

**Influence of Organic Manures and Inorganic  
Fertilizers on Growth, Yield and Quality of Okra  
[*Abelmoschus esculentus* (L.) Moench]**

**Mushtaq Ahmad Chattoo  
(2003-87-D)**



**Division of Olericulture**

**Faculty of Post-Graduate Studies**

**Sher-e-Kashmir University of Agricultural Sciences and Technology  
of Kashmir**

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Fertilizers on Growth, Yield and Quality of Okra  
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*Thesis*

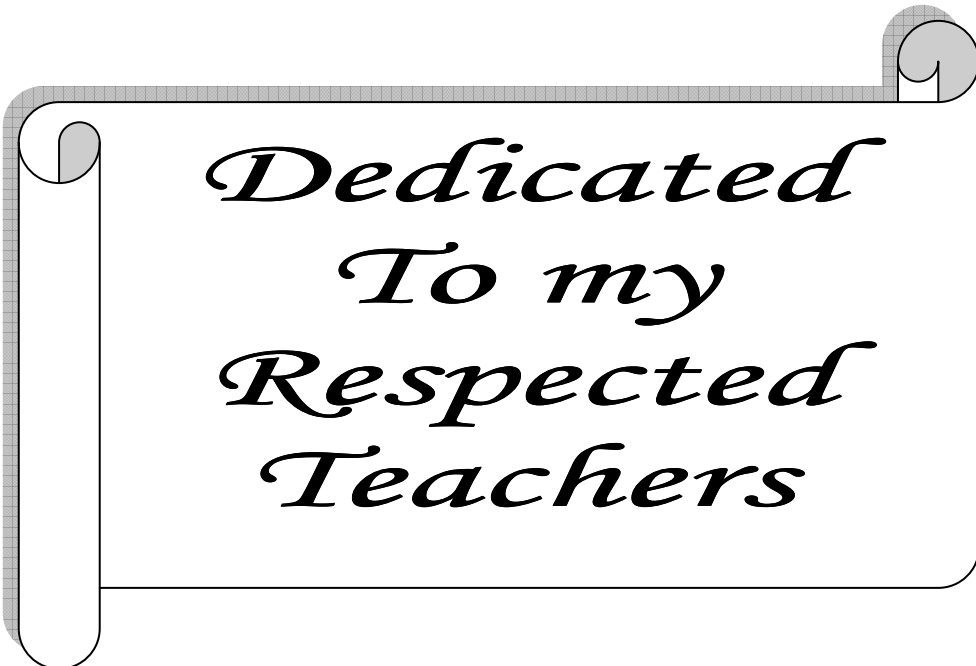
Submitted to

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Sher-e-Kashmir University of Agricultural Sciences &  
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in partial fulfillment of the requirements for award of the Degree of

**Doctor of Philosophy in Agriculture  
(Olericulture)**

**2006**



*Dedicated  
To my  
Respected  
Teachers*

**Sher-e-Kashmir**  
**University of Agricultural Sciences and Technology of Kashmir**  
**Division of Olericulture, Shalimar, Srinagar - 191121**

-:-

**Certificate - I**

This is to certify that the thesis entitled “**Influence of Organic Manures and Inorganic Fertilizers on Growth, Yield and Quality of Okra [*Abelmoschus esculentus* (L.) Moench]**” submitted in partial fulfillment of the requirements for the award of the degree of **Doctor of Philosophy in Agriculture (Olericulture)** to the **Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir** is a record of bona-fide research work carried out by **Mr. Mushtaq Ahmad Chattoo (Registration No. 2003-87-D)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that any help or information received during the course of investigation has duly been acknowledged.

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Division of Olericulture

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**University of Agricultural Sciences and Technology of Kashmir**  
**Division of Olericulture, Shalimar, Srinagar - 191121**

--:

**Certificate - II**

We, the members of Advisory Committee of **Mr. Mushtaq Ahmad Chattoo (Registration No. 2003-87-D)**, a candidate for the degree of **Doctor of Philosophy in Agriculture (Olericulture)**, have gone through the manuscript of the thesis entitled, “**Influence of Organic Manures and Inorganic Fertilizers on Growth, Yield and Quality of Okra [*Abelmoschus esculentus* (L.) Moench]**” and recommend that it may be submitted by the student in partial fulfillment of the requirements for the degree.

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Division of Olericulture

**Director**

**Resident Instruction-cum-Dean** Post-  
Graduate Studies, SKUAST (K)

**(External Examiner)**

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**University of Agricultural Sciences and Technology of Kashmir**  
**Division of Olericulture, Shalimar, Srinagar - 191121**

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**Sher-e-Kashmir**  
**University of Agricultural Sciences & Technology of Kashmir**  
**Division of Olericulture, Shalimar Campus, Srinagar 191 121**

Name of the student : **Mushtaq Ahmad Chattoo**

Registration No. : 2003-87-D

Major Subject : Olericulture

Minor Subject : Soil Science

Major Advisor : **Dr. Nazeer Ahmed**  
Professor & Head,  
Division of Olericulture,  
SKUAST (K), Shalimar

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**ABSTRACT**

The present investigation “Influence of organic manures and inorganic fertilizers on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]” was carried out at experimental fields of Division of Olericulture, SKUAST (K), Shalimar during kharief 2004 and 2005. Residual crop pea was immediately raised after the harvest of okra during rabi 2004-2005 and 2005-2006. The experiment was laid out in simple square lattice design with two replications. The

experiment comprised of 25 treatments. Observations in main crop okra were recorded on plant growth, fruit and seed yield, fruit and seed quality, nutrient uptake, soil physical and chemical characteristics, nutrient availability, rhizosphere microbial population of studied soil. In residual crop pea, observations were recorded on plant height, yield and yield related attributes and nodule number plant<sup>-1</sup>.

Treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded significantly higher values for plant height (186.82 cm), number of branches plant<sup>-1</sup> (3.08), internodal distance (6.99 cm), number of nodes plant<sup>-1</sup> (main stem) (26.82), number of fruits plant<sup>-1</sup> (28.93), fruit length (14.74 cm), fruit diameter (1.41 cm), average fruit weight (14.14 g), fruit yield ha<sup>-1</sup> (272.71 q), seed yield ha<sup>-1</sup> (26.62 q), protein content of dry seeds (22.65%), protein content of fresh fruits (3.01%), vitamin C (17.59 mg), dry matter content (12.95%), nutrient uptake (132.23 kg N, 31.91 kg P, 139.35 kg K, 21.51 kg S, 135.37 kg Ca and 70.58 kg Mg ha<sup>-1</sup>), porosity (45.81%), organic carbon content (1.65%), electrical conductivity (0.145 d sm<sup>-1</sup>), available nutrients (266.13 kg N, 52.36 kg P, 197.10 kg K, 29.20 kg S, 3526.08 kg Ca and 1078.87 kg Mg ha<sup>-1</sup>), rhizosphere microbial population (fungal 60.11 x 10<sup>5</sup> and bacterial 74.15 x 10<sup>5</sup> g<sup>-1</sup> of soil) and pod yield of residual crop pea 123.56 q ha<sup>-1</sup>. Treatment T<sub>24</sub> also registered significantly lower values for fibre content of fresh fruits (1.28%), bulk density (1.24 g cm<sup>3</sup>), particle density (2.29 g cm<sup>3</sup>) and soil

$P_H$  (6.51). However,  $T_1$  and  $T_{21}$  were at par with  $T_{24}$  for some characters. Treatment  $T_{21}$ ,  $T_{22}$  and  $T_{20}$  were next best to  $T_{24}$  exhibiting superiority for most of the characters over rest of treatments. Organic integrations proved superior over sole applications of organics. Treatment  $T_7$  (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) proved better followed by  $T_{15}$ ,  $T_{12}$ ,  $T_{16}$  and  $T_{17}$ . Among sole application of organic sources, PM 6 t ha<sup>-1</sup> ( $T_4$ ) proved better than FYM, SM, VC and BF. Organics either alone or in combination, recorded lower yield as compared to recommended fertilizer dose in main crop. In okra,  $T_7$  recorded maximum net returns of Rs. 1,25,140.80 ha<sup>-1</sup> with returns Re<sup>-1</sup> invested of 3.39. However, maximum cost benefit ratio of 3.63 Re<sup>-1</sup> was recorded with  $T_{16}$ . Minimum BEP (32.70 q ha<sup>-1</sup>) and maximum margin of safety (224.89 q ha<sup>-1</sup>) was recorded with  $T_7$  and  $T_{24}$ , respectively. Lower values for relative shares of land (0.158), labour (0.093) and capital (0.072) were registered in  $T_{25}$ ,  $T_7$  and  $T_{16}$ , respectively. In residual crop pea,  $T_{24}$  recorded maximum net returns of Rs. 22,944.30 with returns Re<sup>-1</sup> invested of 1.59. Minimum BEP of 59.69 q ha<sup>-1</sup> and maximum margin of safety 65.87 q ha<sup>-1</sup> were recorded with  $T_{24}$ . Lower values for relative shares of land (-0.125), labour (0.193) and capital were recorded with  $T_{25}$  and  $T_{24}$ , respectively. In okra pea rotation  $T_7$  recorded maximum net returns of Rs. 1,44,125.10 ha<sup>-1</sup> with returns Re<sup>-1</sup> invested of 2.56. However,  $T_{16}$  registered highest cost benefit ratio of 2.59 Re<sup>-1</sup>. Thus, the present study revealed that integration of organics (farmyard manure, sheep manure, poultry manure, vermi compost and biofertilizers) with

inorganic fertilizers in equal proportion (50:50) exhibited superiority over sole application of organics, inorganics and integration of organic sources with respect to almost all the characters of main crop, residual crop and soil health under study.

**Key words:** *Abelmoschus*, Growth, Inorganic fertilizers, Okra, Organic manures, Quality and Yield.

**Signature of Student**

Dated:\_\_\_\_\_

**Signature of Major Advisor**

Dated:\_\_\_\_\_

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***Mushtaq Ahmad Chattoo***

*Place:* \_\_\_\_\_

*Dated:* \_\_\_\_\_

## Chapter 1

### INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] commonly known as “Bhindi” in India, “Lady’s finger” in England and “Gumbo” in USA belongs to family *Malvaceae*, is an annual vegetable cultivated mostly in tropical, subtropical regions of the world. The cultivated okra is of old world origin and is believed to have originated in Africa and Asia as a polyphyletic species (Bista *et al.*, 1995).

