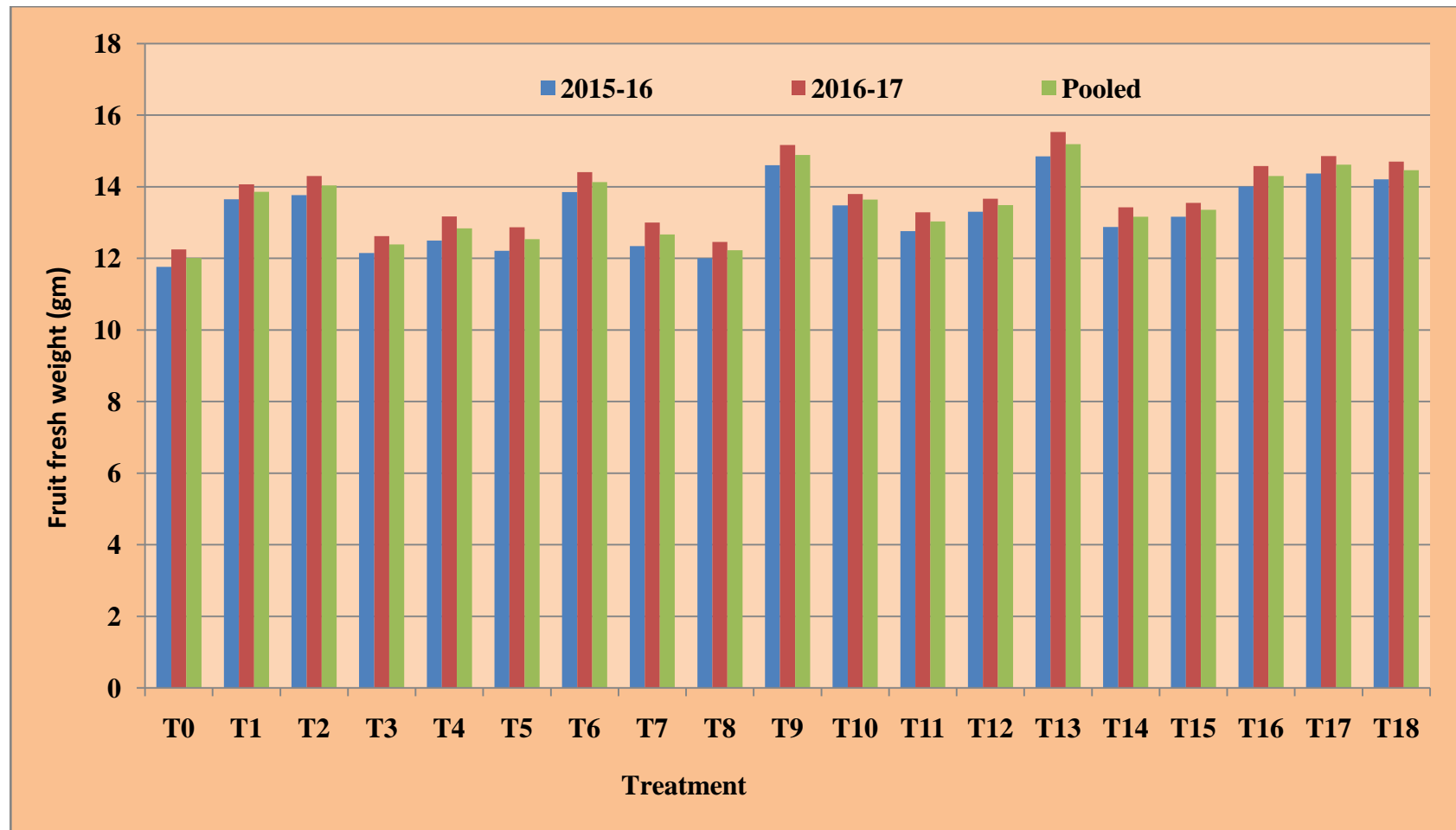
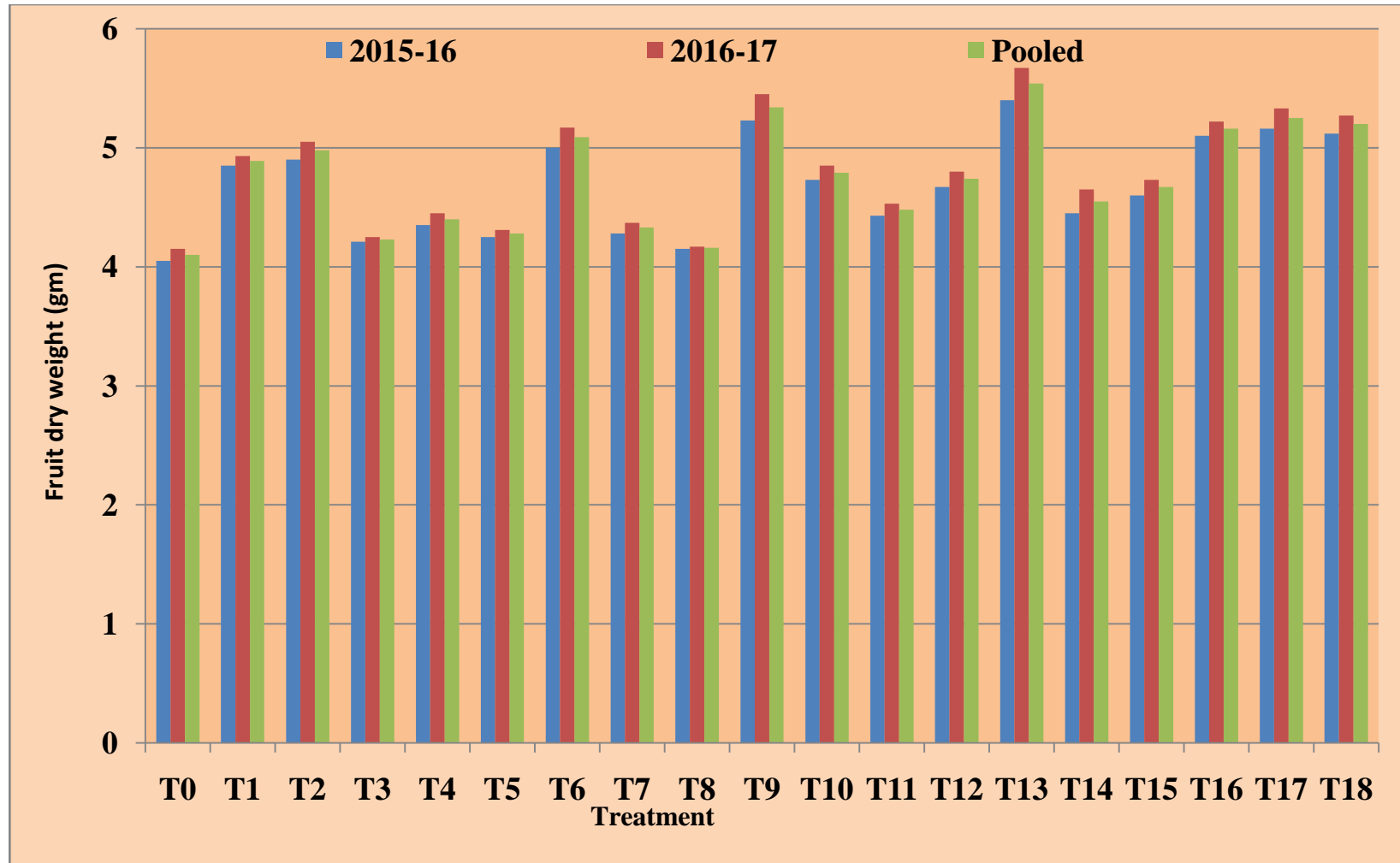


Fig. 4.16: Effect of organic, inorganic fertilizers and biofertilizers on fruit dry weight (g) of okra.



## 4.4 Fruit biochemical characters

### 4.4.1 Titratable Acidity (%)

The mean values on account of titratable (%) due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been displayed in Table 4.17 and graphically represented in Figure 4.17. The analysis of variance of data on this parameter has been mentioned in Appendix XVII. Data presented in above table clearly marked out that different treatment caused significant response on titratable acidity. The minimum titratable acidity (0.14 % gm and 0.12%) was recorded under the treatment T<sub>13</sub>- RDF + vermicompost during 2015-16 and 2016-17, respectively. The values recorded by T<sub>9</sub> – RDF + FYM i.e. 0.17 % and 0.16 % being at par with T<sub>13</sub> and it was significantly superior over remaining treatments. The maximum titratable acidity (0.39 % and 0.36 %) were recorded in T<sub>0</sub> (control) treatment during both the year of experimentation.

During both the years, mean titratable acidity was noticed to be minimum (0.13 %) in the treatment T<sub>13</sub> followed by T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub> and maximum (0.38 %) was reported in T<sub>0</sub> (control).

### 4.4.2 Total Soluble Solids (TSS °Brix)

Mean values on account of T.S.S (°Brix) as influenced by the use of organic, inorganic fertilizer and biofertilizers have been tabulated in Table 4.18, graphically illustrated in figure 4.18 and analysis of variance of data depicted in Appendix XVIII. A cursory look on the table clearly marked out that T.S.S was significantly improved due to use of various treatments. Maximum T.S.S. (2.48 °Brix and 2.95 °Brix) was obtained by the use of T<sub>13</sub> – RDF + Vermicompost closely followed by T<sub>9</sub> – RDF +FYM i.e. 2.38 °Brix and 2.88 °Brix and T<sub>17</sub> – RDF + VAM i.e. 2.25 °Brix and 2.82 °Brix during 2015-16 and 2016-17, respectively. Minimum value i.e. 1.05 °Brix and 1.20 °Brix was recorded under the treatment T<sub>0</sub> (control) in both the year of experimentation.

During both the year, mean T.S.S. was found to be highest (2.72 °Brix) in the treatment T<sub>13</sub> followed by T<sub>9</sub> and lowest (1.13 °Brix) was reported in T<sub>0</sub> (control).

Table 4.12: Effect of organic, inorganic fertilizers and biofertilizers on titratable acidity (%) of okra.

Treatment	Titratable acidity (%)		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	0.39	0.36	0.38
T <sub>1</sub> -RDF	0.24	0.24	0.24
T <sub>2</sub> -FYM	0.28	0.27	0.28
T <sub>3</sub> -Neem Cake	0.38	0.35	0.37
T <sub>4</sub> -Karanj Cake	0.34	0.32	0.33
T <sub>5</sub> -Bone Meal	0.37	0.34	0.36
T <sub>6</sub> -Vermi compost	0.22	0.23	0.23
T <sub>7</sub> -Fish gyano	0.36	0.33	0.35
T <sub>8</sub> -Mahua Cake	0.40	0.38	0.39
T <sub>9</sub> -RDF + FYM	0.17	0.16	0.17
T <sub>10</sub> -RDF + Neem Cake	0.26	0.25	0.26
T <sub>11</sub> -RDF +Karanj Cake	0.33	0.31	0.32
T <sub>12</sub> -RDF + Bone Meal	0.30	0.28	0.29
T <sub>13</sub> -RDF + Vermicompost	0.14	0.12	0.13
T <sub>14</sub> -RDF + Fish gyano	0.32	0.30	0.31
T <sub>15</sub> -RDF + Mahua Cake	0.31	0.29	0.30
T <sub>16</sub> -RDF + <i>Azospirillum</i>	0.21	0.20	0.21
T <sub>17</sub> -RDF + VAM	0.18	0.17	0.18
T <sub>18</sub> -RDF + PSB	0.19	0.18	0.19
CD (P = 0.05)	0.028	0.033	0.031
SEm±	0.010	0.011	0.011

Fig. 4.17: Effect of organic, inorganic fertilizers and biofertilizers on titratable acidity (%) of okra.