Okra is highly nutritious vegetable besides having medicinal importance. It is a potential source of numerous minerals like phosphorus, potassium, sulphur, calcium, iron, sodium, etc and vitamins A, B and C. The amount of ascorbic acid content varies from 13-18 mg 100 g<sup>-1</sup> of fresh fruit weight, while as green tender fruits and immature seeds have a little protein content of 2.08 and 2.09 per cent, respectively (Singh *et al.*, 2001). Dry mature seeds contain 18-20 per cent oil and 20-23 per cent crude protein (Berry *et al.*, 1988). Ekka *et al.* and Singh *et al.* (2001) reported that fresh okra fruits have a fibre content of 1.2, 1.94 and 12.43 per cent depending upon variety and days to harvest.

As far as its medicinal importance is concerned, it is supposed to be good for people suffering from renal, colic, leucorrhoea, spermatorrhoea, chronic dysentery and general weakness. Fageria *et*

*al.* (2003) reported its usefulness in people suffering from genitourinary disorders while as Singh (1989) described okra fruit as an excellent source of fibre and iodine an anti-giotre factor.

Ripe seeds are roasted, grounded and used as substitute for coffee (Martin, 1982) besides being used for extraction of edible oil. Mature fruits with fibrous stocks are used in paper industry while as roots and stems of okra are also used in cleaning of raw sugar. Fruits are generally marketed in fresh state but some times they are canned as well as dehydrated. Green tender fruits are fried, cooked in curry and are also used in soups.

India is the largest producer of okra in the world and occupies an area of 3.49 lakh hectares with an annual production of 33.45 lakh tones (Anonymous, 2003). It is grown as a spring and rainy season crop on large scale in Uttar Pradesh, Orissa, Bihar, West Bengal, Karnataka and Maharashtra. In Jammu and Kashmir, it is mostly grown as kharif crop on an area of about 2050 ha, with an annual production of 28700 metric tones (Anonymous, 2005). However, realizing its nutritional and economic importance, the area under this crop is increasing. Okra has a tremendous export potential as a fresh vegetable. Nearly 102 crore rupees are being earned by export of fresh vegetables in our country and out of this okra contributes 65 crores (Singh, 2002). Our major target for export of okra has been Gulf and South Asian countries and India has now started exporting it to European and Japanese markets,

where quality restrictions are very stringent and competitive. Kashmir valley has a potential to produce organic okra capable of competing the international quality standards, as the crop almost remains free from insects, pests, diseases and can be grown with minimum or no pesticides.

Okra produces fruits for long time and thus needs proper and sufficient supply of plant nutrients both macro and micro for higher yields and better quality. For harnessing the higher yields and better quality, adequate quantities of plant nutrients is a pre-requisite, which can be supplied both by organic and inorganic sources.

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

With the increase in population, the demand for the crop has significantly increased which has led to extensive use of inorganic fertilizers without least consideration for soil health, which is a critical factor for realizing sustainable high yields of any vegetable crop. Besides this, the residual effects of inorganic fertilizers on environment, underground water resources, soil micro-flora, vegetables and vegetable products, is a matter of great concern. The residual toxicity

level is reported to be more in vegetables and fruits as compared to grains. The ill effects of chemicals in agriculture has been well documented (Carson, 1962). Amines produced from nitrogenous fertilizers cause cancer in human beings. Most of the toxic residues affect the central nervous system, respiratory and gastro-intestinal system in human beings (Ghosh, 2000). Hence application of higher doses of chemical inputs is highly hazardous to human health.

Large scale use of chemical fertilizers has resulted in the deterioration of soil structure and a decrease in microbial population in the soil (Ganeshe *et al.*, 1998). Use of chemical fertilizers is associated with other problems like loss of applied nutrients through leaching, volatilization and denitrification of nitrogen and fixation of phosphorus. Besides this, the prices of chemical fertilizers are increasing tremendously and due to inherent financial strains, the marginal farmers are unable to purchase such expensive inputs in time. The continuous and indiscriminate use of inorganic fertilizers has resulted in decreased nutrient uptake and adversely affected the quality of vegetables (Agarwal, 2003). Thus there is an emergent need to utilize other sources of plant nutrients for sustainable okra production. The answer lies in the use of organic manures, which aims at cooperating rather than confronting with nature. A wide range of organic manures like farm yard manure, sheep manure, poultry manure, composts and biofertilizers are used. However, poultry manure/sheep manure/vermi

compost are superior and nutritionally rich, as they contain growth promoting substances which induce better plant growth. Organic manures constitute a dependable source of micro and macro nutrients, besides being helpful in building a strong organic matter base, resulting in improvement of soil structural properties like bulk density, porosity, aeration and water holding capacity, regulates soil pH near neutral, maintains soil health, enhances biological diversity and soil micro-flora, reduces nutrient leaching, increase availability and uptake of nutrients leading to sustainable vegetable production, devoid of harmful residues (Singh *et al.*, 2000; Achary and Mandal, 2002). Biofertilizers are carrier based micro-organisms which help to enhance productivity by biological nitrogen fixation or solubilization of insoluble phosphate or by producing hormones, vitamins and other growth promoters required for plant growth (Bhattacharyya *et al.*, 2000), besides being economical in saving 25 per cent of chemical nitrogen and phosphorus (Chattoo *et al.*, 1997, 2003). Organic manures are known to improve the quality of vegetables (Singh *et al.*, 2000; Chattoo *et al.*, 2003) and such vegetables are preferred for their flavour, taste, lusture, nutritive value and are being sold at premium prices.

The cost of production of high-tech farming has gone up to 90-95 per cent, leaving only or margin of 5-10 per cent. The only way to improve productivity and to cut the cost is to use locally available organic manures. The yields are lower as compared to high-tech

farming but the cost of production is so low that the net returns per rupee spent are higher (Kumar *et al.*, 2004). It has been observed that neither the chemical fertilizers alone nor the organic manures are able to sustain the soil fertility/productivity and crop productivity. On the other hand organic manures supply major nutrients in a moderate quantity, as such soil has to be supplemented with inorganic fertilizers. The integration has proved superior than individual components separately with respect to growth, yield, quality and nutrient uptake (Malewar *et al.*, 1998; Abusaleha and Shanmugavelu, 1988; Chattoo *et al.*, 1997; Ushakumari *et al.*, 1999; Bage *et al.*, 2000; Bhardwaj *et al.*, 2000; Bhadoria *et al.*, 2002; Magray, 2002; Chattoo *et al.*, 2003).

Since a very meager work has been conducted under Kashmir conditions, an investigation has been carried out to assess the beneficial effects of organic manures and inorganic fertilizers both as sole application as well as in conjugation on okra with the following objectives:

- To study the response of different organic manures on growth, yield and quality of okra;
- to work out the optimum combination of organic and inorganic sources of nutrients for optimizing the yield of okra;
- to study the impact of organic manures on soil health and nutrient availability;

- to ascertain the effect of organic manures on rhizosphere microbial population;
- to assess the residual effect on succeeding crop pea;
- to study the comparative economics of various organic and inorganic sources of plant nutrients; and
- to study the factor shares of important factors of production.

## Chapter 2

### REVIEW OF LITERATURE

Sufficient literature is available on manurial and fertilizer requirement of okra crop, which indicates that it requires sufficient quantum of plant nutrients and can be effectively supplemented by application of both organic and inorganic sources. Application of inorganic fertilizers ensure quick supply of nutrients, resulting in increased fruit yield but due to their ill effects on soil health and vegetable quality, they need to be replaced by organic manures for obtaining sustainable and higher yields. Organic manures constitute a dependable source of plant nutrients and improve soil physical, chemical and biological properties.

During decomposition organic manures yield many organic compounds, organic acids and antibiotics, thus they play nutritional, stimulatory and therapeutic role. As such addition of organic manures results in economic, viable and quality vegetable production. The nutrient content of organic manures indicates that it can be used either alone or in combination with inorganic fertilizers. Many vegetable crops do not require the use of inorganic fertilizers if soils are supplemented with organic manures @ 30-35 t ha<sup>-1</sup> (Singh *et al.*, 2000). The literature pertaining to organic manures and their integration with inorganic fertilizers is reviewed as under:

## **Effect of Farm yard Manure**

Farm yard manure is bulky manure and most commonly used and plays an additional role than its capacity to contribute NPK. Abusaleha and Shanmugavelu (1988) observed that sole application farm yard manure (FYM) exhibited lower response in enhancing growth attributes in okra as compared to other organic manures and chemical nitrogen. Lower values for plant height, number of branches plant<sup>-1</sup> were exhibited by pea, brinjal, okra and soybean due to sole application of FYM as compared to 100 per cent NPK (Jose *et al.*, 1988; Datt *et al.*, 2003; Dash *et al.*, 2005; Ray *et al.*, 2005). Marked increase in growth related attributes of okra were observed due to FYM application (Montaseer, 1990). Higher values for plant height, number of branches were recorded in FYM amended plots as compared to those amended with chemical fertilizers in okra (Singh *et al.*, 1998). Application of FYM, as individual source of plant nutrients, could not produce any significant effect on growth attributes of okra and onion (Bhardwaj *et al.*, 2000; Sharma *et al.*, 2003). Subba Rao and Ravi Sanker (2001) reported significant increase in growth related attributes of brinjal due to FYM application. Sole application of FYM were either at par or superior than inorganic fertilizers in improving growth attributes in brinjal (Subba Rao and Sanker, 2001). In okra FYM application recorded values for growth

attributes which were at par with recommended fertilizer dose (Prabu *et al.*, 2003). In potato combined application of FYM and poultry manure (PM) in equal proportions exhibited a higher growth response than individual applications (Singh *et al.*, 1973). Combined application of FYM + biofertilizers in cucumber recorded higher values for growth as compared to recommended fertilizer dose (RFD) and control (Nirmala and Vadivel, 2000).

Farm yard manure in conjugation with vermi compost enhanced the values for growth related attributes in okra (Prakash *et al.*, 2002). FYM in combination with biofertilizers improved the growth related attributes in okra (Nuruzzaman *et al.*, 2003) while as conjugation of FYM and biofertilizer recorded higher values for number of nodes plant<sup>-1</sup>, leaf number and fresh weight of plants in okra (Prabu *et al.*, 2003). Combination of FYM with crop residues and zinc in soybean recorded values for plant height, number of branches, which were at par with those recorded with 100 per cent NPK (Dash *et al.*, 2005). Combination of FYM with other organic sources of plant nutrients exhibited slightly lower values as compared to recommended fertilizer dose in soybean (Dash *et al.*, 2005). Integration of FYM and chemical fertilizer to substitute 80 kg N, influenced the growth attributes more prominently as compared to sole and combined application of organic manures in potato (Singh *et al.*, 1973). Proportional combination of FYM and chemical nitrogen recorded significant improvement in growth

attributes of okra (Abusaleha and Shanmugavelu, 1988). FYM in combination with nitrogenous fertilizers however, could not produce significant effect on growth attributes of okra (Singh *et al.*, 1998). Naidu *et al.* (2000) reported that application of FYM @ 20 t ha<sup>-1</sup> along with NPK (80, 60, 50 kg ha<sup>-1</sup>) recorded maximum values for growth in okra cv. Arka Anamika. Sole application of FYM recorded lower yield in potato and chinese cabbage as compared to standard chemical fertilizer (Singh *et al.*, 1973; Sittirungsum *et al.*, 2001).