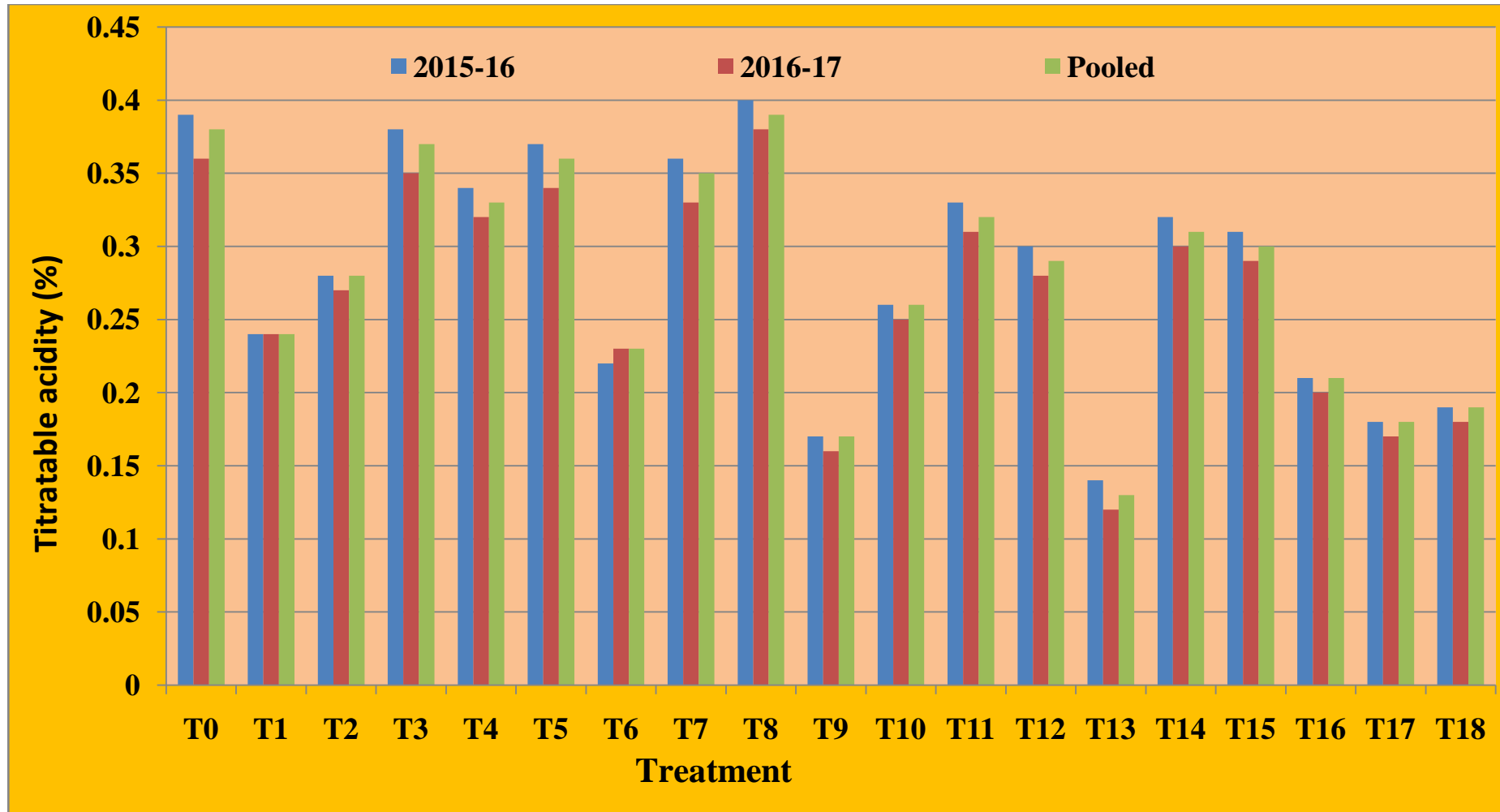
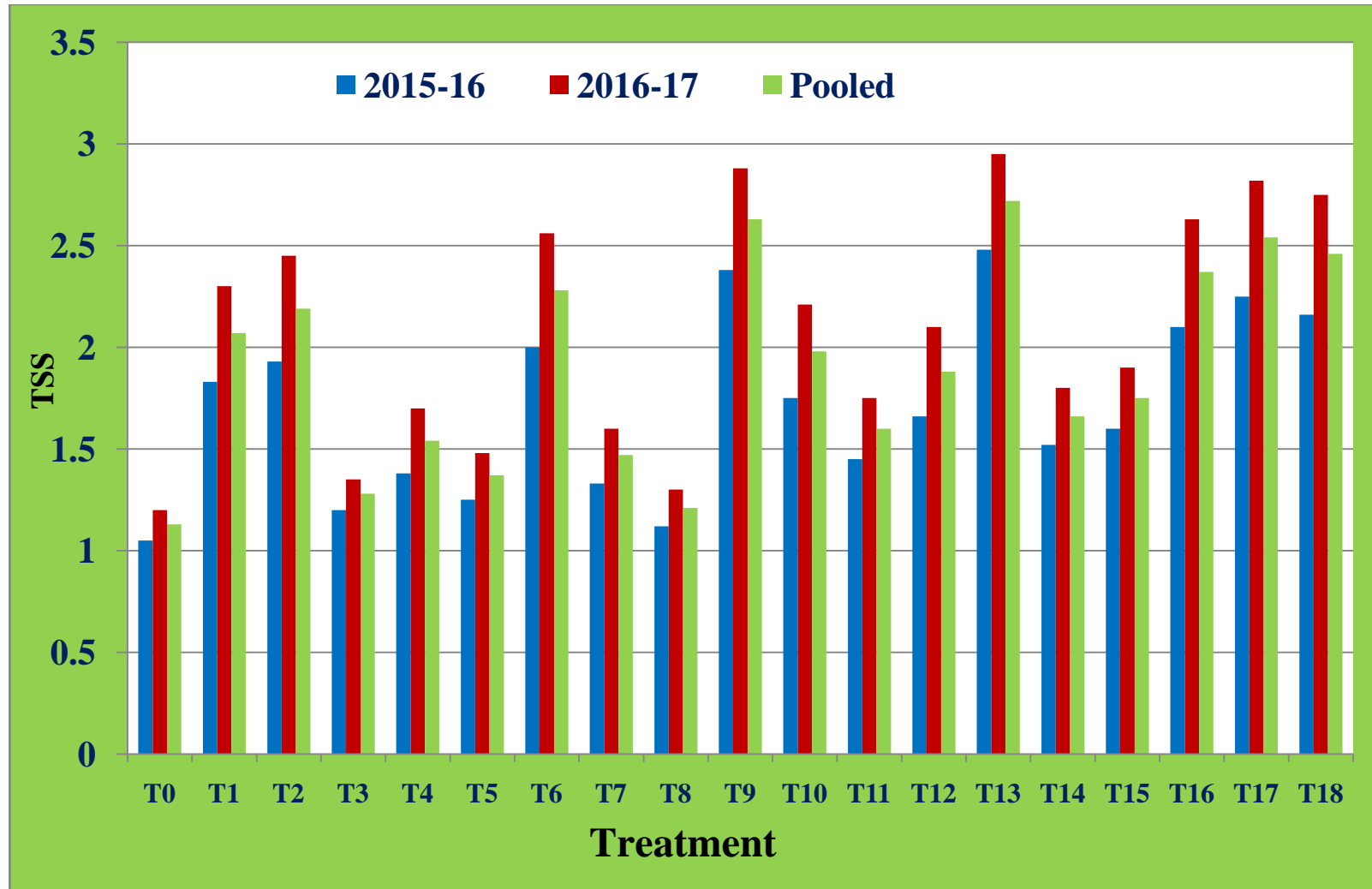


Table 4.14: Effect of organic, inorganic fertilizers and biofertilizers on total soluble solids (TSS <sup>0</sup>Brix) of okra.

Treatment	TSS		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	1.05	1.20	1.13
T <sub>1</sub> -RDF	1.83	2.30	2.07
T <sub>2</sub> -FYM	1.93	2.45	2.19
T <sub>3</sub> -Neem Cake	1.20	1.35	1.28
T <sub>4</sub> -Karanj Cake	1.38	1.70	1.54
T <sub>5</sub> -Bone Meal	1.25	1.48	1.37
T <sub>6</sub> -Vermi compost	2.00	2.56	2.28
T <sub>7</sub> -Fish gyano	1.33	1.60	1.47
T <sub>8</sub> -Mahua Cake	1.12	1.30	1.21
T <sub>9</sub> -RDF + FYM	2.38	2.88	2.63
T <sub>10</sub> -RDF + Neem Cake	1.75	2.21	1.98
T <sub>11</sub> -RDF +Karanj Cake	1.45	1.75	1.60
T <sub>12</sub> -RDF + Bone Meal	1.66	2.10	1.88
T <sub>13</sub> -RDF + Vermicompost	2.48	2.95	2.72
T <sub>14</sub> -RDF + Fish gyano	1.52	1.80	1.66
T <sub>15</sub> -RDF + Mahua Cake	1.60	1.90	1.75
T <sub>16</sub> -RDF + <i>Azospirillum</i>	2.10	2.63	2.37
T <sub>17</sub> -RDF + VAM	2.25	2.82	2.54
T <sub>18</sub> -RDF + PSB	2.16	2.75	2.46
CD (P = 0.05)	0.640	0.984	0.760
SEm±	0.222	0.342	0.264

Fig. 4.18: Effect of organic, inorganic fertilizers and biofertilizers on total soluble solids (TSS <sup>0</sup>Brix) of okra.

#### 4.4.3 Ascorbic acid (mg/100g)

The mean value obtained on ascorbic acid of okra as affected by the use of organic, inorganic fertilizer and biofertilizer have been tabulated in Table 4.19, graphically illustrated in Figure 4.19 and analysis of variance of data depicted in Appendix XIX. A critical look on the table indicated that the use of various treatments caused enormous increase in ascorbic acid content of okra. It was further observed that use of T<sub>13</sub> – RDF + vermicompost treatment proved to be more useful in improving ascorbic acid 19.43 mg/100g and 19.57 mg/100g values with respect to ascorbic acid mg/100g was also found to be at par with T<sub>9</sub>- RDF + FYM and T<sub>17</sub> – RDF + VAM during the both the year of study. The minimum ascorbic acid content of okra 13.67 mg/100g and 13.80 mg/100g was observed with T<sub>0</sub> (control) treatment in both the year of investigation.

During both the years, mean ascorbic acid was noticed to be maximum (19.50 mg/100g) in the treatment T<sub>13</sub> followed by T<sub>9</sub> and T<sub>17</sub> and minimum (13.74 mg/100g) was reported in T<sub>0</sub> (control)

#### 4.4.4 Reducing Sugar

Data collected in connection with reducing sugar of okra due to influence of various levels of organic, inorganic fertilizers and biofertilizers have been summarized in Table 4.20, graphically represented in Figure 4.20 and analysis of variance computed for the data depicted in Appendix XX. The data presented in above table clearly indicated that maximum reducing sugar was noticed under the treatment T<sub>13</sub> - RDF + vermicompost i.e 2.04 % and 2.14 % during 20015-16 and 2016-17, respectively. The values recorded by T<sub>9</sub> – RDF + FYM treatments being at par with T<sub>13</sub> and it was significantly superior over remaining treatment. The minimum values (1.03% and 1.19%) were recorded under the control treatment i.e.T<sub>0</sub>.

A perusal of data for mean over two years reveal that mean reducing sugar was recorded to be maximum (2.09 %) in the treatment T<sub>13</sub> followed by T<sub>9</sub> and minimum (1.11%) was reported in T<sub>0</sub> (control).

Table 4.14: Effect of organic, inorganic fertilizers and biofertilizers on ascorbic acid (vitamin C) (mg/100g) of okra.

Treatment	Vitamin C		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	13.67	13.80	13.74
T <sub>1</sub> -RDF	17.14	17.25	17.20
T <sub>2</sub> -FYM	17.37	17.60	17.49
T <sub>3</sub> -Neem Cake	14.33	14.45	14.39
T <sub>4</sub> -Karanj Cake	15.25	15.40	15.33
T <sub>5</sub> -Bone Meal	14.70	14.85	14.78
T <sub>6</sub> -Vermi compost	17.80	18.00	17.90
T <sub>7</sub> -Fish gyano	14.95	15.15	15.05
T <sub>8</sub> -Mahua Cake	14.00	14.15	14.08
T <sub>9</sub> -RDF + FYM	19.15	19.20	19.18
T <sub>10</sub> -RDF + Neem Cake	16.78	16.90	16.84
T <sub>11</sub> -RDF +Karanj Cake	15.55	15.70	15.63
T <sub>12</sub> -RDF + Bone Meal	16.48	16.60	16.54
T <sub>13</sub> -RDF + Vermicompost	19.43	19.57	19.50
T <sub>14</sub> -RDF + Fish gyano	15.80	16.00	15.90
T <sub>15</sub> -RDF + Mahua Cake	16.15	16.30	16.23
T <sub>16</sub> -RDF + <i>Azospirillum</i>	18.20	18.33	18.27
T <sub>17</sub> -RDF + VAM	18.77	18.87	18.82
T <sub>18</sub> -RDF + PSB	18.50	18.60	18.55
CD (P = 0.05)	1.817	1.061	1.414
SEm±	0.631	0.368	0.491

Fig. 4.19: Effect of organic, inorganic fertilizers and biofertilizers on ascorbic acid (vitamin C) (mg/100g) of okra.

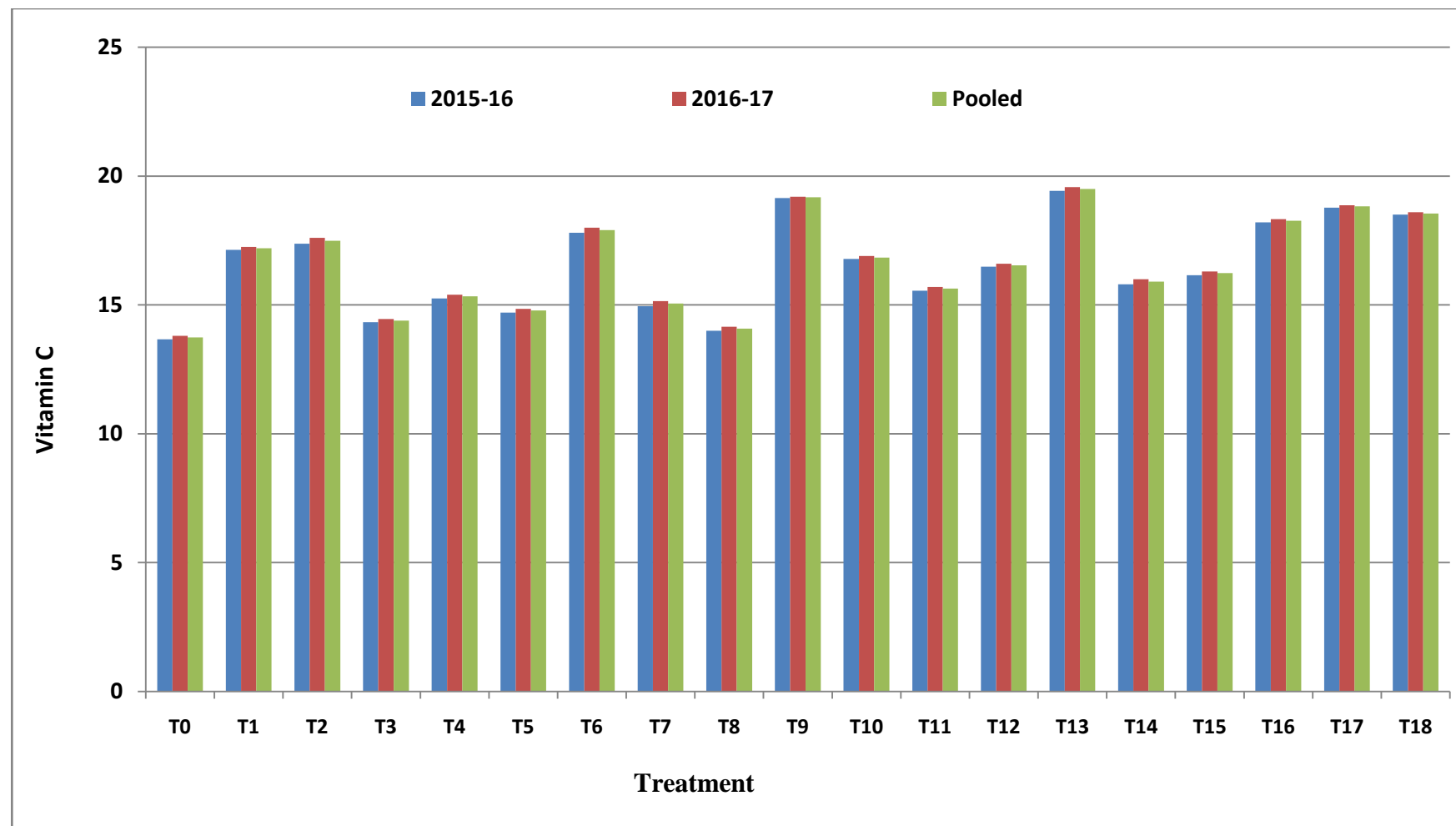
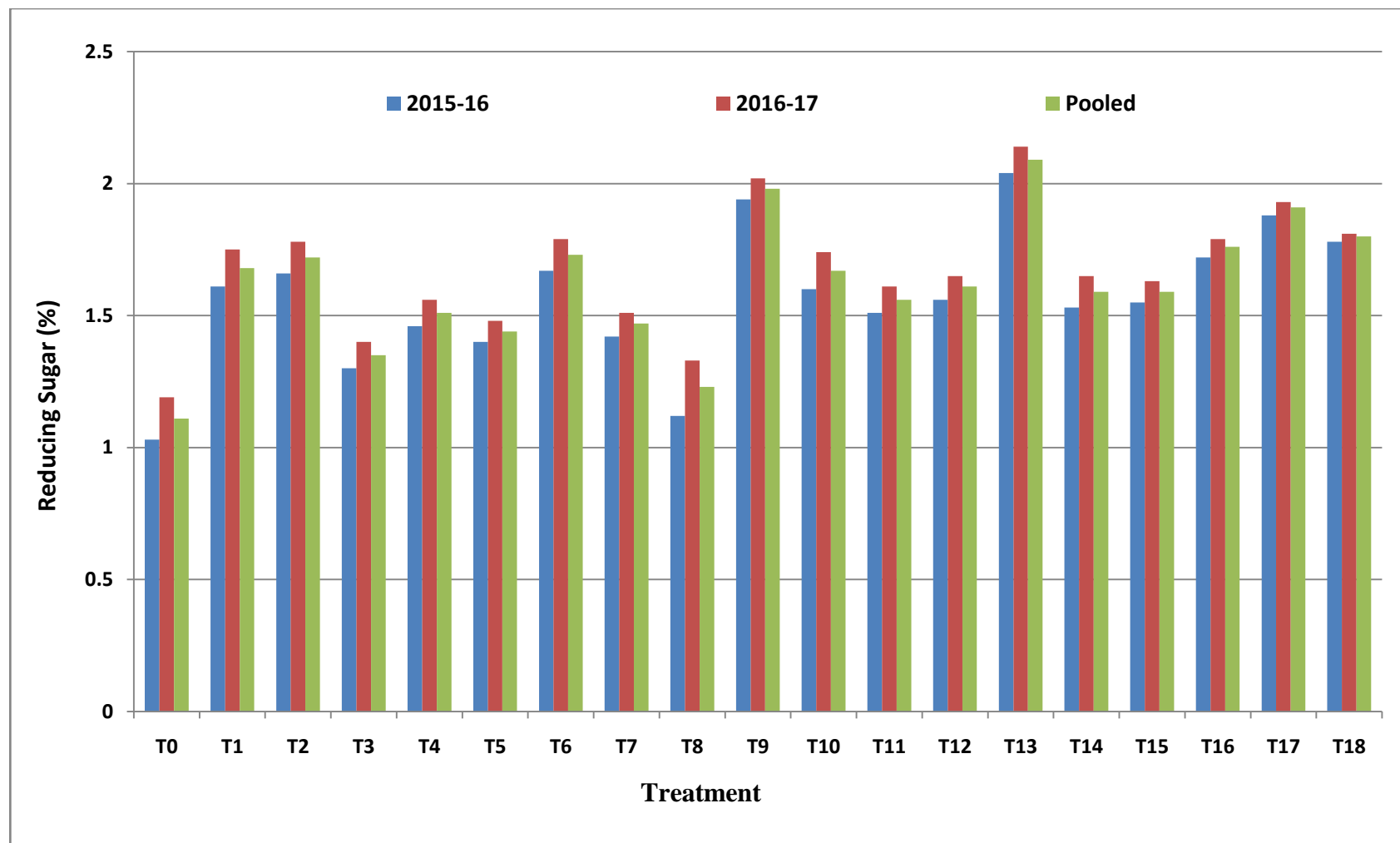


Table 4.15: Effect of organic, inorganic fertilizers and biofertilizers on reducing sugar (%), non reducing sugar (%) and total sugar (%) of okra.

Treatment	Reducing sugar			Non reducing sugar			Total sugars		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	1.03	1.19	1.11	0.78	0.74	0.76	1.87	1.97	1.92
T <sub>1</sub> -RDF	1.61	1.75	1.68	1.09	1.05	1.07	2.70	2.80	2.75
T <sub>2</sub> -FYM	1.66	1.78	1.72	1.08	1.05	1.07	2.74	2.83	2.79
T <sub>3</sub> -Neem Cake	1.30	1.40	1.35	0.81	0.75	0.78	2.11	2.15	2.13
T <sub>4</sub> -Karanj Cake	1.46	1.56	1.51	0.87	0.81	0.84	2.33	2.37	2.35
T <sub>5</sub> -Bone Meal	1.40	1.48	1.44	0.84	0.78	0.81	2.18	2.22	2.20
T <sub>6</sub> -Vermi compost	1.67	1.79	1.73	1.14	1.08	1.11	2.81	2.87	2.84
T <sub>7</sub> -Fish gyano	1.42	1.51	1.47	0.84	0.79	0.82	2.26	2.30	2.28
T <sub>8</sub> -Mahua Cake	1.12	1.33	1.23	0.83	0.77	0.80	1.95	2.10	2.03
T <sub>9</sub> -RDF + FYM	1.94	2.02	1.98	1.23	1.18	1.21	3.17	3.20	3.19
T <sub>10</sub> -RDF + Neem Cake	1.60	1.74	1.67	1.05	1.01	1.03	2.65	2.75	2.70
T <sub>11</sub> -RDF +Karanj Cake	1.51	1.61	1.56	0.89	0.85	0.87	2.40	2.46	2.43
T <sub>12</sub> -RDF + Bone Meal	1.56	1.65	1.61	1.02	0.98	1.00	2.58	2.63	2.61
T <sub>13</sub> -RDF + Vermicompost	2.04	2.14	2.09	1.26	1.19	1.23	3.30	3.33	3.32
T <sub>14</sub> -RDF + Fish gyano	1.53	1.65	1.59	0.92	0.89	0.91	2.45	2.54	2.50
T <sub>15</sub> -RDF + Mahua Cake	1.55	1.63	1.59	0.98	0.94	0.96	2.53	2.57	2.55
T <sub>16</sub> -RDF + Azospirillum	1.72	1.79	1.76	1.16	1.12	1.14	2.88	2.91	2.90
T <sub>17</sub> -RDF + VAM	1.88	1.93	1.91	1.20	1.18	1.19	3.08	3.11	3.10
T <sub>18</sub> -RDF + PSB	1.78	1.81	1.80	1.18	1.18	1.18	2.96	2.99	2.98
CD (P = 0.05)	0.337	0.273	0.302	0.318	0.322	0.313	0.388	0.393	0.389
SEm±	0.117	0.095	0.105	0.110	0.112	0.109	0.135	0.136	0.135

Fig 4.20: Effect of organic, inorganic fertilizers and biofertilizers on reducing sugar (%) of okra.



#### 4.4.5 Non Reducing Sugar

Data recorded towards non-reducing sugar due to the use of organic, inorganic fertilizer and biofertilizers have been tabulated in Table 4.21, graphically represented in Figure 4.21 and analysis of variance computed for this character given in Appendix XXI. Critical analysis of data revealed that various treatments significantly enhanced the non reducing sugar due to various treatments of organic, inorganic fertilizers and biofertilizers. The maximum non reducing sugar i.e. 1.26 % and 1.19% were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 1.23 % and 1.18 % and T<sub>17</sub>- RDF +VAM i.e. 1.20 % and 1.18 % while minimum non reducing sugar 0.78 % and 0.74 % were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

The mean non reducing over two years, irrespective of treatments was obtained maximum (1.23 %) under the treatment T<sub>13</sub> while, minimum (0.76%) mean non reducing sugar was obtained under the treatment T<sub>0</sub> (control)

#### 4.4.6 Total Sugars (%)

Data recorded towards total sugar due to the use of organic, inorganic fertilizer and biofertilizers have been tabulated in Table 4.21, graphically represented in Figure 4.21 and analysis of variance computed for this character given in Appendix XXII. Critical analysis of data revealed that various treatments significantly enhanced the total sugar due to various treatments of organic, inorganic fertilizers and biofertilizers. The maximum total sugars i.e. 3.30 % and 3.33 % were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 3.17 % and 3.20 % and T<sub>17</sub>- RDF +VAM i.e. 3.08 % and 3.11 % while minimum total sugars 1.87 % and 1.97 % were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

The mean total sugars over two years, irrespective of treatments was obtained maximum (3.32 %) under the treatment T<sub>13</sub> while, minimum (1.92 %) mean total sugar was obtained under the treatment T<sub>0</sub> (control).

Fig. 4.21: Effect of organic, inorganic fertilizers and biofertilizers on non reducing sugar (%) of okra.