The yield in FYM amended plots was lower to the control (RFD) as compared to other organic manures that was significantly superior over no manured plots (Abusaleha and Shanmugavelu, 1988; Raj and Kumari, 2001). Ahmad (1993) reported that application of FYM @ 19 t ha<sup>-1</sup> recorded the highest fruit yield in tomato var. Pusa Ruby. Sole application of FYM could not produce better effect on yield attributes of okra and all the treatments with FYM recorded lower values for fruit number plant<sup>-1</sup>, fruit weight and fruit yield as compared to RFD (Singh *et al.*, 1998). The yields of carrot and white cabbage were 25 and 37 per cent more in conventional than that of organic one (Rembialkowska *et al.*, 2000). Application of organic fertilizers @ 10 t ha<sup>-1</sup> in okra under green house condition recorded highest pod yield (Taiwo *et al.*, 2002). Sole application of FYM @ 10 t ha<sup>-1</sup> resulted in significant increase in root yield and other characters over control (Sharma *et al.*, 2003). FYM and poultry manure @ 5t ha<sup>-1</sup> each to supplement 50 kg N ha<sup>-1</sup>

significantly increased the fruit yield of pepper (Aliyu, 2000). Integration of FYM and biofertilizer (*Azospirillum* + *Phosphobacteria*) recorded higher fruit yield in cucumber (Nirmala and Vadivel, 2000). FYM in conjugation with biofertilizers recorded low yield in okra, while its combination with dense organic manures recorded higher yields, which were at par with conventional method (Singh *et al.*, 2000). Combined application of FYM and biofertilizers (*Azospirillum*) recorded significantly higher yields in okra over that of sole application (Ray *et al.*, 2005). Farm yard manure in conjugation with Neem cake and *Azospirillum*, recorded higher fruit yield in okra (Asha and Geetha, 2001). Similar finding with respect to yield in tomato were observed by Renuka and Ravi Sanker (2001), when FYM was used in combination with biogas slurry, vermi compost and biofertilizers. Combination with vermi compost recorded maximum fruit yield in brinjal (Subba Rao and Sankar, 2001). In potato yield improvement was more prominent when FYM was used in conjugation with chemical fertilizer (Singh *et al.*, 1973). Substitution of N in equal proportions through FYM and amm.sulphate exhibited a significant increase in fruit yield plant<sup>-1</sup> in okra over sole application of FYM and amm.sulphate (Abusaleha and Shanmugavelu, 1988). Integration of N in equal proportions through urea and FYM recorded a fruit yield of 39.6 t ha<sup>-1</sup> in brinjal, which was higher than the yield recorded with sole applications of urea and FYM (Jose *et al.*, 1988). In onion highest bulb yield was recorded (64% more than control which received no fertilizer), when FYM was applied in

conjugation with biofertilizers and 75 per cent chemical nitrogen (Warade *et al.*, 1995). Integration of FYM with chemical fertilizer in onion recorded a marketable yield of 313.69 q ha<sup>-1</sup> which was 11.09 per cent more than the yield recorded with sole application of FYM (Singh *et al.*, 1997). Fruit yield in okra exhibited an enhancement due to combined application of FYM and chemical fertilizer (Isaac and Pushpakumari, 1998). Substitution of 75 kg N through FYM and 75 kg N through urea was found beneficial in increasing the yield of chilli crop (Malewar *et al.*, 1998). Application of farm yard manure in combination with nitrogenous fertilizers could not show better effect on yield attributes of okra and all the treatments with FYM produced lesser values for fruit number plant<sup>-1</sup>, fruit weight and fruit yield as compared to RFD (Singh *et al.*, 1998). Maheswarappa *et al.* (1999) recorded significantly higher yield of fresh rhizomes in arrow root, when FYM was used in conjugation with NPK fertilizers.

Furgo (2000) suggested combined application of FYM and chemical fertilizer for maximizing the crop yield in chilli. Integration of FYM along with 120 kg N ha<sup>-1</sup> in potato produced a tuber yield of 39.5 t ha<sup>-1</sup> which was higher than the yield recorded with 60 and 120 kg N ha<sup>-1</sup> alone (Shanmugasundaram and Savithri, 2000). Integration of FYM and 75 kg N recorded higher yield in okra as compared to sole application of FYM and RFD (Patil *et al.*, 2000). Combined application of FYM @ 20t ha<sup>-1</sup> and chemical fertilizer (100:50:50 NPK kg ha<sup>-1</sup>) exhibited significant

influence on yield of tomato (Naidu *et al.*, 2001). Sannigrahi and Borah, (2001) reported higher yields in okra due to integration of FYM @ 20 t ha<sup>-1</sup> + 50 per cent NPK. In chinese cabbage, combined application of FYM (3 t ha<sup>-1</sup>) + ½ of standard chemical fertilizer recorded a yield of 320.1 g plant<sup>-1</sup> which is lower than the yield 360.5 g plant<sup>-1</sup> recorded with standard chemical fertilizer (Sittirungsum *et al.*, 2001). Integration of FYM along with 75 per cent of NPK in tomato recorded a fruit yield of 54.32 t ha<sup>-1</sup> as compared to sole application of FYM @ 30.13 t ha<sup>-1</sup> (Harikrishna *et al.*, 2002). Substitution of plant nutrients in equal proportions through FYM and chemical fertilizer recorded significantly higher yield in tomato (Rafi *et al.*, 2002). Reddy *et al.* (2002) observed an increase in yield of tomato by 4.7 per cent when nitrogen was substituted in equal proportion (50:50) through FYM and urea, indicating that integrated application of organic manures and inorganic fertilizers significantly increased the fruit yield as compared to sole applications of both. Farm yard manure in combination with inorganic fertilizers resulted in improvement of yield and yield related attributes of garden pea (Datt *et al.*, 2003). FYM proved instrumental in enhancing the tuber yield in potato, when used in conjugation with different levels of NPK fertilizers (Sasani *et al.*, 2003). Conjugation of FYM and RFD in 50:50 ratio exhibited significantly higher values for yield in capsicum cv. Nishat-1 (Narayan *et al.*, 2004). Combined application of FYM and chemical recorded significantly higher yield than sole application of both in watermelon (Yadav and Luthra, 2004). Ray *et al.* (2005)

reported that combined application of FYM and 50 per cent NPK recorded significantly higher pod yield in okra over that of sole applications of FYM, NPK and biofertilizers.

Isaac and Pushpakumari (1998) reported that application of FYM along with chemical fertilizers enhanced the seed yield in okra. Integrated use of  $\frac{1}{2}$  dose of N and  $P_2O_5$  + 2.5t farm yard manure  $ha^{-1}$  in French bean proved better in increasing the number of pods  $plant^{-1}$  and seed yield  $ha^{-1}$  over control and sole application of farm yard manure (Chaudhari *et al.*, 2001). Higher seed yields were recorded in late cauliflower following amendments with organic manures (Thakur and Singh, 2001). Application of FYM @ 5t  $ha^{-1}$  in soybean recorded a seed yield of 13.35 q  $ha^{-1}$ , which was significantly superior to control but was statistically at par with the seed yield 14.57 q  $ha^{-1}$  recorded with RFD. Conjugation of FYM with other organic sources of plant nutrients produced significantly higher seed yield in soybean (Dash *et al.*, 2005).

Organic sources exhibit differential effect on protein content of dry mature seeds. Abusaleha and Shanmugavelu (1988) reported that sole application of FYM in okra depicted a marginal increase in protein content over that of sole application of amm.sulphate. However, substitution of N in equal proportions through FYM and amm.sulphate recorded a significant increase in protein content (20.76%). Combined application of FYM, poultry manure and biofertilizers in okra, recorded a protein content of 17.95 per cent (Raj and Kumari, 2001). Sole

application of farm yard manure in okra enhanced the vitamin-C content over amm.sulphate by 5.38 per cent. However, combined application of FYM and amm.sulphate in 30:10 proportions exhibited a pronounced increase (Abusaleha and Shanmugavelu, 1988). Substitution of 75 kg N through FYM and 75 kg N through urea was found beneficial in increasing the vitamin-C content in chilli (Malewar *et al.*, 1998). Rembialkowska *et al.* (2000) reported 30 per cent more vitamin-C content in organic cabbage than that of conventional one. Application of FYM + dense organic manures recorded higher vitamin-C content (14.90 mg 100 g<sup>-1</sup>) than RFD (14.09 mg 100 g<sup>-1</sup>) as reported by Singh *et al.* (2000). Application of FYM increased the vitamin-C content in *Brassica chinensis* and *Raphanus sativus* (Sittirungsum *et al.*, 2001). Bhardoria *et al.* (2002) reported that FYM either alone or in combination with microbial cultures or vermi compost produced okra with better nutritional quality.

Xu *et al.* (2003) observed high soluble sugar, vitamin-C content and low nitrate levels in vegetables grown with organics as compared to those raised with inorganic fertilizers.

Narayan *et al.* (2004) reported that sole application of FYM in capsicum cv. Nishat-1 recorded a vitamin-C content which was at par with that of recorded with RFD. However, its conjugation with RFD in 50:50 ratio produced significantly higher vitamin-C content as compared to sole applications. Sole application of FYM to supplement

80 kg N ha<sup>-1</sup> exhibited a non-significant increase in crude protein content of potato. Combined application of FYM, poultry manure and fertilizer to supplement N in equal proportions depicted a significant increase in crude protein content over control (Singh *et al.*, 1973).

Singh *et al.* (2000) reported that combined application of FYM and dense organic manures registered high protein content (2.18 g 100 g<sup>-1</sup>) in fresh okra pods as compared to 2.14 g 100 g<sup>-1</sup> recorded with conventional method involving chemical fertilizers. Similar trend was observed in cabbage and French beans. However, in case of brinjal, pea and radish, the values for protein content were lower than those recorded with conventional method.