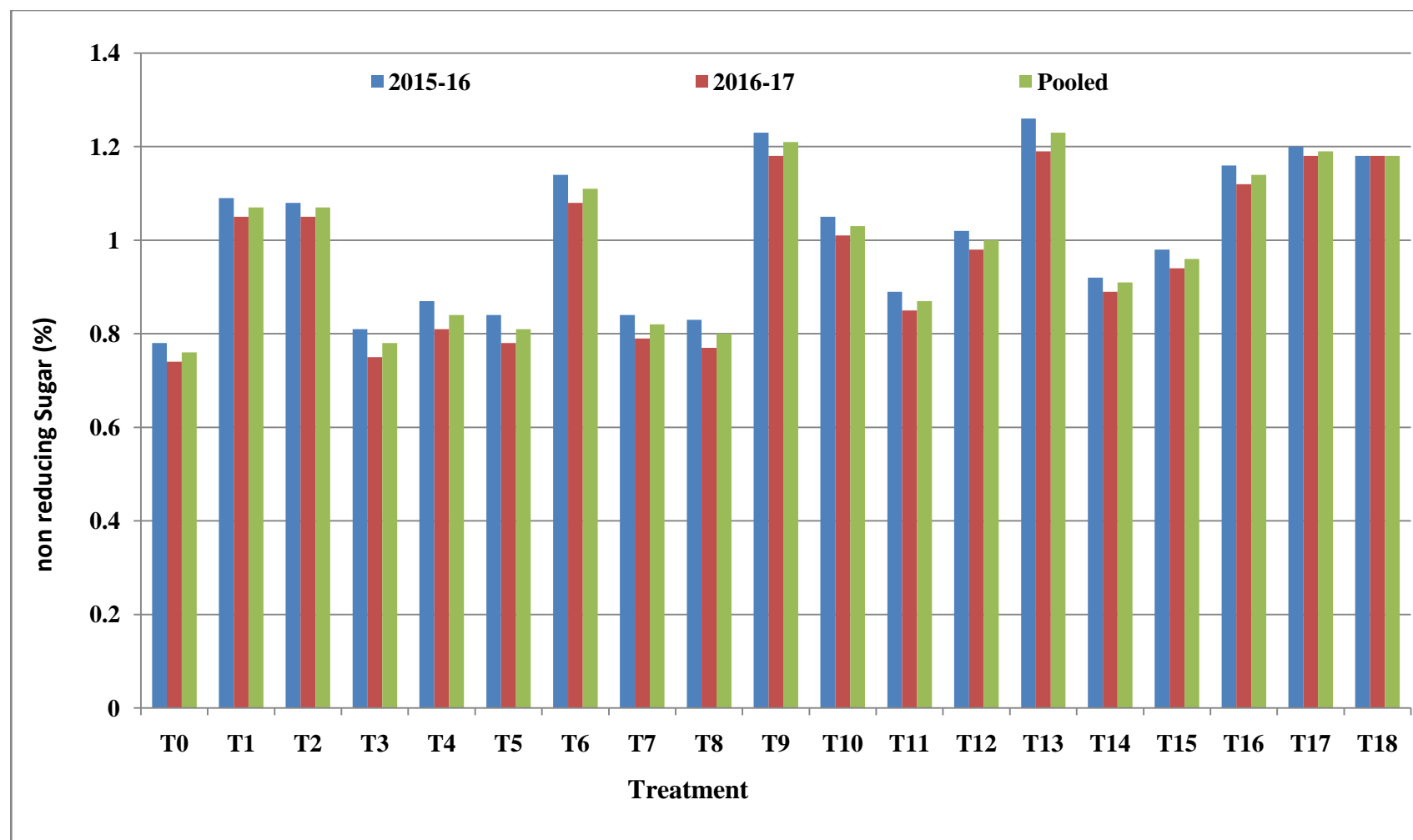
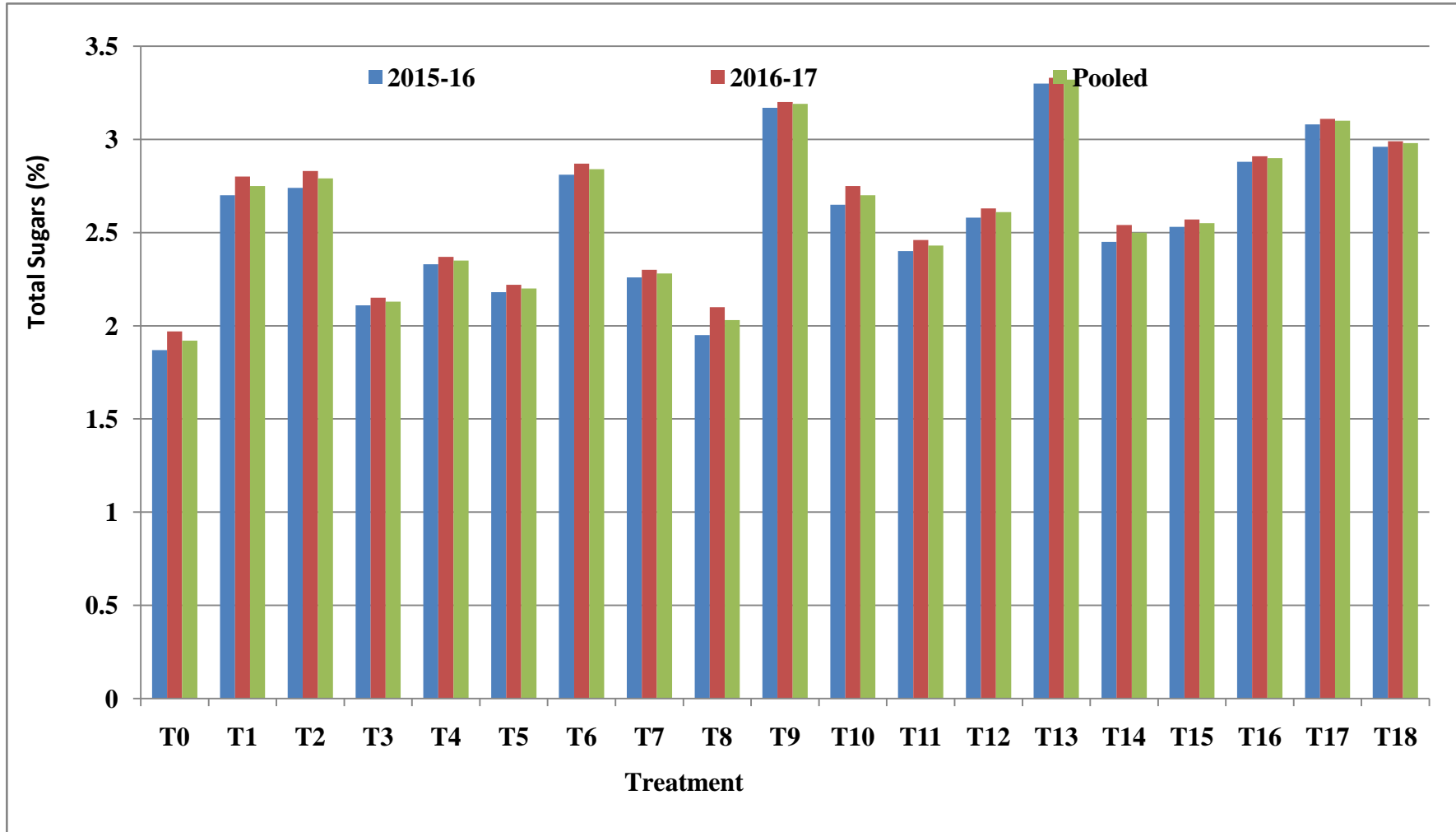


Fig. 4.22: Effect of organic, inorganic fertilizers and biofertilizers on total sugars (%) of okra.



#### 4.4.7 Protein

Mean values on account of protein (%) as influenced by the use of organic, inorganic fertilizer and biofertilizers have been tabulated in Table 4.23, graphically represented in Figure 4.23 and analysis of variance computed for this character given in Appendix XXIII. Critical analysis of data revealed that various treatments significantly enhanced the protein (%) due to various treatments of organic, inorganic fertilizers and biofertilizers. The maximum Protein percent i.e. 16.37 % and 16.50 % were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 16.05 % and 16.23 % and T<sub>17</sub>- RDF + VAM i.e. 15.85 % and 16.01 % while minimum protein 12.77 % and 12.90 % were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

The mean protein (%) over two years, irrespective of treatments was obtained maximum (16.44 %) under the treatment T<sub>13</sub> while, minimum (12.84 %) mean protein was obtained under the treatment T<sub>0</sub> (control).

#### 4.4.8 Phosphorus (mg/100g)

Mean values on account of phosphorus content as influenced by the use of organic, inorganic fertilizer and biofertilizers have been tabulated in Table 4.24, graphically represented in Figure 4.24 and analysis of variance computed for this character given in Appendix XXIV. An examination of data presented in above table exhibited marked variation in phosphorus content of okra 55.83 mg/100g in 2015-16 and 56.43 mg/100g in 2016-17 were recorded with the application of T<sub>13</sub> - RDF + vermicompost which was significantly highest closely followed by T<sub>9</sub> – RDF + FYM i.e. 55.33 mg/100g and 56.17 mg/100g and T<sub>17</sub> – RDF + VAM i.e. 54.95 mg/100g and 55.65 mg/100g. The minimum phosphorus content of okra 48.87 mg/100g and 49.15 mg/100g was observed with T<sub>0</sub> (control) treatment in both the year of investigation.

A perusal of data for mean over two year reveal that mean phosphorus content in okra was maximum (56.13 mg/100g) in the treatment T<sub>13</sub> which was at par with the treatment T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub> whereas, minimum ( 49.01 mg/100g) was observed in T<sub>0</sub> i.e. control.

Table 4.16: Effect of organic, inorganic fertilizers and biofertilizers on proteins of okra.

Treatment	Protein		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	12.77	12.90	12.84
T <sub>1</sub> -RDF	13.47	13.50	13.49
T <sub>2</sub> -FYM	14.97	15.12	15.05
T <sub>3</sub> -Neem Cake	13.60	13.67	13.64
T <sub>4</sub> -Karanj Cake	13.81	13.95	13.88
T <sub>5</sub> -Bone Meal	14.76	14.95	14.86
T <sub>6</sub> -Vermi compost	15.27	15.33	15.30
T <sub>7</sub> -Fish gyano	13.23	13.35	13.29
T <sub>8</sub> -Mahua Cake	12.95	13.20	13.08
T <sub>9</sub> -RDF + FYM	16.05	16.23	16.14
T <sub>10</sub> -RDF + Neem Cake	14.63	14.70	14.67
T <sub>11</sub> -RDF +Karanj Cake	14.33	14.47	14.40
T <sub>12</sub> -RDF + Bone Meal	14.25	14.33	14.29
T <sub>13</sub> -RDF + Vermicompost	16.37	16.50	16.44
T <sub>14</sub> -RDF + Fish gyano	14.45	14.58	14.52
T <sub>15</sub> -RDF + Mahua Cake	14.02	14.18	14.10
T <sub>16</sub> -RDF + <i>Azospirillum</i>	15.45	15.52	15.49
T <sub>17</sub> -RDF + VAM	15.85	16.01	15.93
T <sub>18</sub> -RDF + PSB	15.60	15.75	15.68
CD (P = 0.05)	1.159	0.931	1.021
SEm±	0.403	0.323	0.355

Fig. 4.23: Effect of organic, inorganic fertilizers and biofertilizers on proteins of okra.

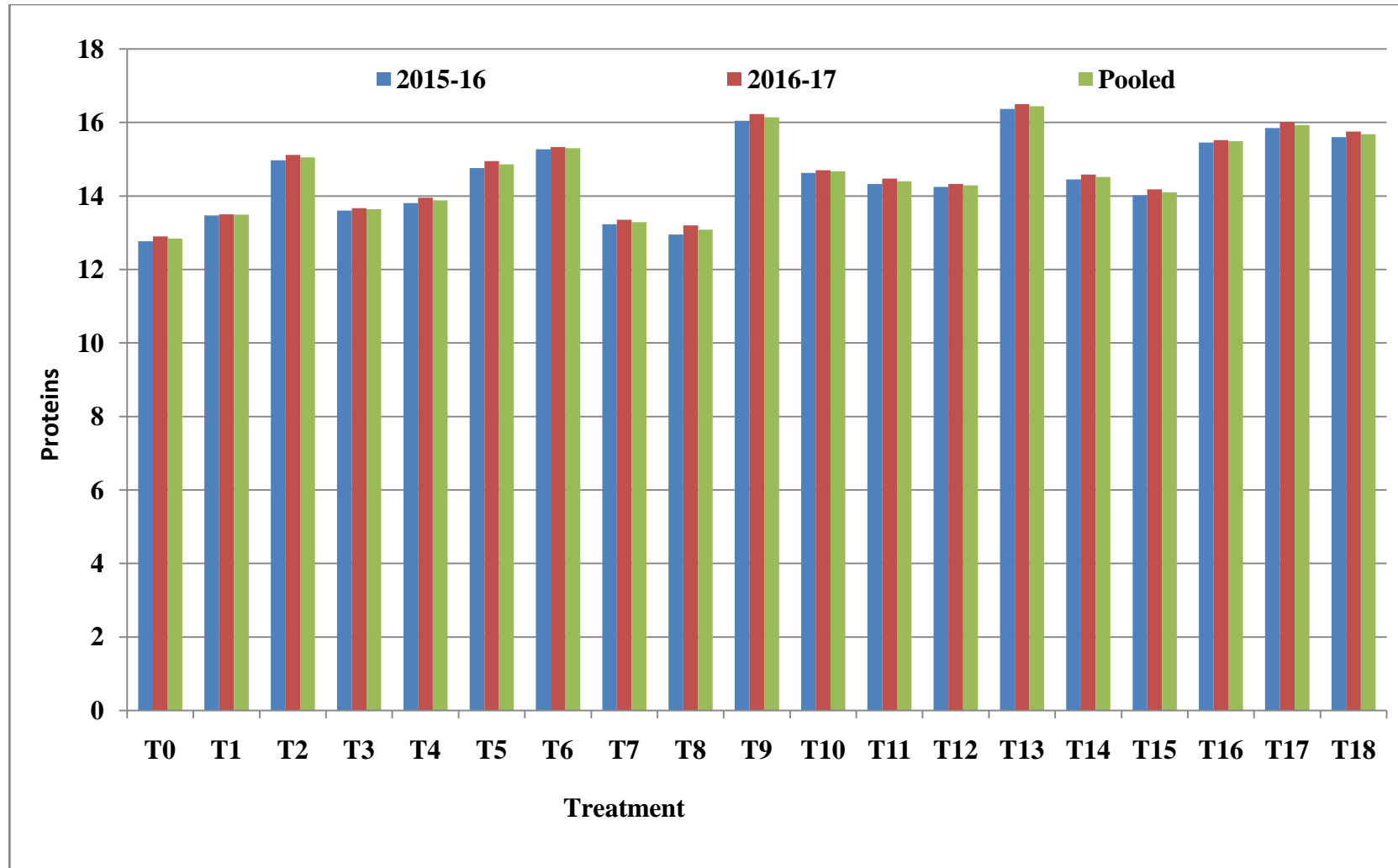
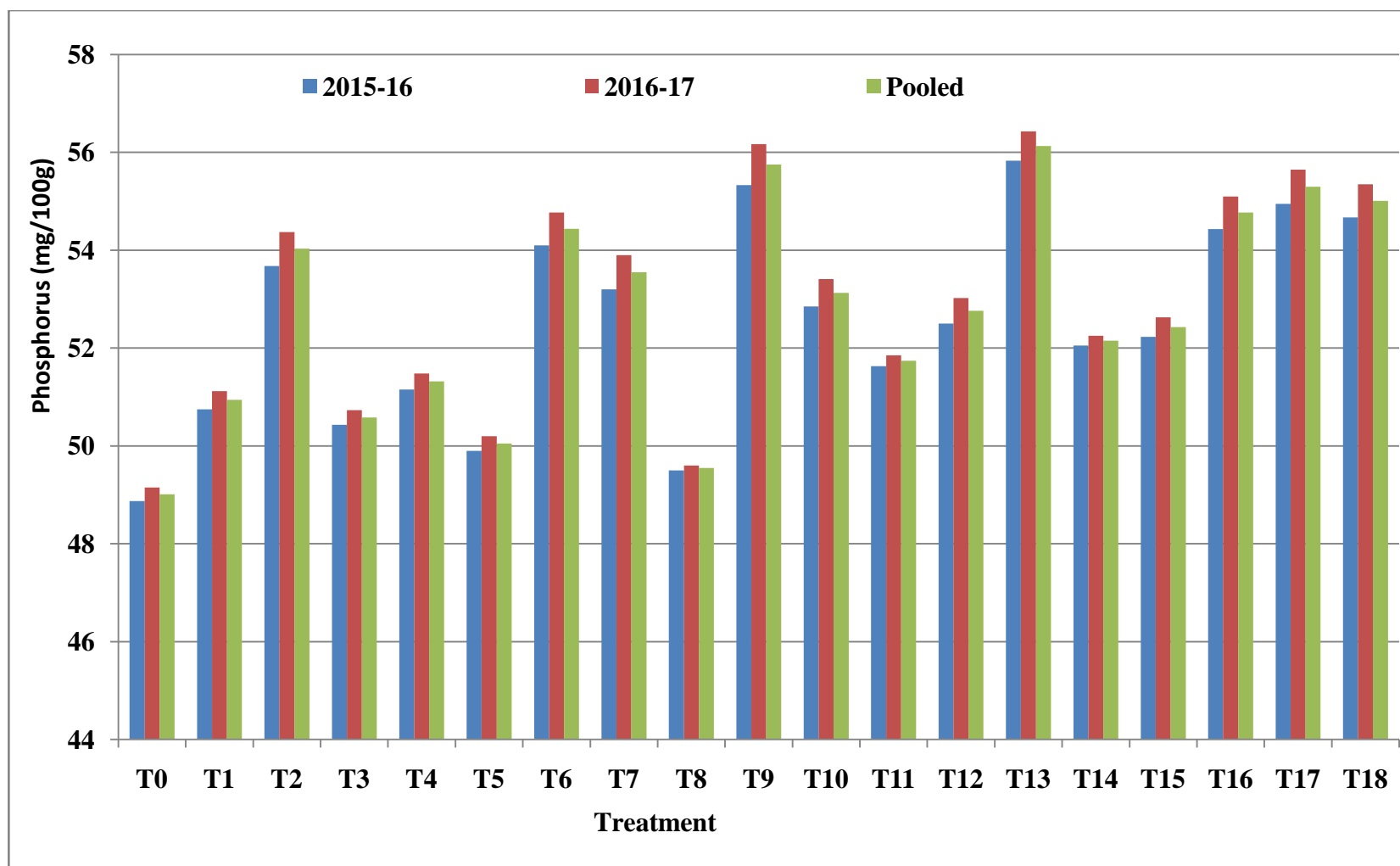


Table 4.17: Effect of organic, inorganic fertilizers and biofertilizers on phosphorus (mg/100g) of okra.

Treatment	Phosphorus		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	48.87	49.15	49.01
T <sub>1</sub> -RDF	50.75	51.12	50.94
T <sub>2</sub> -FYM	53.68	54.37	54.03
T <sub>3</sub> -Neem Cake	50.43	50.73	50.58
T <sub>4</sub> -Karanj Cake	51.15	51.48	51.32
T <sub>5</sub> -Bone Meal	49.90	50.20	50.05
T <sub>6</sub> -Vermi compost	54.10	54.77	54.44
T <sub>7</sub> -Fish gyano	53.20	53.90	53.55
T <sub>8</sub> -Mahua Cake	49.50	49.60	49.55
T <sub>9</sub> -RDF + FYM	55.33	56.17	55.75
T <sub>10</sub> -RDF + Neem Cake	52.85	53.41	53.13
T <sub>11</sub> -RDF +Karanj Cake	51.63	51.85	51.74
T <sub>12</sub> -RDF + Bone Meal	52.50	53.02	52.76
T <sub>13</sub> -RDF + Vermicompost	55.83	56.43	56.13
T <sub>14</sub> -RDF + Fish gyano	52.05	52.25	52.15
T <sub>15</sub> -RDF + Mahua Cake	52.23	52.63	52.43
T <sub>16</sub> -RDF + <i>Azospirillum</i>	54.43	55.10	54.77
T <sub>17</sub> -RDF + VAM	54.95	55.65	55.30
T <sub>18</sub> -RDF + PSB	54.67	55.35	55.01
CD at 5% (P=0.05)	1.514	1.448	1.430
SE(m)±	0.526	0.503	0.496

Fig. 4.24: Effect of organic, inorganic fertilizers and biofertilizers on phosphorus (mg/100g) of okra.



#### 4.4.9 Calcium (mg/100g)

Mean values on account of calcium content as influenced by the use of organic, inorganic fertilizer and biofertilizers have been tabulated in Table 4.25, graphically represented in Figure 4.25 and analysis of variance computed for this character given in Appendix XXV. An examination of data presented in above table exhibited marked variation in calcium content of okra 68.33 mg/100g in 2015-16 and 69.90 mg/100g in 2016-17 were recorded with the application of T<sub>13</sub>- RDF + vermicompost which was significantly highest closely followed by T<sub>9</sub> – RDF + FYM i.e. 67.78 mg/100g and 68.62 mg/100g and T<sub>17</sub> –RDF + VAM i.e. 67.07 mg/100g and 67.83 mg/100g. The minimum calcium content of okra 55.68 mg/100g and 56.35 mg/100g was observed with T<sub>0</sub> (control) treatment in both the year of investigation.

A perusal of data for mean over two year reveal that mean calcium content in okra was maximum (69.12 mg/100g) in the treatment T<sub>13</sub> which was at par with the treatment T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub> whereas, minimum ( 56.02 mg/100g) was observed in T<sub>0</sub> i.e. control.

#### 4.4.10 Magnesium (mg/100g)

Mean values on account of magnesium content as influenced by the use of organic, inorganic fertilizer and biofertilizers have been tabulated in Table 4.26, graphically represented in Figure 4.26 and analysis of variance computed for this character given in Appendix XXVI. An examination of data presented in above table exhibited marked variation in magnesium content of okra 49.62 mg/100g in 2015-16 and 50.22 mg/100g in 2016-17 were recorded with the application of T<sub>13</sub>- RDF + vermicompost which was significantly highest closely followed by T<sub>9</sub> – RDF + FYM i.e. 48.87 mg/100g and 49.50 mg/100g and T<sub>17</sub> –RDF + VAM i.e. 48.55 mg/100g and 49.42 mg/100g. The minimum magnesium content of okra 38.73 mg/100g and 39.85 mg/100g was observed with T<sub>0</sub> (control) treatment in both the year of investigation.

A perusal of data for mean over two year reveal that mean calcium content in okra was maximum (49.92 mg/100g) in the treatment T<sub>13</sub> which was at par with the treatment T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub> whereas, minimum ( 39.29 mg/100g) was observed in T<sub>0</sub> i.e. control.

Table 4.18: Effect of organic, inorganic fertilizers and biofertilizers on calcium (mg/100g) of okra.

Treatment	Calcium		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	55.68	56.35	56.02
T <sub>1</sub> -RDF (Recommended dose of fertilizer)	62.49	63.00	62.75
T <sub>2</sub> -FYM (Farm yard manure)	63.23	63.87	63.55
T <sub>3</sub> -Neem Cake	56.73	57.30	57.02
T <sub>4</sub> -Karanj Cake	58.43	59.08	58.76
T <sub>5</sub> -Bone Meal	57.55	58.18	57.87
T <sub>6</sub> -Vermi compost	64.60	64.80	64.70
T <sub>7</sub> -Fish gyano	58.00	58.68	58.34
T <sub>8</sub> -Mahua Cake	56.25	56.70	56.48
T <sub>9</sub> -RDF + FYM	67.78	68.62	68.20
T <sub>10</sub> -RDF + Neem Cake	61.58	62.37	61.98
T <sub>11</sub> -RDF +Karanj Cake	60.10	61.02	60.56
T <sub>12</sub> -RDF + Bone Meal	59.65	60.23	59.94
T <sub>13</sub> -RDF + Vermicompost	68.33	69.90	69.12
T <sub>14</sub> -RDF + Fish gyano	60.81	61.52	61.17
T <sub>15</sub> -RDF + Mahua Cake	58.70	59.53	59.12
T <sub>16</sub> -RDF + <i>Azospirillum</i>	65.40	65.55	65.48
T <sub>17</sub> -RDF + VAM	67.07	67.83	67.45
T <sub>18</sub> -RDF + PSB	66.35	66.95	66.65
CD (P = 0.05)	1.454	1.277	1.344
SEm±	0.505	0.443	0.467

Fig 4.25: Effect of organic, inorganic fertilizers and biofertilizers on calcium (mg/100g) of okra.