FYM application to supplement 40 kg N recorded 3.5 per cent less fibre content in okra fruits than 40 kg N supplied through amm. sulphate. However, the extent of decrease was 12.58 per cent when farm yard manure and amm.sulphate was used in equal proportions to supplement to 40 kg N (Abusaleha and Shanmugavelu, 1988). Combined application of FYM and Neem cake reduced the crude fibre content in okra (Asha and Geethakumari, 2001). Combined application of FYM, poultry manure and biofertilizers recorded lowest crude fibre content in okra (Raj and Kumari, 2001). Organic manures in combination with *Azospirillum* increased the dry matter content in tomato (Ranganathan *et al.*, 1995).

Alkaff and Hassan (2003) reported that application of FYM @ 5 t ha<sup>-1</sup> recorded maximum values for dry matter accumulation in okra plants<sup>-1</sup>. Interaction between farm yard manure and chemical fertilizer registered higher dry matter content than individual applications (Dadmal and Dongale, 2004). Sole application of FYM in soybean recorded higher values for dry matter accumulation than crop residues. However, combined application of FYM, crop residues and zinc produced slightly lower values as compared to RFD (Dash *et al.*, 2005). In okra, dry matter accumulation got significantly increased over control due to sole application of FYM. Substitution of N in equal proportions, recorded maximum uptake of NPK which was higher than the sole application of both components (Jose *et al.*, 1988).

Abusaleha (1992) reported that sole application of FYM registered a lower uptake of NPK as compared to sole application of chemical fertilizer. However, substitution of N in equal proportions through FYM and amm.sulphate, exhibited significantly higher uptake than sole application of FYM and amm.sulphate in okra. Sole application of chemical fertilizer recorded higher values for calcium and magnesium uptake by okra plants as compared to sole application of FYM. However, their integration recorded significantly higher uptake over that of sole application of FYM and chemical fertilizer. Application of FYM enhanced the uptake of plant nutrients in potato and chilli (Sud *et al.*, 1992; Hangarge *et al.*, 2002). Malewar *et al.* (1998) reported that

application of 75 kg N through FYM and 75 kg N through urea enhanced nutrient uptake in chilli plants. Combined application of FYM and NPK significantly increased the NPK uptake in onion (Sharma *et al.*, 2003). Inorganic form of nitrogen through urea, exhibited higher uptake of NPK as compared to sole application of FYM in brinjal.

Dademaal *et al.* (2004) reported that FYM application recorded higher uptake of NPK by okra plants as compared to control (no manure). Interaction effects due to FYM and fertilizer levels on nutrient uptake were significantly superior over remaining treatments. In capsicum cv. Nishat-1, sole application of FYM exhibited a lower NPK uptake as compared to RFD. However, combined application of FYM and RFD (50:50) recorded higher NPK uptake as compared to sole applications of both (Narayan *et al.*, 2004). The available N content in soil got increased due to FYM application (Chellamuthu, 1978; Chellamuthu *et al.*, 1988 and Raju, 1991). FYM and its combination with inorganic N increased the available NPK content in the soil (Chitdeshwari and Pravikesavan, 1998). Application of 75 kg N through FYM and 75 kg N through urea in chilli enhanced the available N and P content in the soil (Malewar *et al.*, 1998). The availability of micro-nutrients in soils was significantly influenced due to FYM application (Reddy and Reddy, 1999). Addition of organic manures increased the availability of N, P, K, Ca, Mg and S in the soil (Wong *et al.*, 1999). Application of FYM in conjugation with chemical fertilizer and

*Azospirillum* enhanced the availability of NPK in soil (Harikrishna *et al.*, 2002). Farm yard manure in combination with increasing levels of NPK, recorded maximum buildup of soil NPK content and the lowest buildup was observed among NPK treatments, where FYM was not added, indicating the significance of organics in soil fertility buildup (Datt *et al.*, 2003). Combined application of FYM and NPK fertilizers in onion, resulted in a significant improvement in available NPK status of soil (Sharma *et al.*, 2003).

Dadmal and Dongale. (2004) reported that available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O content in soil at harvest stage of okra was slightly improved by FYM application but the effects were non-significant. The available status was much better with integrated use of FYM and NPK fertilizers. In okra, sole application of FYM enhanced the available status of NPK as compared to 50 and 100 per cent NPK applications. Combined application of FYM and biofertilizers enhanced the NPK content than that of sole application. However, the results were much more pronounced when FYM was used in integration with 50 per cent NPK (Ray *et al.*, 2005). Malewar *et al.* (1998) reported that application of FYM was found to improve bulk density, porosity and water holding capacity as compared to the application of urea. Maheswarappa *et al.* (1999) reported that FYM application decreased the bulk density and increased soil porosity either as an individual source or in integration with NPK fertilizers. Appavu *et al.* (2000) reported that FYM application

improved soil physical properties in terms of reduced bulk density and increased porosity.

Soil physical and biological properties depicted an improvement after addition of organic manures (Marinari *et al.*, 2000). Renuka and Sankar (2001) reported that sole application of FYM or its integration with vermi compost or biofertilizer, resulted in lower levels of bulk density. Sheeba and Kumaraswamy (2001) reported that bulk density and particle density of the soil was lower (1.18 and 2.18 Mg cm<sup>3</sup>) in treatments that received FYM as compared to control (1.25 and 2.30 Mg cm<sup>3</sup>) which received no FYM application. Soil porosity was significantly higher than control.

Bhattacharyya *et al.* (2004) reported that FYM application significantly decreased the bulk density, recording maximum bulk density in control. Fertilizer application did not drastically change the mean soil bulk density. FYM application had a positive impact in enhancing porosity and recorded maximum values with FYM + NPK treatment. Walia and Kler (2005) reported that organic farming system improves soil physical properties like reduction in bulk density. Improvement in soil organic carbon content due to integration of FYM and inorganic N has also been reported by Chitdeshwari and Pravikesavan (1998). Organic farming system improves soil organic carbon content (Walia and Kler, 2005).

Badole and More (1999) reported that FYM application exhibited relatively higher organic content than inorganic ones. FYM either alone or in combination with NPK recorded higher values for organic carbon content (Maheswarappa *et al.*, 1999). Soil organic carbon content due to FYM application got increased over that of control (no fertilizer/manure). Integration of FYM and NPK exhibited an increase (Datt *et al.*, 2003). Application of FYM at the rate of 20 t ha<sup>-1</sup> enhanced the electrical conductivity (Ec) of the soil (Sharma *et al.*, 2003). FYM application had a positive impact in enhancing soil organic carbon content and recorded maximum values when FYM was integrated with NPK (Bhattacharyya *et al.*, 2004). Sole application of FYM and its integration with chemical fertilizers in okra exhibited a decrease in soil pH. The organic carbon status was found higher with FYM applications, but there was a depletion of organic carbon content of soil when crop was raised with chemical fertilizer alone (Ray *et al.*, 2005). Microbial population in the rhizosphere of arrow root exhibited a marked increase when FYM was used either alone or in combination with NPK (Maheswarappa *et al.*, 1999). EL-Din *et al.* (2000) reported that application of FYM increased the microbial count in rhizosphere of tomato plants.

Soil biological activities were stimulated by organic treatments, probably due to enrichment of soil organic matter (Marinari *et al.*, 2000). Combined application of FYM + PM + VC + *Azospirillum* +

*Phosphobacteria* harboured significantly more microbial population in the rhizosphere of okra plants (Naidu *et al.*, 2000). Application of organic manures in okra exhibited a significant increase in rhizosphere microbial population (Taiwo *et al.*, 2002). Organic fertilizers had a positive effect on the soil microbial population, resulting in enhanced soil biomass (Xu *et al.*, 2003). Sole application of FYM produced higher number of nodules as compared to control, however, FYM in combination with *rhizobium* and *phosphobacteria* produced higher number of nodules, followed by FYM + *rhizobium* + *Azospirillum* + *Phosphobacteria* in groundnut ) Balasubramanian and Palaniappam, 1994). FYM application increased the nodule number in soybean as compared to control but was not at par with vermi compost (Thanunathan *et al.*, 2002).

Application of FYM recorded higher nodule number as compared to control in pea. Nodule number depicted an increase when FYM was used in integration with various levels of NPK (Datt *et al.*, 2003).

### **Effect of Sheep manure**

It is a bulky manure and a rich source of plant nutrients as compared to farm yard manure. Sole application of sheep manure recorded a plant height of 45.30 cm which was significantly superior to control (38.4 cm) but was less than the plant height (57.4 cm) recorded with 100 kg N through urea. However, substitution of 100 kg N, through urea and sheep manure in equal proportion recorded a plant height of

68.3 cm which was significantly superior to sole applications of both (Jose *et al.*, 1988). Sheep manure application in okra registered an improvement in growth attributes as compared to other organic amendments (Montasser, 1991). Khan (1994) reported that application of sheep manure exhibited an increase in growth and growth related attributes of okra cv. Long Green. Application of goat manure enhanced the growth and growth related attributes in tomato plants (Umar and Jada, 2000). Application of sheep manure exhibited or better response at different levels of combination with chemical fertilizers in improving growth and growth related attributes of capsicum cv. Nishat-1 (Margay, 2002). Sheep manure recorded lower values for fruit number (7.6) and fruit weight plant<sup>-1</sup> (841.3 g) as compared to the values (8.7, 907.9 g) recorded with 100 kg N, but were significantly superior over control. Conjugation of sheep manure with urea to substitute 100 kg N in equal proportion recorded significantly higher values for fruit number and fruit weight plant<sup>-1</sup> (11.0, 1000.7 g) over that of sole application of sheep manure and 100 kg N through urea (Jose *et al.*, 1988). Appavu *et al.* (2000) reported that application of goat manure @ 5t ha<sup>-1</sup> in soybean recorded a grain yield of 1863 kg ha<sup>-1</sup> which was significantly superior to control. Sole application of sheep manure in capsicum cv. Nishat-1 recorded a fruit yield (185.32 q ha<sup>-1</sup>) which was significantly superior to control (128.16 q ha<sup>-1</sup>) but was less than the yield (248.66 q ha<sup>-1</sup>) recorded with RFD. However, combined application 50 per cent SM and 50 per cent of RFD, recorded a fruit

yield of 273.86 q ha<sup>-1</sup> which was significantly superior to sole application of sheep manure and RFD (Narayan *et al.*, 2004). Sheep manure application in brinjal plants recorded low dry matter content (57.4 g plant<sup>-1</sup>) as compared to 100 kg N through urea (63.6 g plant<sup>-1</sup>). However, combined application of sheep manure and urea in 50:50 ratio recorded a dry matter content of 88.3 g plant<sup>-1</sup>, which was significantly higher than sole application of both urea and sheep manure (Jose *et al.*, 1988). Sheep manure influenced the various quality parameters in vegetable crops. Sole application of sheep manure in capsicum cv. Nishat-1 recorded a vitamin-C content of 110.36 mg 100 g<sup>-1</sup> which was significantly superior to the vitamin-C content (104.40, 99.36 mg 100 g<sup>-1</sup>) recorded with RFD and control, respectively. Integration of 50 per cent sheep manure with 50 per cent RFD recorded a vitamin-C content 118.80 mg 100 g<sup>-1</sup>, which was 12.12, 7.10 per cent more than RFD and sole application of sheep manure, respectively (Narayan *et al.*, 2004). Jose *et al.* (1988) reported that nutrient uptake (N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Ca) in brinjal plants was comparatively low as compared to that of recorded with 100 kg N through urea. However, uptake of Mg was more in sheep manure amended plots. Substrate application of half N (50 kg) as sheep manure and half N (50 kg) as urea increased the uptake of N, P, K, Ca and Mg significantly.