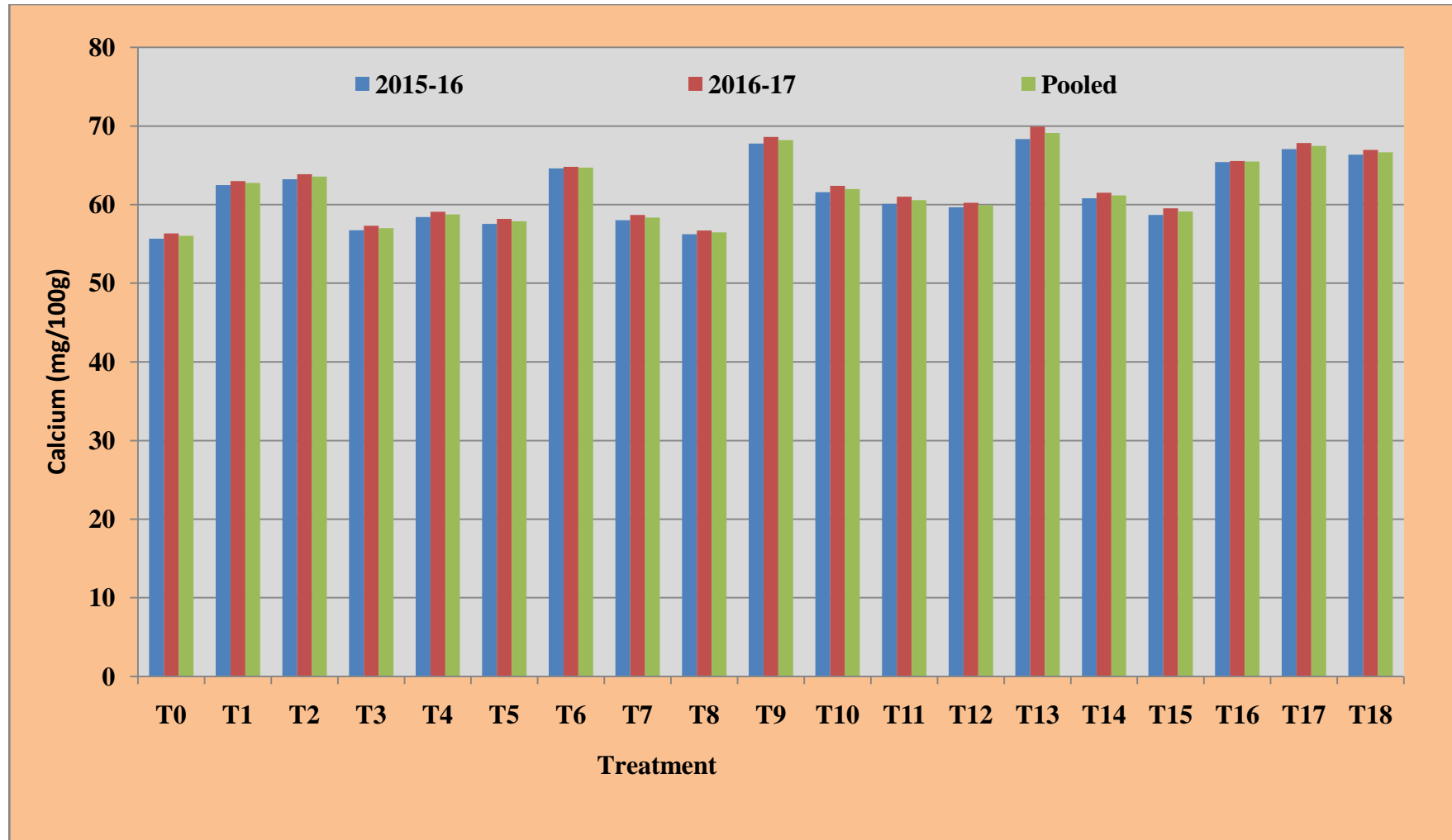
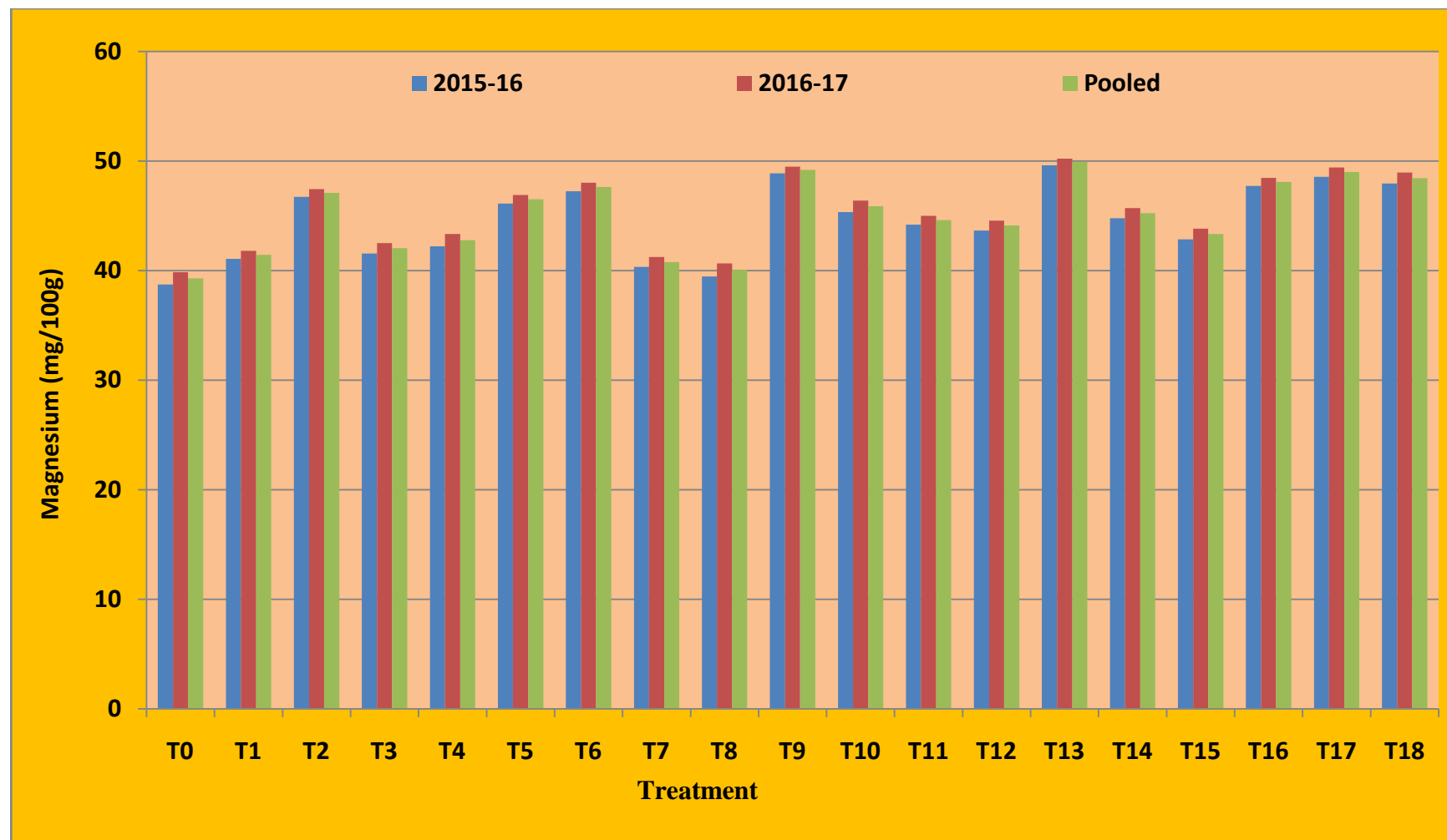
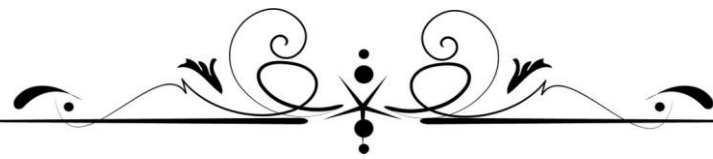


Table 4.19: Effect of organic, inorganic fertilizers and biofertilizers on magnesium (mg/100g) of okra.

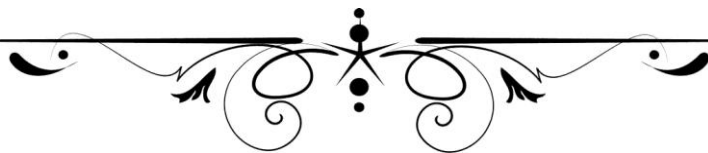
Treatment	Magnesium		
	2015-16	2016-17	Pooled
T <sub>0</sub> -Control	38.73	39.85	39.29
T <sub>1</sub> -RDF	41.08	41.80	41.44
T <sub>2</sub> -FYM	46.72	47.45	47.09
T <sub>3</sub> -Neem Cake	41.57	42.50	42.04
T <sub>4</sub> -Karanj Cake	42.23	43.33	42.78
T <sub>5</sub> -Bone Meal	46.11	46.90	46.51
T <sub>6</sub> -Vermi compost	47.25	48.02	47.64
T <sub>7</sub> -Fish gyano	40.33	41.25	40.79
T <sub>8</sub> -Mahua Cake	39.47	40.67	40.07
T <sub>9</sub> -RDF + FYM	48.87	49.50	49.19
T <sub>10</sub> -RDF + Neem Cake	45.35	46.40	45.88
T <sub>11</sub> -RDF +Karanj Cake	44.20	45.00	44.60
T <sub>12</sub> -RDF + Bone Meal	43.65	44.56	44.11
T <sub>13</sub> -RDF + Vermicompost	49.62	50.22	49.92
T <sub>14</sub> -RDF + Fish gyano	44.77	45.70	45.24
T <sub>15</sub> -RDF + Mahua Cake	42.85	43.82	43.34
T <sub>16</sub> -RDF + <i>Azospirillum</i>	47.73	48.47	48.10
T <sub>17</sub> -RDF + VAM	48.55	49.42	48.99
T <sub>18</sub> -RDF + PSB	47.95	48.95	48.45
CD (P = 0.05)	1.259	1.700	1.319
SEm±	0.437	0.590	0.458

Fig. 4.26: Effect of organic, inorganic fertilizers and biofertilizers on magnesium (mg/100g) of okra.





*Chapter 5*  
*Discussion*



## Discussion

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The presenting results of the field experiment entitled “**Effect of integrated nutrient management on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]**” was carried out at the Horticulture Research Farm-II, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, (A Central University), Lucknow. The experimental findings presented in the previous chapter provided a detailed account of response of integrated nutrient management in term of vegetative growth, flowering, yield, quality of okra, beside treatments under investigation, difference in productivity of okra between years of present investigation was also observed, so as to establish cause and effect relationship in the light of available evidences and literature. In present section, an attempt has been made to highlight the salient experimental findings and the possible explanation and evidence with a view to determine the cause and effect relationship with regard to different characters and shorting information of practical the results pertaining to the field experiments are discussed under here:-

The basic concept of integrated nutrient management is to maintain or adjust the soil fertility and plant nutrient supply in long run to reach the optimum level for sustaining crop production and optimization of the benefits from all possible sources involving inorganic fertilizers, biological sources and organic manures. Fertilizer, even though comparatively a costly input of production is essential for securing higher yield and should be supplied in adequate quantity as it an important input in crop production. Some soil micro-organisms play an important role in improving soil fertility and crop productivity due to their capability to fix atmospheric nitrogen, solubilise insoluble phosphate and decompose farm waste resulting in the release of plant nutrients. When the number and activity of specific micro-organisms called microbial inoculants or biofertilizers is used to haste’s biological activity to improve availability of plant nutrient. The use of biofertilizers like *Azospirillum*, *Azotobacter* and PSB are recently attempted for improvement of yield of okra crop. The effective utilization of organic and inorganic manure would not only provide economic benefits to the farmers but also improve and maintain soil fertility and sustainability in natural eco-system. It has become the matter of research for the use of organic manure which

is eco-friendly and low in cost along with chemical fertilizers for the production of okra crop.

Vermicompost, other important source of organic matter is a stable, fine, granular organic matter. When added to the soil, it improves the physio-chemical and biological status of soil which helps in improving the soil productivity. Release of some growth regulators from vermicompost also helps in growth and yield of the crops. Keeping in view the beneficial effects of INM in vegetable crop production, the combined use of organics (FYM, vermicompost), inorganic fertilizers (urea, single super phosphate and muriate of potash) and biofertilizers (*Azotobactor* and *Azospirillum*) with chemical and bio pesticides was carried out in the present experiment. The results obtained on different parameters are discussed below:-

### 5.1 Vegetative growth attributes

The significant difference in the plant height was recorded due to application of different combinations of organic, inorganic fertilizer and biofertilizers. During the both years (2015-16 and 2016-17) maximum plant height at 30 DAS (43.40 cm and 46.13 cm) was recorded from T<sub>13</sub> treatment (RDF + Vermicompost) followed by T<sub>9</sub> and T<sub>17</sub> while the minimum plant height at 30 DAS (27.43 cm and 29.77 cm) was recorded from T<sub>0</sub> control which was statistically similar with T<sub>8</sub> - Mahua Cake (29.25 cm and 31.01 cm).

The maximum plant height at 60 DAS i.e. 92.50 cm and 95.33 cm were noted by the application of T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 90.87 cm and 93.57 cm and T<sub>17</sub>- RDF + VAM i.e. 88.96 cm and 91.45 cm during 2015-16 and 2016-17, respectively and this improvement was significantly highest than rest of the treatment, however, minimum values i.e. 66.68 cm and 69.18 cm were in control where plots were deprived off by the use of any organic, inorganic fertilizers and biofertilizers in both the years.

The maximum plant height at 90 DAS i.e. 148.83 cm and 150.63 cm were noted by the application of T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 145.82 cm and 147.82 cm and T<sub>17</sub>- RDF + VAM i.e. 143.57 cm and 145.67 cm during 2015-16 and 2016-17, respectively and this improvement was significantly

highest then rest of the treatment, however, minimum values i.e. 117.65 cm and 119.55 cm were in control where plots were deprived off by the use of any organic, inorganic fertilizers and biofertilizers in both the years. **Amiry et al., (2017)** in okra and **Atiyeh et al., (2000)** found in similarly in tomato crop.

The data revealed that various treatments significantly enhanced the number of branch per plant at all stages of growth except at 100 days after sowing and maximum number of branch per plant i.e. 4.73 and 5.33 were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 4.60 and 5.15 and T<sub>17</sub>- RDF +VAM i.e. 4.53 and 5.01 while lowest number of branch per plant 3.12 and 3.31 were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively. **Kumar and Gowda, (2010)** in brinjal and **Amiry et al., (2017), Barani and Anburani (2004)** in okra.

The maximum stem diameter i.e. 29.67 mm and 30.10 mm were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 28.33 mm and 29.25 mm and T<sub>17</sub>- RDF +VAM i.e. 27.78 mm and 28.45 mm while minimum stem diameter 16.96 mm and 17.75 mm were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively. The increasing levels of vermicompost significantly increased the vegetative growth of okra plant. The improvement in plant height may be due to better moisture holding capacity, supply of micronutrients and availability of major nutrients due to favorable soil conditions. The increased nitrogen nutrition may also have accelerated the process of cell division and differentiation. Similar findings were also reported by **Barani and Anburani (2004)** in okra,

The maximum number of flower buds i.e. 19.30 and 18.82 were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 18.68 and 18.43 and T<sub>17</sub>- RDF +VAM i.e. 18.08 and 18.15 while minimum number of flower buds 12.98 and 13.68 were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

The maximum leaf area i.e. 881.25 cm<sup>2</sup> and 891.52 cm<sup>2</sup> were recorded with T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 856.50 cm<sup>2</sup> and 866.74 cm<sup>2</sup> and T<sub>17</sub>- RDF +VAM i.e. 823.25 cm<sup>2</sup> and 832.47 cm<sup>2</sup> while minimum

leaf area 578.56 cm<sup>2</sup> and 584.04 cm<sup>2</sup> were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

The minimum days to 50% flowering i.e. 42.67 and 41.33 were recorded during 2015-16 and 2016-17, respectively, with the application of T<sub>13</sub>- RDF + vermicompost closely followed by T<sub>9</sub>- RDF + FYM i.e. 43.00 and 41.67 and T<sub>17</sub>- RDF +VAM i.e. 43.33 and 41.89. The maximum (47.67 and 48.11) days to 50% flowering was found under the treatment T<sub>0</sub> (control). Early 50% flowering might be due to the enhanced production of growth positive influence on the physiological activity of the plants thereby resulting in early flowering. The result of this study is in agreements with the finding of **Shahriazzaman *et al.* (2014)**, **Prabhu *et al.*, (2002)** in okra. Similar results were obtained by **Laxmi *et al.*, (2015)** in tomato crop.

## 5.2 Fruiting and yield

The maximum number of fruit per plant was noticed under treatment T<sub>13</sub>- RDF + vermicompost i.e. 18.11 and 17.63. The values recorded by T<sub>9</sub>- RDF + FYM i.e. 17.50 and 17.25 being at par with T<sub>13</sub> and it was significantly superior over remaining treatments, however, minimum values i.e. 11.78 and 12.48 were in control where plots were deprived off by the use of organic, inorganic fertilizer and biofertilizers in both the years. This might be due to the better availability and uptake of nutrients by plants for a longer duration of crop growth. Similar findings of significantly higher number of fruits per plant by integrated application of fertilizers have also been reported by **Prabhu *et al.*, (2002)**, **Amiry *et al.*, (2017)** in okra.

The maximum fruit yield per plant was recorded under treatment T<sub>13</sub>- RDF + vermicompost i.e. 0.242 Kg and 0.264 kg. The values recorded by T<sub>9</sub>- RDF + FYM i.e. 0.233 kg and 0.251 kg being at par with T<sub>13</sub> and it was significantly superior over remaining treatments, however, minimum values i.e. 0.134 kg and 0.150 kg were in control where plots were deprived off by the use of organic, inorganic fertilizer and biofertilizers in both the years.

The highest fruit yield per plot (3.877 kg and 4.224 kg) was recorded under the treatment T<sub>13</sub>- RDF + vermicompost during 2015-16 and 2016-17, respectively. The values recorded by T<sub>9</sub> – RDF +FYM i.e. 3.728 kg and 4.016 kg being at par with T<sub>13</sub>

and it was significantly superior over remaining treatments. The minimum (2.149 kg and 2.400 kg) fruit yield per plot were observed in T<sub>0</sub> (control) treatment during both the year of experimentation.

The maximum fruit yield per hectare (17.95 t/ha and 19.55 t/ha) was recorded under the treatment T<sub>13</sub>- RDF + vermicompost during 2015-16 and 2016-17, respectively. The values recorded by T<sub>9</sub> – RDF + FYM i.e. 17.26 t/ha and 18.59 t/ha being at par with T<sub>13</sub> and it was significantly superior over remaining treatments. The minimum fruit yield per hectare (9.95 t/ha and 11.11 t/ha) were recorded in T<sub>0</sub> (control) treatment during both the year of experimentation. The reason for increase in yield and yield attributing traits might be solubilization effect of plant nutrients by the addition of RDF and Vermicompost as evidenced by increase in the uptake of N, P, K, Ca, and Mg etc. These results are in accordance with those reported by **Prabhu *et al.* (2002)**, **Mishra *et al.*, (2009)**, **Bharadiya *et al.*, (2007)** and **Ghosh *et al.*, (2018)** in okra.

### 5.3 Fruit physical characters

The maximum fruit length was recorded under the treatment T<sub>9</sub> – RDF + FYM i.e. 14.89 cm and 16.24 cm during 2015-16 and 2016-17, respectively. The values recorded by T<sub>13</sub>- RDF + vermicompost i.e. 14.15 cm and 15.50 cm being at par with T<sub>9</sub> and it was significantly superior over remaining treatments. The minimum values (8.47 cm and 9.87 cm) fruit length were recorded in T<sub>0</sub> (control) treatment during both the year of experimentation.

The data presented in above table clearly indicated that the fruit diameter was recorded under treatment T<sub>9</sub>- RDF + FYM i.e. 3.63 cm and 3.83 cm. The values recorded by T<sub>13</sub>- RDF + vermicompost i.e. 3.50 cm and 3.65 cm being at par with T<sub>9</sub> and it was significantly superior over remaining treatments, however, minimum values i.e. 1.98 cm and 2.07 were in Treatment T<sub>0</sub> (control) where plots were deprived off by the use of organic, inorganic fertilizer and biofertilizers in both the years. This might be attributed to the increased availability of NPK and water at the critical stages of the crop growth resulting early establishment, vigorous growth and development of plants leading to longer and wider fruits. Higher value in fruit diameter of okra observed due to integrated application of fertilizers as reported by **Kumar (2017)**.

The maximum fruit fresh weight was recorded under the treatment T<sub>13</sub> – RDF + vermicompost i.e 14.85 gm and 15.53 gm during 2015-16 and 2016-17, respectively. The values recorded by T<sub>9</sub>- RDF + FYM i.e. 14.60 gm and 15.17 gm being at par with T<sub>13</sub> and it was significantly superior over remaining treatments. The minimum values (11.76 gm and 12.25 gm) fruit fresh weight were recorded in T<sub>0</sub> (control) treatment during both the year of experimentation.

The maximum fruit dry weight (5.40 gm and 5.67 gm) was recorded under the treatment T<sub>13</sub>- RDF + vermicompost during 2015-16 and 2016-17, respectively. The values recorded by T<sub>9</sub> – RDF +FYM i.e. 5.23 gm and 5.45 gm being at par with T<sub>13</sub> and it was significantly superior over remaining treatments. The minimum fruit dry weight (4.05 gm and 5.15 gm) were recorded in T<sub>0</sub> (control) treatment during both the year of experimentation.

#### 5.4 Fruit biochemical characters

The minimum titratable acidity (0.14 % gm and 12%) was recorded under the treatment T<sub>13</sub>- RDF + vermicompost during 2015-16 and 2016-17, respectively. The value recorded by T<sub>9</sub> – RDF +FYM i.e. 0.17 % and 0.16 % being at par with T<sub>13</sub> and it was significantly superior over remaining treatments. The maximum titratable acidity (0.39 % and 0.36 %) was recorded in T<sub>0</sub> (control). **Kalalbandi et al., (2007)** found in cabbage.

The maximum T.S.S. (2.48 °Brix and 2.95 °Brix) was obtained by the use of T<sub>13</sub> – RDF + Vermicompost closely followed by T<sub>9</sub> – RDF +FYM i.e 2.38 °Brix and 2.88 °Brix and T<sub>17</sub> – RDF + VAM i.e 2.25 °Brix and 2.82 °Brix during 2015-16 and 2016-17, respectively. Minimum value i.e. 1.05 °Brix and 1.20 °Brix was recorded under the treatment T<sub>0</sub> (control) in both the year of experimentation. **Vennila and Jayanti et al., (2008)** found in Okra, **Sachan et al., (2017)** similarly found in ridge gourd.

It was further observed that use of T<sub>13</sub> –RDF + vermicompost treatment proved to be more useful in improving ascorbic acid 19.43 mg/100g and 19.57 mg/100g values with respect to ascorbic acid mg/100g was also found to be at par with T<sub>9</sub>- RDF + FYM and T<sub>17</sub> – RDF + VAM during the both the year of study. The

minimum ascorbic acid content of okra 13.67 mg/100g and 13.80 mg/100g was observed with T<sub>0</sub> (control) treatment in both the year of investigation. This might be due to the availability of nitrogen leading to balanced C:N ratio enhancing the vegetative growth resulting in high photosynthetic activity (**Gayathri and Krishnaveni, 2015**) in okra crop. **Laxmi et al., (2015)** found similarly in tomato crop.

The data indicated that maximum reducing sugar was noticed under the treatment T<sub>13</sub> (RDF + vermicompost) i.e. 2.04 % and 2.14 % during 2015-16 and 2016-17, respectively. The values recorded by T<sub>9</sub> – RDF + FYM treatments being at par with T<sub>13</sub> and it was significantly superior over remaining treatment. The minimum values (1.03% and 1.19%) were recorded under the control treatment i.e.T<sub>0</sub>.

The maximum non reducing sugar i.e. 1.26 % and 1.19% were recorded with T<sub>13</sub> (RDF + vermicompost) closely followed by T<sub>9</sub> and T<sub>17</sub> while minimum non reducing sugar 0.78 % and 0.74 % were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively.

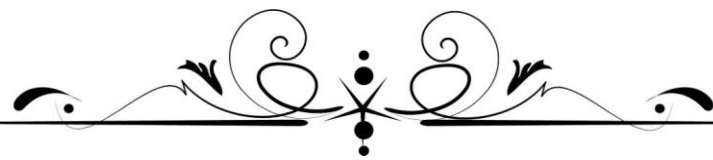
The maximum total sugar i.e. 3.30 % and 3.33 % were recorded with T<sub>13</sub>-RDF + vermicompost while minimum total sugar 1.87 % and 1.97 % were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively. It could be due to readily available of major nutrients in RDF and Vermicompost which increased metabolism activity in plant and reflected in increasing sugar content as reported by **Mishra et al. (2009)**.

The maximum Protein percent i.e. 16.37 % and 16.50 % were recorded with T<sub>13</sub>- (RDF + vermicompost) closely followed by T<sub>9</sub> and T<sub>17</sub> while minimum protein 12.77 % and 12.90 % were recorded with T<sub>0</sub> (control) during 2015-16 and 2016-17, respectively. Combine use of organic sources like, vermicompost and neem cake gave highest protein content as compared to other treatments. **Singhal and Aggarwal (2005)** found that highest protein content in treatment receiving conjunction of organic manure and inorganic fertilizer. The protein content of fruit increased with nitrogen from organic + inorganic sources. This may be due to its being constituents of amino acids which over building block of protein. **Wagh et al., (2014)** found similar in okra crop.

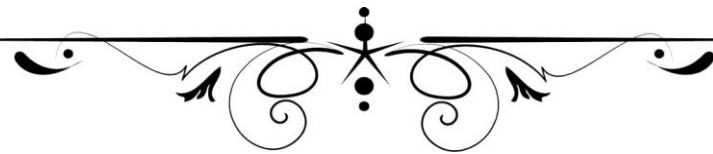
The maximum phosphorus content of okra 55.83 mg/100g in 2015-16 and 56.43 mg/100g in 2016-17 were recorded with the application of T<sub>13</sub> (RDF + vermicompost) which was significantly highest closely followed by T<sub>9</sub> and T<sub>17</sub>. The minimum phosphorus content of okra 48.87 mg/100g and 49.15 mg/100g was observed with T<sub>0</sub> (control) treatment in both the year of investigation. According to **Sharma *et al.*, (2010)** in okra.

The highest calcium content of okra 68.33 mg/100g in 2015-16 and 69.90 mg/100g in 2016-17 were recorded with the application of T<sub>13</sub>- RDF + vermicompost which was significantly highest closely followed by T<sub>9</sub> and T<sub>17</sub> while minimum calcium content of okra 55.68 mg/100g and 56.35 mg/100g was observed with T<sub>0</sub> (control) treatment in both the year of investigation.

The maximum magnesium content of okra 49.62 mg/100g in 2015-16 and 50.22 mg/100g in 2016-17 were recorded with the application of T<sub>13</sub>- RDF + vermicompost which was significantly highest while minimum magnesium content of okra 38.73 mg/100g and 39.85 mg/100g was observed with T<sub>0</sub> (control) treatment in both the year of investigation. **Singhal and Aggarwal (2005) and Wagh *et al.*, (2014)** found similar in okra crop.