Narayan *et al.* (2004) reported that sheep manure application registered a low NPK uptake in capsicum cv. Nishat-1 as compared to

RFD. Conjugation of sheep manure and RFD in equal proportions recorded significantly higher NPK uptake over that of sole applications of sheep manure and RFD. Umar and Jada (2000) reported that goat manure application in tomato enhanced the nutrient supply in the soil. Goat manure application improved the bulk density of the soil in both the surface and sub-surface, resulting an increase in total porosity of the soil (Appavu *et al.*, 2000).

### **Effect of Poultry manure**

Poultry manure is a valuable/potential source of plant nutrients since liquid and solid excreta are excreted together, resulting in no loss of urine and ferments quickly. Poultry manure contains uric acid having 60 per cent nitrogen, which changes rapidly to ammoniacal form, hence efficiently utilized for better growth and yield of plants (Smith, 1950). Besides this, it contains certain growth promoting substances and act as soil conserving material (Brown, 1958 and Garg., 1980). Growth and growth related attributes of cauliflower got significantly increased over control due to poultry manure application (Singh *et al.*, 1970). Sole application of poultry manure to supplement 80 kg N, recorded higher values for growth related attributes of potato as compared to that of control and FYM (Singh *et al.*, 1973).

Abusaleha and Shanmugavelu (1988) reported maximum plant height (158.5 cm) in okra due to sole application of poultry manure as compared to plant height recorded with amm.sulphate, FYM and horse

manure. Jose *et al.* (1988) reported significant increase in plant height over control in brinjal plants due to poultry manure application, but the plant height 49.8 cm was less than that recorded with 100 kg urea (57.4 cm). Abusaleha and Shanmugavelu (1988) reported that treatment combination of 20 kg N (amm. sulphate) + 20 kg N (poultry manure) recorded highest values for plant height and other growth related characters. Substrate application of half N (50 kg) as poultry manure and half N (50 kg) as urea increased the plant height in brinjal (Jose *et al.*, 1988). Combined application of poultry manure (12.5 t ha<sup>-1</sup>) with 150 kg N ha<sup>-1</sup> increased the plant height in okra cv. Pusa Sawani, while as substitution of 40 per cent N through urea and 50 per cent N through poultry manure recorded significantly higher values for plant height, number of branches in brinjal (Kannan, 1990; Shelke *et al.*, 1999). Poultry manure application considerably increased the shoot length, root weight and other growth attributes in okra (Montasser, 1990). Montasser (1991) reported that poultry manure enhanced the growth attributes of okra and proved superior to other organic manures. Growth and growth related attributes in okra cv. Long Green exhibited an increase due to poultry manure application (Khan, 1994). John (1997) reported that combined application of 75 kg N ha<sup>-1</sup>, poultry manure 10 t ha<sup>-1</sup> and *Azospirillum* recorded significantly increased plant height in brinjal as compared to control. Poultry manure proved superior to mustard cake in enhancing growth, length of vines, fresh weight of root and shoot in bottle gourd and okra (Dahiya *et al.*, 1998).

Application of poultry manure at different levels of combination exhibited better response in improving growth and growth related attributes in capsicum cv. Nishat-1 (Magray, 2002). Maximum values for growth and growth related attributes were recorded in foot yam due to poultry manure application (Prasad *et al.*, 2004). Combined application of poultry manure and FYM to contribute 80 kg N depicted higher response with respect to growth attributes of potato than individual applications of both (Singh *et al.*, 1973). Application of poultry manure @ 169.6 q ha<sup>-1</sup> recorded maximum values for yield and yield related attributes in cauliflower (Singh *et al.*, 1970). Poultry manure either alone or in combination with farm yard manure produced significantly higher marketable yield in potato than control (Singh *et al.*, 1973). Singh *et al.* (1973) reported that conjugation of poultry manure along with chemical fertilizer to supplement 80 kg N in equal proportions recorded significantly higher marketable yield (80.18 q ha<sup>-1</sup>) in potato as compared to sole application (55.14 q ha<sup>-1</sup>), PM + FYM application (59.70 q ha<sup>-1</sup>) and control (48.70 q ha<sup>-1</sup>). Pelaez *et al.* (1984) concluded that yield and number of marketable fruits of squash were highest from plots receiving 10 t ha<sup>-1</sup> poultry manure. Abusaleha and Shanmugavelu (1988) reported sole application of poultry manure in okra recorded 27.7 nodes plant<sup>-1</sup> which was higher than recorded with amm. sulphate (26.6), FYM (23.3) and horse manure (24.6). Similarly, PM recorded a yield of 13.03 t ha<sup>-1</sup> which was significantly higher than the yield 10.83 t ha<sup>-1</sup> recorded with amm. sulphate. Combined application of poultry

manure and amm. sulphate to substitute 40 kg N in equal proportion in okra cv. Pusa Sawani recorded maximum fruit yield of 181.01 t ha<sup>-1</sup>. Poultry manure as a sole source of 100 kg N, in brinjal recorded a fruit yield of 35.5 t ha<sup>-1</sup>, which was higher than recorded with other organic manures but was lower than 37.8 t ha<sup>-1</sup> recorded with 100 kg N through urea. Substrate application of half N (50 kg) as poultry manure and half N (50 kg) as urea, recorded highest yield of 51.03 t ha<sup>-1</sup> in brinjal, the extent of increase over control was 29.92 per cent (Jose *et al.*, 1988). Poultry manure exhibited superior performance in terms of yield and vigour in tomato, while sterilized poultry manure increased the yield in tomato by 25.57 per cent over that of nutrient solutions (Wang *et al.*, 1992). Sharma and Rana (1993) in a comparative study using organic and inorganic forms of nitrogen on brinjal, recorded the highest fruit yield (51.03 t ha<sup>-1</sup>) from plots supplied with half N (50 kg) as poultry manure and half N (50 kg) as urea. Khan (1994) reported that poultry manure application enhanced the fruit yield in okra cv. Long Green. Maynard (1994) reported that the yield recorded in capsicum, tomato and cauliflower were equal to or greater for plots receiving poultry manure than those plots receiving NPK fertilizers. Verghese (1996) reported that combined application poultry manure (5 t ha<sup>-1</sup>) and 50 per cent of NPK recorded higher yield of cabbage (609.52 q ha<sup>-1</sup>). Combined application of poultry manure (10 t ha<sup>-1</sup>) + *Azospirillum* + 75 kg N ha<sup>-1</sup> recorded maximum marketable fruit yield of 392.5 q ha<sup>-1</sup> in brinjal (John, 1997). Poultry manure as a nutrient source increased the

fruit yield in okra (Isaac and Pushpakumari, 1998). Sharu and Meerabai (2001) obtained significantly highest fruit yield in chilli due to application of poultry manure and chemical fertilizer in the ratio of 1:1 on N equivalent basis. Application of 40 per cent N through urea and 60 per cent N through poultry manure in brinjal recorded highest fruit yield of 581 q ha<sup>-1</sup> (Shelke *et al.*, 2001). Chattoo *et al.* (2003) observed that application of poultry manure @ 7 t ha<sup>-1</sup> in cabbage recorded the head yield, which was comparable with the yield recorded with recommended fertilizer dose + 10 t FYM.

Narayan *et al.* (2004) reported that poultry manure application in capsicum cv. Nishat-1 as a sole source of nutrients recorded a fruit yield of 193.95 q ha<sup>-1</sup> which was significantly superior to control, sheep manure and farm yard manure. Maximum values for yield and yield related attributes in elephant foot yam were recorded due to poultry manure application (Prasad *et al.*, 2004).

Highest fruit yield of 296.63 q ha<sup>-1</sup> in capsicum cv. Nishat-1 was recorded in a treatment combination 50 per cent PM and 50 per cent NPK. The increase in yield was 131.45 per cent more than control and 19.29 per cent than RFD. Isaac and Pusphakumari (1998) reported that application of poultry manure along with chemical fertilizer recorded highest seed yield in okra.

Abusaleha and Shanmugavelu (1988) reported that sole application of poultry manure contributing 40 kg N, recorded a protein

content of 19.80 per cent which was higher than recorded with amm. sulphate (18.20%). However, substitution of 10 kg N through amm. sulphate and 30 kg N through poultry manure recorded the highest protein content of 24.21 per cent. Combined application of poultry manure and farm yard manure recorded highest protein content of 17.92 per cent in okra, while as combined application of poultry manure, farm yard manure and biofertilizers registered the maximum protein content of 17.95 per cent (Raj and Kumari, 2001). Poultry manure application in cauliflower @ 169.6 q ha<sup>-1</sup>, recorded an increase in protein content as compared to control (Singh *et al.*, 1970).

Singh *et al.* (1973) reported that poultry manure either alone or in combination with farm yard manure in potato recorded or crude protein content of 1.46 and 1.40 per cent, respectively and both values were higher than control (1.2%). Combined application poultry and chemical fertilizer in equal proportion, recorded significantly higher protein content (1.62%). Combined application of PM, VC and inorganic fertilizers in okra, recorded higher protein content (Naidu *et al.*, 2000). Application of poultry manure was found effective in enhancing crude protein content in tomato (Prabakarn and Pichai, 2002).