*Chapter 6*  
*Summary and*  
*Conclusion*



# Summary and Conclusion

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The present investigation entitled “**Effect of integrated nutrient management on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]**” was carried out at Horticulture Research-II, Department of Applied Plant Science (Horticulture), School for Bioscience & Biotechnology, Bhasaheb Ambedkar, (A Central University) Vidya Vihar, raebareli Road, Lucknow -226 025 during the year 2015-16 and 2016-17, respectively. The experiment was laid out in Randomized Block Design with three replication and nineteen different treatment combination. The studies were concentrated on plant vegetative growth, yield and quality. The salient features of the findings of the investigation are summarized below:-

- ❖ The maximum plant height at 30, 60 and 90 DAS was obtained under the treatment T<sub>13</sub> followed by T<sub>9</sub>, respectively as compared to the treatment T<sub>0</sub> (control).
- ❖ The maximum number of branch per plant was found under the treatment T<sub>13</sub> followed by T<sub>9</sub> and T<sub>17</sub> respectively as compared to the treatment T<sub>0</sub> (control).
- ❖ The maximum stem diameter (mm) was noted under the treatment T<sub>13</sub> followed by T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub> respectively as compared to the control (T<sub>0</sub>) treatment.
- ❖ The maximum number of flower buds were recorded with T<sub>13</sub> closely followed by T<sub>9</sub> and T<sub>17</sub> while minimum number of flower buds were recorded with T<sub>0</sub> (control).
- ❖ The maximum leaf area in cm<sup>2</sup> were found under treatment T<sub>13</sub> closely followed by T<sub>9</sub> and T<sub>17</sub> while minimum leaf area were recorded with T<sub>0</sub> (control) respectively.
- ❖ The minimum days to 50% flowering were recorded with the application of T<sub>13</sub> closely followed by T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub>. The maximum days to 50% flowering was found under the treatment T<sub>0</sub> (control).

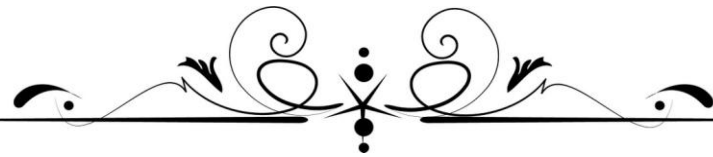
- ❖ The maximum number of fruit per plant was recorded under the treatment T<sub>13</sub>. The minimum number of fruit per plant was recorded in treatment T<sub>0</sub> (control).
- ❖ The maximum fruit yield per plant was increased significantly under treatment T<sub>13</sub> followed by T<sub>9</sub>, T<sub>17</sub> and T<sub>18</sub> respectively as compared to control (T<sub>0</sub>) treatment.
- ❖ The highest fruit yield per plot was recorded under the treatment T<sub>13</sub> while the minimum fruit yield per plot were observed in T<sub>0</sub> (control) treatment.
- ❖ The maximum fruit yield per hectare was recorded under the treatment T<sub>13</sub> while the minimum fruit yield per hectare was recorded in treatment T<sub>0</sub> (control).
- ❖ The maximum fruit length was recorded under the treatment T<sub>9</sub> closely followed by T<sub>13</sub> and T<sub>17</sub> while the minimum values fruit length was recorded in T<sub>0</sub> (control) treatment.
- ❖ The data presented in above table clearly indicated that the fruit diameter was recorded under treatment T<sub>9</sub> closely followed by T<sub>13</sub> and T<sub>17</sub> while the minimum values fruit length was recorded in T<sub>0</sub> (control) treatment.
- ❖ The maximum fruit fresh weight was recorded under the treatment T<sub>13</sub> while the minimum values fruit fresh weight was recorded in T<sub>0</sub> (control).
- ❖ The maximum fruit dry weight was recorded under the treatment T<sub>13</sub> while the minimum fruit dry weight was recorded in T<sub>0</sub> (control).
- ❖ The minimum acidity was recorded under the treatment T<sub>13</sub> closely followed by T<sub>9</sub> and T<sub>17</sub> while the maximum acidity was recorded in T<sub>0</sub> (control) treatment.
- ❖ The maximum T.S.S. was obtained by the use of T<sub>13</sub> closely followed by T<sub>9</sub> and T<sub>17</sub> respectively as compared to control treatment (T<sub>0</sub>).
- ❖ It was further observed that use of T<sub>13</sub> proved to be more useful in improving ascorbic acid values with respect to ascorbic acid mg/100g was also found to

be at par with T<sub>9</sub>. The minimum ascorbic acid content of okra was observed with T<sub>0</sub> (control) treatment.

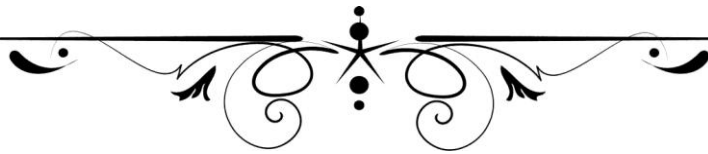
- ❖ The data indicated that maximum reducing sugar was noticed under the treatment T<sub>13</sub> which was significantly highest closely followed by T<sub>9</sub> and T<sub>17</sub>. The minimum values were recorded under the control treatment T<sub>0</sub>.
- ❖ The maximum non reducing sugar was recorded with T<sub>13</sub> closely followed by T<sub>9</sub> and T<sub>17</sub> while minimum non reducing sugar was recorded with T<sub>0</sub> (control).
- ❖ The maximum total sugars was recorded with T<sub>13</sub> while minimum total sugars was recorded with T<sub>0</sub> (control) respectively.
- ❖ The maximum Protein percent was recorded with T<sub>13</sub> closely followed by T<sub>9</sub> and T<sub>17</sub> while minimum protein was recorded with T<sub>0</sub> (control) respectively.
- ❖ The maximum phosphorus content of okra was recorded with the application of T<sub>13</sub> which was significantly highest closely followed by T<sub>9</sub> and T<sub>17</sub>. The minimum phosphorus content of okra was observed with T<sub>0</sub> (control) treatment.
- ❖ The highest calcium content of okra was recorded with the application of T<sub>13</sub> which was significantly highest closely followed by T<sub>9</sub> and T<sub>17</sub> while minimum calcium content of okra was observed with T<sub>0</sub> (control) treatment in both the year of investigation.
- ❖ The maximum magnesium content of okra were recorded with the application of T<sub>13</sub> which was significantly highest while minimum magnesium content of okra was observed with T<sub>0</sub> (control) treatment in both the year of investigation.

## **Conclusion**

The overall results obtained from this present investigation clearly revealed that the application of T<sub>13</sub> (RDF + vermicompost) showed the better performance for vegetative growth (plant height, number of branch per plant, stem diameter, number of flower buds, leaf area, days to 50% flowering), yield attributes [number of fruit per plant, fruit yield per plant (kg), fruit yield per plot (kg), fruit yield per hectare (t), fruit fresh weight (g), fruit dry weight (g)] and quality [titratable acidity (%), T.S.S. (°Brix), ascorbic acid (mg/100g), reducing sugar (%), non reducing sugar (%), total sugars (%), protein (%), phosphorus (mg/100g), calcium (mg/100g), magnesium (mg/100g)] of okra except fruit length and fruit diameter and would be useful to enhance the productivity of okra. Thus integrated use of nutrients may be suggested for higher crop productivity along with over all betterment of okra under Lucknow conditions.



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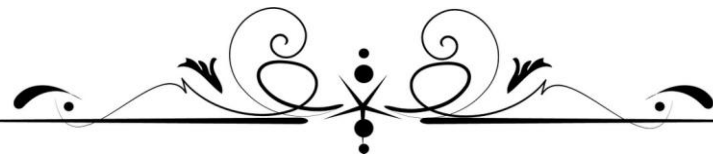
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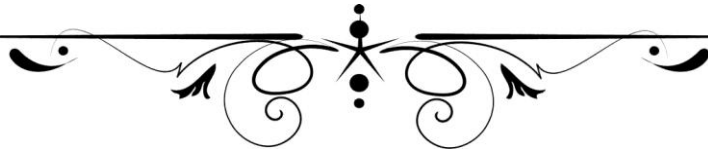
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# *Appendices*



# Appendices

Appendix: i Effect of integrated nutrient management on plant height 30 DAS

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	9.488			
Treatment	18	1,130.589	62.810	15.622	0.00000
Error	36	144.741	4.021		
Total	56	1,284.819			

Appendix: ii Effect of integrated nutrient management on plant height 60 DAS

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	135.213			
Treatment	18	3,370.780	187.266	133.190	0.00000
Error	36	50.616	1.406		
Total	56	3,556.609			

Appendix: iii Effect of integrated nutrient management on plant height 90DAS

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	99.816			
Treatment	18	5,062.664	281.259	94.098	0.000000
Error	36	107.605	2.989		
Total	56	5,270.084			

Appendix: iv Effect of integrated nutrient management on no. of branch per plant

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	0.013			
Treatment	18	15.941	0.886	28.761	0.000000
Error	36	1.109	0.031		
Total	56	17.063			

Appendix: v Effect of integrated nutrient management on Stem diameter

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	10.843			
Treatment	18	784.214	43.567	13.643	0.000000
Error	36	114.961	3.193		
Total	56	910.019			

Appendix: vi Effect of integrated nutrient management on No. of flower bud

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	5.246			
Treatment	18	157.399	8.744	33.716	0.00000
Error	36	9.337	0.259		
Total	56	171.982			

Appendix: vii Effect of integrated nutrient management on Leaf area

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	202.325			
Treatment	18	444,583.916	24,699.106	1,498.947	0.00000
Error	36	593.195	16.478		
Total	56	444,379.436			

Appendix: viii Effect of integrated nutrient management on Days to 50 % flowering

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	38.308			
Treatment	18	155.829	8.657	21.735	0.00000
Error	36	14.339	0.393		
Total	56	208.477			

Appendix: ix Effect of integrated nutrient management on no. of fruit per plant

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	1.317			
Treatment	18	158.165	8.787	35.302	0.00000
Error	36	8.961	0.249		
Total	56	168.443			

Appendix: x Effect of integrated nutrient management on Fruit yield per plant

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	0.001			
Treatment	18	0.054	0.003	26.473	0.00000
Error	36	0.004	0.000		
Total	56	0.060			

Appendix: xi Effect of integrated nutrient management on Fruit yield per plot (kg)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	0.178			
Treatment	18	12.174	0.676	7.387	0.00000
Error	36	3.296	0.092		
Total	56	15.648			

Appendix: xii Effect of integrated nutrient management on Fruit yield per ha (t)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	7.569			
Treatment	18	298.051	16.558	26.501	0.00000
Error	36	22.494	0.625		
Total	56	328.114			

Appendix: xiii Effect of integrated nutrient management on fruit length (cm)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	6.160			
Treatment	18	181.183	10.066	2,413.309	0.00000
Error	36	0.150	0.004		
Total	56	187.494			

Appendix: xiv Effect of integrated nutrient management on Fruit diameter (cm)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	0.988			
Treatment	18	15.058	0.837	9.595	0.00000
Error	36	3.139	0.087		
Total	56	19.184			

Appendix: xv Effect of integrated nutrient management on fruit fresh weight (g)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	4.130			
Treatment	18	47.696	2.650	8.052	0.00000
Error	36	11.847	0.329		
Total	56	63.673			

Appendix: xvi Effect of integrated nutrient management on Fruit dry weight (g)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	0.343			
Treatment	18	10.333	0.574	19.327	0.00000
Error	36	1.069	0.030		
Total	56	11.746			

Appendix: xvii Effect of integrated nutrient management on titratable acidity (%)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	0.003			
Treatment	18	0.327	0.018	53.765	0.00000
Error	36	0.012	0.000		
Total	56	0.343			

Appendix: xviii Effect of integrated nutrient management on T.S.S. (<sup>0</sup> Brix)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	2.648			
Treatment	18	13.889	0.772	3.695	0.00041
Error	36	7.517	0.209		
Total	56	24.054			

Appendix: xix Effect of integrated nutrient management on ascorbic acid (Vitamin C)  
(mg/100g)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	8.699			
Treatment	18	173.363	9.631	13.312	0.00000
Error	36	26.046	0.724		
Total	56	208.108			

Appendix: xx Effect of integrated nutrient management on reducing sugar

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	0.391			
Treatment	18	3.210	0.178	5.409	0.00001
Error	36	1.187	0.033		
Total	56	4.788			

Appendix: xxi Effect of integrated nutrient management on non reducing sugar

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	0.032			
Treatment	18	1.407	0.078	2.200	0.02165
Error	36	1.279	0.036		
Total	56	2.719			

Appendix: xxii Effect of integrated nutrient management on total sugar (%)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	0.284			
Treatment	18	8.491	0.472	8.610	0.00000
Error	36	1.973	0.055		
Total	56	10.747			

Appendix: xxiii Effect of integrated nutrient management on Proteins

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	4.491			
Treatment	18	61.322	3.407	9.030	0.00000
Error	36	13.583	0.377		
Total	56	79.396			

Appendix: xxiv Effect of integrated nutrient management on Phosphorus (mg/100g)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	8.173			
Treatment	18	253.228	14.068	19.022	0.00000
Error	36	26.625	0.740		
Total	56	288.026			

## Appendix: xxv Effect of integrated nutrient management on Calcium (mg/100g)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	8.096			
Treatment	18	929.576	51.643	79.010	0.00000
Error	36	23.531	0.654		
Total	56	961.202			

## Appendix: xxvi Effect of integrated nutrient management on Magnesium (mg/100g)

Source of variation	DF	S. S.	MS	F-Cal	Significance
Replication	2	9.048			
Treatment	18	594.695	33.039	52.515	0.00000
Error	36	22.649	0.629		
Total	56	626.391			