Taiwo *et al.* (2002) reported that combined application of poultry manure, vermi compost and 90 kg K<sub>2</sub>O in okra, recorded highest crude protein percentage. Abusaleha and Shanmugavelu (1988) observed that application of organic forms of nitrogen (poultry manure)

combined with inorganic forms of nitrogen (amm. sulphate) lowers the crude fibre content of okra fruits, thereby enhancing the palatability. Combined application of poultry manure, farm yard manure and biofertilizers recorded lower values for crude fibre content in okra (Raj and Kumari, 2001).

Abusaleha and Shanmugavelu (1988) reported that the influence of poultry manure in enhancing the vitamin-C content ( $16.11 \text{ mg } 100 \text{ g}^{-1}$ ) in okra was superior than that of recorded with amm. sulphate ( $13.71 \text{ mg } 100 \text{ g}^{-1}$ ) and farm yard manure ( $14.49 \text{ mg } 100 \text{ g}^{-1}$ ). Poultry manure with inorganic form of nitrogen in 50:50 ratio registered higher vitamin-C content ( $17.25 \text{ mg } 100 \text{ g}^{-1}$ ).

Treatment combination comprising 25 per cent N as chemical fertilizer and 75 per cent N as poultry manure registered highest vitamin-C content of  $98.67 \text{ mg } 100 \text{ g}^{-1}$  of fresh chilli fruits (Sharu and Meerabai, 2001). (49) Jose *et al.* (1988) reported that in brinjal application of half N (50 kg) as poultry manure and half N (50 kg) as urea increased the dry matter accumulation. Application of poultry manure effectively enhanced the vitamin-C content in tomato (Prabakaran and Pichai, 2002). Narayan *et al.* (2004) concluded that poultry manure recorded higher values for vitamin-C content ( $113.30 \text{ mg } 100 \text{ g}^{-1}$ ) in capsicum cv. Nishat-1 as compared to RFD ( $104.40 \text{ mg } 100 \text{ g}^{-1}$ ). Combined application of 50 per cent poultry manure and 50 per cent RFD recorded the maximum vitamin-C content of  $144.26 \text{ mg}$

100 g<sup>-1</sup>. Similar increase in dry matter accumulation of okra cv. Pusa Samani due to combined application of poultry manures (12.5 t ha<sup>-1</sup>) and 50 kg N ha<sup>-1</sup> has been reported by Kannan (1990). Substrate application of half N (50 kg) as poultry manure and half N (50 kg) as urea recorded maximum values of 135.5, 34.0, 126.3, 80.7 and 38.7 kg ha<sup>-1</sup> N, P, K, Ca and Mg uptake, respectively in brinjal (Jose *et al.*, 1988).

The uptake of nitrogen and phosphorus in okra cv. Pusa Sawani was greater in treatment combinations of half inorganic and organic from poultry manure. The highest potassium uptake was observed in plants applied with equal quantities of organic and inorganic nitrogen. Calcium and magnesium uptake was markedly influenced by the application of 20 kg nitrogen (as amm. sulphate) and 20 kg nitrogen from poultry manure (Abusaleha, 1992). Maximum NPK uptake in brinjal was observed in treatment combination where 40 per cent N is substituted through urea and 60 per cent through poultry manure (Shelke *et al.*, 1999). Highest values for NPK uptake in tomato at harvest stage were recorded with poultry manure (Prabakaran, 2003).

Singh and Srivastava (1977) reported that presence of high phosphorus content in poultry manure increased the availability of native soil phosphorus. Narayan *et al.* (2004) concluded that NPK uptake by capsicum plants was influenced significantly by the application of organic and inorganic fertilizers. The maximum of 134.56, 14.91 and 104.46 kg ha<sup>-1</sup> NPK, respectively was recorded in treatment

combination of 50 per cent poultry manure and 50 per cent of recommended NPK. Prasad *et al.* (1984) described poultry manure as a potential source of major nutrients besides increasing the availability of micro-nutrients in the soil. Cattle slurry, FYM and pig manure applications are significantly related to the amount of amm. nitrogen, while poultry manure applications are significantly related to ammonium and uric acid nitrogen which becomes easily available to plants (Chambers and Smith, 1992). Poultry manure application resulted in significant buildup of available and total phosphorus in the soil (Kaistha *et al.*, 1997). Reddy and Reddy (1999) reported that poultry manure application along with chemical fertilizers significantly influenced the availability of micro-nutrients in the soil. Shelke *et al.* (2001) observed highest available NPK content in treatment combination where 40 per cent N was supplied through urea and 60 per cent N through poultry manure in brinjal. Hori *et al.* (2002) reported that poultry manure application increased water soluble phosphorus and available nitrogen in soil.

Appavu *et al.* (2000) reported that incorporation of poultry manure improved soil physical properties in terms of reduced bulk density and increased porosity. Incorporation of 40 per cent N through urea and 60 per cent N through poultry manure in brinjal recorded the highest organic carbon content (Shelke *et al.*, 1999). Hori *et al.* (2002)

reported poultry manure application resulted inadequate pH, increased electrical conductivity.

Singh and Srivastava (1977) reported increased biological activities after addition of poultry manure. Application of poultry manure @ 10 t ha<sup>-1</sup> lead to a significant increase in microbial population in root zone of okra plants (Taiwo *et al.*, 2002).

### **Effect of Vermi compost**

Vermi compost is a complex organic manure, besides supplying NPK, it contains many micro-nutrients like Mn, Fe, Mo, B, Cu, Zn etc and some of the growth regulators, thereby influencing growth and yield of crops.

Thanunathan *et al.* (1997) reported that vermi compost application in mine soils exhibited an increase in growth of onion. Earthworm processed pig manure proved a suitable medium for growing vegetable seedlings (Atiyeh *et al.*, 2000). Renuka and Sankar (2001) registered vigorous growth in tomato due to combined application of vermi compost and farm yard manure. Sole application of vermi compost had a significant influence on root and shoot weight of tomato (Samawat *et al.*, 2001). Shanthi *et al.* (2002) reported that vermi compost along with NPK increased the root length in okra as compared to control. Thanunathan and Arulmurugan (2002) reported that application of vermi compost in soybean increased the growth attributes like plant height as compared to farm yard manure.

Application of vermi compost exhibited an increase in yield of onion (Thanunathan *et al.*, 1997). Vermicompost at 4 t ha<sup>-1</sup> + 50 per cent of the recommended fertilizer, realized highest fruit yield in tomato genotype Megha (Patil *et al.*, 1998). Tomar *et al.* (1998) reported that vermicompost application increased the root yield in carrot by 68.49 and 62.08 per cent over control (un-amended soil) and farm yard manure amended plots, respectively. Substitution of plant nutrients in equal proportions through liquid fertilizer and vermicompost recorded highest fruit yield in tomato (Kolte *et al.*, 1999). Lozek and Gracova (1999) reported that application of vermisol (a vermicompost extract) increased the yield in tomato by 7.3 per cent over control. Grain yield in soybean got significantly increased due to integration of inorganic fertilizer and vermicompost (Reddy and Reddy, 1999). Ushakumari *et al.* (1999) reported that integration of vermicompost with recommended fertilizer dose in okra registered the highest yield. Fugro (2000) suggested combined application of vermicompost, farm yard manure and chemical fertilizer for maximizing the yield in chilli. Mahendran and Kumar (2001) reported that yield related attributes in cabbage were significantly influenced due to vermicompost application. Renuka and Sankar (2001) reported improvement in yield of tomato due to combined application of vermicompost and farm yard manure. Aliyeh *et al.* (2002) reported that incorporation of vermicompost in soil less cultures of cucumber increased the yield and yield related attributes significantly.

Reduced yields in tomato were recorded with sole application of vermi compost and combined application of vermi compost and FYM (Reddy *et al.*, 2002). Application of N in equal proportion through vermi compost and urea in tomato recorded at par values for yield with that of recommended dose of fertilizer (Reddy *et al.*, 2002).

Highest yield in ridge gourd was recorded in treatment combination of 10 t vermi compost + 50 per cent NPK ha<sup>-1</sup> (Sreenivas *et al.*, 2002). Perumal *et al.* (2003) reported that organic manures including vermi compost increased the productivity of carrot from 14.26 tonnes to 18.92 t ha<sup>-1</sup> in plains. Vermicompost in combination with *Azospirillum* and 60 kg N, recorded maximum yield of 20.03 t ha<sup>-1</sup> in broccoli (Prasad *et al.*, 2004). Vermicompost in conjugation with biofertilizers (*Azospirillum*) in cabbage recorded a head yield of 540 q ha<sup>-1</sup> which was 9.01 per cent more than the yield recorded with recommended dose alone (Bahadur *et al.*, 2004). Integration of vermicompost (10 t ha<sup>-1</sup>) with recommended fertilizer dose (100: 40: 40 NPK kg ha<sup>-1</sup>) produced significantly higher yield than recommended fertilizer dose in watermelon (Yadav and Luthra, 2004). Dhiman and Battish (2005) reported that yield and yield related attributes in capsicum recorded maximum values when vermicompost and farm yard manure were used in equal proportions. The values were higher than sole application of farm yard manure. Application of vermicompost along with chemical fertilizer recorded highest seed yield in okra (Isaac and

Pusphakumari, 1998). Integration of  $\frac{1}{2}$  dose of N and  $P_2O_5$  along with vermi compost at the rate of  $2.5 \text{ t ha}^{-1}$  in French beans registered higher number of pods  $\text{plant}^{-1}$  and higher seed yield as compared to control or sole application of vermi compost (Chaudhari *et al.*, 2001). Amendment of soil with vermi compost significantly increased the dry matter content in cucumber (Sainz *et al.*, 1998). Quality attributes like total soluble solids and vitamin-C content in cabbage got significantly increased due to combined application of vermi compost, digested organic supplements and 75 per cent recommended fertilizer dose (Mahendran and Kumar, 2001). Raj and Kumari (2001) reported that enriched compost recorded lower values for crude fibre content in okra. Rafi *et al.* (2002) reported that combined application of vermi compost and chemical fertilizer in 50:50 ratio in tomato resulted in significant improvement of quality attributes as compared to recommended fertilizer dose.

Taiwo *et al.* (2002) reported that combined application of vermi compost, poultry manure and  $90 \text{ kg K}_2\text{O}$  exhibited highest crude protein per cent in okra. Increased concentration of P, Ca and Mg was observed in cucumber shoots, following application of vermi compost (Sainz *et al.*, 1998). Sreenivas *et al.* (2000) reported that highest N uptake by ridge gourds plants was recorded in treatment combination of 50 per cent NPK + vermi compost ( $10 \text{ t ha}^{-1}$ ). Vermicompost application increased the availability of phosphorus and other mineral

elements in the soil (Sainz *et al.*, 1998). Increasing levels of vermi compost exhibited a significant increase in soil available N content. However, the increase was maximum among interactions than individual factors (Sreenivas *et al.*, 2000). Combined application of compost, *phosphobacteria* and nitrogen fertilizer in okra enhanced the nutrient availability (Estefanous *et al.*, 2003).

Perumal *et al.* (2003) reported that application of vermi compost increased the availability of nutrients in the soil. The available NPK content in soil at harvest stage of okra was slightly improved by vermi compost but the effects were non-significant. The available status was much better with integration of vermi compost and chemical fertilizer (Dademaal *et al.*, 2004). Vermicompost application recorded lower bulk density and increased porosity (Maheswarappa *et al.*, 1999).

Vermicompost either alone or in combination with farm yard manure maintained lower levels of bulk density, (Atiyeh *et al.*, 2001). Renuka and Sankar (2001) reported that vermicompost application in tomato, recorded lower levels of bulk density.

Sole application of vermicompost increased the organic carbon content of soil (Maheswarappa *et al.*, 1999). Vermicompost application kept the pH near neutral (Renuka and Sankar, 2001). Increase in organic carbon content due to combined application of composts, phosphate bacteria and nitrogen has also been reported by Estefanous *et al.* (2003). Addition of compost increased the electrical conductivity and

reduced the pH slightly (Estefanous *et al.*, 2003). Perumal *et al.* (2003) reported that vermi compost application in carrot exhibited an increase in organic carbon content. Maheswarappa *et al.* (1999) observed that sole application of vermi compost exhibited higher microbial population while in NPK and control treatments a decrease in microbial population was recorded. Combined application of vermi compost, FYM, poultry manure, *Azospirillum* and phosphorus solubilizing bacteria harboured significantly more microbial population in the rhizosphere of okra plants (Naidu *et al.*, 2000).

Taiwo *et al.* (2002) reported that organic manures, vermi compost and biofertilizers harboured significantly more microbes in the soil than control. Vermicompost application exhibited an increase in the number of beneficial microbes in the rhizosphere of carrot roots (Perumal *et al.*, 2003). Thanunathan *et al.* (2002) reported that vermicompost application significantly increased the effective nodules plant<sup>-1</sup> in soybean as compared to farm yard manure application.

### **Effect of Biofertilizers**

Biofertilizers are eco-friendly micro-organisms which play a vital role in improving the soil fertility and crop productivity due to their ability to fix atmospheric nitrogen and solubilize insoluble phosphates. They play a significant role in improving the growth, yield and quality of vegetable crops.

Indi *et al.* (1990) reported that *Azospirillum* inoculation improved plant height and other growth related characters in brinjal. Combined application of *Azospirillum* and *Phosphobacteria* exhibited superiority in growth characters like plant height and number of branches plant<sup>-1</sup> over control in okra (Sharma and Bhalla, 1995). Biofertilizers (PSB) in combination with 80 kg P<sub>2</sub>O<sub>5</sub> markedly increased the growth components in soybean (Thirumurugan *et al.*, 1999). Ganeshe *et al.* (2000) reported that combined application of *Azospirillum* + 20 kg N ha<sup>-1</sup> recorded higher values for plant height and leaf number in okra. Combined application of *Azospirillum*, *phosphobacteria*, FYM and *Vesicular arbuscular mycorrhizae*, recorded maximum values for vine length and other growth related characters in cucumber (Nirmala and Vadivel, 2000). *Azospirillum* inoculation improved crop growth in tomato as compared to control (Sengupta *et al.*, 2002). Chattoo *et al.* (2003) reported that combined application of microbial inoculants depicted beneficial effect on growth of garlic. Nuruzaman *et al.* (2003) reported that *Azospirillum* in conjugation with cow-dung recorded higher values for growth attributes in okra. Sharma and Bhalla (1995) reported that sole application of biofertilizers (*Azospirillum* and PSB) and its integration with compost (10 t ha<sup>-1</sup>) in okra produced more green fruit yield (36.83, 48.16 q ha<sup>-1</sup>), respectively over that of absolute control (34.60 q ha<sup>-1</sup>). Combined application of *Azospirillum* and *phosphobacteria* produced 6.58 per cent more fruit yield than control. Integrated use of *Azospirillum*, *phosphobacteria* and N fertilizer

increased the fruit yield in pumpkin cv. CO-2 (Karuthamani *et al.*, 1995). Combined application of *Azospirillum* and *phosphobacteria* increased the bulb yield in garlic (Mahendran and Kumar, 1996). In onion combined application of *Azospirillum*, *phosphobacteria* and chemical fertilizer enhanced the yield (Thilakavathy and Ramaswamy, 1999). Combined application of *Azotobacter* and *phosphobacteria* registered significant increase in yield of okra (Bhattacharyya *et al.* 2000). Patil *et al.* (2000) reported that combined application of biofertilizers and 75 kg N recorded highest yield as compared to control in okra.

Integration of biofertilizers with organic manures recorded lower yields in okra (Singh *et al.*, 2000). Anant *et al.* (2001) reported that *Azospirillum* in combination with 75 per cent chemical nitrogen enhanced the yield and yield related characters in okra cv. VRO-5. Integrated use of *Azospirillum* and chemical nitrogen enhanced head weight per plant in cabbage (Sharma, 2002). Combined application of microbial inoculants depicted beneficial effect on yield of garlic (Chatoo *et al.*, 2003). Swain *et al.* (2003) reported that the yield in okra due to bio-inoculants integrated with 50 per cent chemical N was at par with 100 per cent N.

Biofertilizer application registered higher values for seed yield, number of seeds and 1000 seed weight in tomato (Sharma and Thakur, 2002). Combined application of biofertilizers (*Azospirillum* and phosphorus solubilizing bacteria) increased the seed yield in okra

(Prabu *et al.*, 2003). Bagyarj and Menge (1978) reported that inoculation by biofertilizers significantly increased dry matter accumulation in tomato over that of non-inoculated plants.

Raj and Kumari (2001) reported that biofertilizer application increased the crude protein content and decreased crude fibre levels in okra. Guthane (2005) reported that biofertilizers (rhizobium + PSB) along with 50 per cent RFD recorded higher protein content in soybean as compared to RFD.

Biofertilizer application along with dense organic manures recorded higher values for vitamin-C content as compared to recommended fertilizer dose (Singh *et al.*, 2000). Gaikward and Wani (2001) reported that inoculation of brinjal with *phosphobacteria* along with rock phosphate increased the dry matter content over control (no inoculation). Sengupta *et al.* (2002) reported that sole application of *Azospirillum* recorded slightly lower total soluble solids and vitamin-C content as compared to 100 per cent N in tomato. Indi *et al.* (1990) reported that biofertilizer (*Azospirillum*) inoculation in brinjal significantly improved nitrogen and phosphorus uptake.

Combined application of *Azospirillum* and *phosphobacteria* along with recommended dose of NPK significantly increased NPK uptake by garlic over recommended dose of NPK (Mahendran and Kumar, 1996). Inoculation of brinjal with *phosphobacteria* along with rock phosphate

recorded maximum increase in N and P uptake over un-inoculated control (Gaikwad and Wani, 2001).

Swain *et al.* (2003) reported the uptake of N, P, K, Ca, Mg and S in okra recorded with bio-inoculants + 50 per cent N was higher than recorded with control, bio-inoculants (alone) and 50 per cent N. However, integration of bio-inoculants with 75 per cent chemical N recorded significantly higher uptake than 100 per cent N. Application of *Azospirillum* along with fertilizer N had beneficial effect to improve soil fertility (Subbiah, 1991).

Mehendran and Kumar (1996) reported that application of *Azospirillum* and *phosphobacteria* in garlic recorded significant increase in the availability of N, P and K. Swain *et al.* (2003) reported that the available N dropped in all treatments. Status of P remained at higher level except in the absolute control (no fertilizer/inoculant) while integration of bio-inoculants with 50 per cent N maintained higher status as compared to initial. Gogoi *et al.* (2004) reported that combined applications *Azospirillum*, *phosphobacteria* and 50 per cent RFD banana is maintained higher level of available NPK in soil as compared to 100 per cent RFD.

Swain *et al.* (2003) reported that treatments receiving only inorganic fertilizers, exhibited drop in organic carbon content. Integrated use of bio-inoculants and fertilizer nitrogen had turned the soil acidic. However, the decrease in pH was marginal in the treatments

receiving bio-inoculants. Gogoi *et al.* (2004) reported an increase in organic carbon content and a decrease in pH in treatment combination of *Azospirillum*, *phosphobacteria* and 50 per cent RFD as compared to 100 per cent RFD.

Swain *et al.* (2003) reported that inoculated and fertilizer N added soils had maintained increased microbial population. Gogoi *et al.* (2004) reported that treatment combination of *Azospirillum*, *phosphobacteria* and 50 per cent RFD recorded more microbial population (87.02 µg/g of oven dry soil) as compared to that of recommended with 100 per cent RFD (46.62 µg/g of oven dry soil).

Guthane (2005) reported that biofertilizer inoculation along with 50 per cent RFD recorded higher nodule number than RFD (100%).

### **Residual effect**

Rao (1976) suggested that when high doses of plant nutrients are applied to okra, the residuals left in the soil can be utilized with advantage for raising a short duration crop without applying any fertilizer. Duraisami and Mani (2001) reported that organics, either alone or in combination with biofertilizers or in combination with chemical fertilizers exhibited greater residual effect on yield of soybean.

### **Economics**

Vergheese (1996) reported that maximum net returns of Rs. 48,035.00 with a cost benefit ratio of 1:4.72 was recorded in cabbage

with treatment combination of 50 per cent NPK + 5 t poultry manure ha<sup>-1</sup>. Acharya (1997) reported that vermi compost reduces the outlay on chemical fertilizers. The maximum marketable fruit yield of brinjal (392.5 q ha<sup>-1</sup>) was recorded with a cost benefit ratio of 1:1.93 with the application of 75 kg N + 10 t poultry manure + *Azospirillum* (John, 1997). Ushakumari *et al.* (1999) reported that cost benefit analysis revealed that application of vermi compost significantly reduces the cost of production in okra. Net returns in organically produced vegetables were higher as the produce received premium prices in the market (Bhardwaj *et al.*, 2000).

Ganeshe *et al.* (2000) reported that a combination of *Azospirillum* + 20 kg N ha<sup>-1</sup> recorded the highest net returns of Rs. 16,293 ha<sup>-1</sup> with a cost benefit ratio of 2.37. Naidu *et al.* (2000) reported maximum net income of Rs. 19089.00 along with 0.02 benefit: cost ratio in NPK (80:60:50) + 20 tonnes farm yard manure in okra. Thornsby *et al.* (2000) reported 7 per cent increase in total production and marketing cost of tomato growers due to use of organic wastes as 50 per cent replacement of inorganic fertilizers. Application of farm yard manure + 75 per cent of recommended dose of NPK + phosphate solubilizing bacteria + *Azospirillum* in tomato recorded the highest net income of Rs. 78,565.00 ha<sup>-1</sup> with a cost benefit ratio of 2.72 Re<sup>-1</sup> (Harikrishna *et al.*, 2002). Economic studies reveal that treatment combination of 50 per cent poultry manure (1.5 t ha<sup>-1</sup>) + 50 per cent

NPK (45:30:30 kg ha<sup>-1</sup>) was most profitable with a maximum cost benefit ratio of 2.18 with highest net returns of Rs. 1,09,388.00 ha<sup>-1</sup> (Magray *et al.*, 2004).

### **Effect of chemical fertilizers or inorganic fertilizers**

A robust vegetative growth is a prerequisite for realizing high yield in production of any crop. A judicious application of inorganic sources of nutrients fulfills this criterion, as these ensure quick availability of nutrients to plants. Pandey and Singh (1979) reported improvement in growth related attributes of okra due to application of 150 kg N + 120 kg P<sub>2</sub>O<sub>5</sub> and 60 kg K<sub>2</sub>O ha<sup>-1</sup>. Abusaleha and Shanmugavelu (1988) reported that application of inorganic fertilizers (40 kg N as amm. sulphate) recorded significantly higher values for plant height as compared to control in okra. Recommended dose of fertilizer 80:60:60, N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> produced significantly taller plants with higher number of leaves plant<sup>-1</sup>, compared to control in okra (Sharma and Bhala, 1995). Singh *et al.* (1997) observed maximum values for plant height, number of branches/ leaves plant<sup>-1</sup> in okra due to application of 100 kg N + 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. Naidu *et al.* (2000) reported that maximum values for plant height, number of leaves plant<sup>-1</sup> internodal distance, number of nodes plant<sup>-1</sup> in okra were recorded with recommended dose of chemical fertilizer (80: 50:50, N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> + 20 t FYM). Shoot length in okra was significantly enhanced due to application of 100:50:50, N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (Prabu *et al.*, 2003).

Fertilizer application (150:75:75, N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a significant improvement in growth related attributes like plant height and number of leaves plant<sup>-1</sup> in okra (Dadmal and Dongale, 2004). Ray *et al.* (2005) reported that application of recommended dose of inorganic fertilizer (50:25:25, N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) either as 100 or 50 per cent recorded higher values for plant height as compared to control in okra. Sharma and Shukla (1973) reported positive and significant effect of NPK fertilizers on fruit yield of okra. Hooda *et al.* (1981) and Reddy *et al.* (1984) reported significant improvement in yield related attributes of okra with N and P application.

Abusaleha and Shanmugavelu (1988) reported that application of inorganic fertilizer (40 kg N as amm. sulphate) recorded significantly higher values for fruit length, fruit diameter, fruit yield plant<sup>-1</sup> and fruit yield ha<sup>-1</sup> as compared to control in okra. Chaudhary *et al.* (1995) reported significant effect of NPK fertilizers on fruit yield of okra. Fertilizer treated plots produced higher green fruit yield (65.08 t ha<sup>-1</sup>) as compared to control (36.40 t ha<sup>-1</sup>) in okra (Sharma and Bhalla, 1995). Maximum values for fruit number, fruit weight and fruit yield ha<sup>-1</sup> in okra were recorded in treatments amended with 80:60:20, N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O + 20 t FYM ha<sup>-1</sup> (Naidu *et al.*, 2000). Sing *et al.* (2000) reported that conventional practices involving use of inorganic fertilizers recorded a fruit yield of 65.13 q ha<sup>-1</sup> in okra which was higher than the yield recorded with treatments involving biofertilizers + dense organic

manures. Selvi and Thiageshwari (2002) reported that application of NPK (100: 50: 50 kg ha<sup>-1</sup>) recorded a fruit yield of 14.98 t ha<sup>-1</sup> as compared to 12.64 t ha<sup>-1</sup> recorded with control in okra.

Application of N 100 per cent through chemical fertilizer (urea) recorded significantly higher yields in okra as compared to 50 per cent N through chemical fertilizer, bio-inoculants and control (Swain *et al.*, 2003). Fertilizer application exhibited a gradual increase in yield related attributes of okra and the effects were significant over control (Dadmal and Dongale, 2004). Application of recommended inorganic fertilizer (50:25:25, N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) whether 100 or 50 per cent in okra, recorded higher fruit number as compared to control. Fruit yield recorded with 100 per cent inorganic fertilizer was 22.1 and 18.4 per cent more than the yield recorded with control (Ray *et al.*, 2005). Pandey and Singh (1979) suggested 100 kg N ha<sup>-1</sup> as optimum dose for okra seed crop while as Panday *et al.* (1980) registered maximum values with 120 kg N ha<sup>-1</sup>. Rastogi *et al.* (1987) reported that application of 60 kg N ha<sup>-1</sup> recorded maximum values for seed yield and 1000 seed weight in okra.

Bhat and Dhar (1999) recorded the highest number of seeds pod<sup>-1</sup> (57.65), seed weight plant<sup>-1</sup> (5.77 g), 100 seed weight (8.63 g) and seed yield (9.79 q ha<sup>-1</sup>) with 70 kg N + 70 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. Saffan *et al.* (2002) recorded maximum values for seed yield related attributes in okra like number of branches/ fruits plant<sup>-1</sup>, 100 seed weight and processed seed

yield with 150 kg N ha<sup>-1</sup>. Application of inorganic fertilizer (40 kg N through amm. sulphate) in okra registered a protein content of 18.20 per cent which was 11.70 per cent more than control. While as same treatment recorded lower values for fibre content and higher values for vitamin C in okra fruits as compared to control (Abusaleha and Shanmugavelu, 1988). Increasing levels of chemical nitrogen (90, 120, 150 kg ha<sup>-1</sup>) exhibited a significant increase in dry matter accumulation in chilli (Malewar *et al.*, 1988).

Singh *et al.* (2000) reported that inorganic fertilizers recorded a protein content of 2.14 per cent in fresh okra fruits which was higher than that recorded with treatments comprising of biofertilizers + dense organic manures and a vitamin C content of 13.61 mg 100 g<sup>-1</sup> of fresh okra fruits was recorded in plots amended with inorganic fertilizers. Fertilizer application in okra also exhibited significant increase in dry matter accumulation (Dademaal and Dongale, 2004).

Abuseleha (1992) reported significant increase in uptake of N, P, K, Ca and Mg by okra plants as compared to control. Application of 100 per cent N through urea, registered a significant increase in the uptake of N, P, K, Ca, Mg and S by okra plants over 50 per cent N and bio-inoculants (Swain *et al.*, 2003). Uptake of nutrients (N, P, K) by okra plants exhibited a significant increase over control with the application of chemical fertilizer. Fertilizer dose of 150: 75: 75, N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> recorded highest uptake of N, P and K at harvest in okra (Dademaal *et*

*al.*, 2004). Malewar *et al.* (1988) reported that inorganic fertilizers exhibited a non-significant change in bulk density and porosity over control. Sheeba and Kumarasamy (2001) reported that bulk density does not exhibit a significant change due to NPK applications. Particle density and porosity also exhibited a non-significant variation as the inorganic fertilizers do not influence physical properties of soil. Zaman *et al.* (2002) reported that addition of inorganic fertilizers exhibited a depletion in organic carbon resources. Application of 100 per cent N through urea in okra exhibited a drop in soil pH, decreases in electrical conductivity and soil organic carbon content (Swain *et al.*, 2003).

Combined application of NPK recorded lower bulk density (1.28 Mg m<sup>3</sup>) as compared to N + K (1.30 Mg m<sup>3</sup>), initial (1.34 Mg m<sup>3</sup>) and control (1.32 Mg m<sup>3</sup>) besides, exhibiting more soil organic carbon as compared to NK and NP application (Bhattacharyya *et al.*, 2004). Gogi *et al.* (2004) reported that inorganic fertilizers exhibited a depletion in organic carbon resources. Deshmukh *et al.* (2005) reported that application of NPK (100%) in soybean, registered a drop in soil pH, Ec but a marginal increase in organic carbon content over farmers practices. Ray *et al.* (2005) registered a decrease in soil pH and organic carbon content due to inorganic fertilizer application in okra.

Continuous application of chemical fertilizers recorded a significant decrease in soil pH, nitrogen through urea had the most deleterious effect on soil pH. Organic carbon content exhibited 60 per

cent increase over initial when 100 per cent chemical fertilizer was used in conjugation with farm yard manure (Subehia *et al.*, 2005). Application of 100 per cent N, through urea in okra, exhibited a drop in N status of soil, maintained higher levels of P availability and recorded lower available K status (Swain *et al.*, 2003). Dademal and Dongale (2004) reported that the status of available N, P and K content of soil was significantly improved with the application of chemical fertilizers in okra as compared to no fertilizer application.

Application of inorganic fertilizer in okra, registered a drop in available N and K but the available P was slightly increased (Ray *et al.*, 2005). Application of chemical fertilizers exhibited a decline in the availability of N and K but P availability depicted a significant buildup (Subehia *et al.*, 2005). The microbial population decreased in all chilli plants dressed with higher doses of NPK fertilizers (Azam and Banerjee, 1989). Application of N fertilizer decreased the bacterial population in soil. (Ganeshe *et al.*, 1998). Addition of inorganic fertilizers, registered minimal microbial activity (Zaman *et al.*, 2002). Swain *et al.* (2003) reported that application of fertilizer N in okra exhibited increased microbial population as compared to control.

Gogi *et al.* (2004) reported that sole application of chemical fertilizers exhibited lower values for microbial biomass. Application of inorganic fertilizer (30: 60: 80, NPK kg ha<sup>-1</sup>) recorded a nodule number

(42.67) which was 9.63 per cent more than the nodule number (38.56) recorded with control (Singh *et al.*, 2005).

## Chapter 3

### MATERIALS AND METHODS

The present investigation “Influence of organic manures and inorganic fertilizers on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]” was carried out at the Experimental Fields of Division of Olericulture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar. The main crop okra was raised during kharif 2004 and 2005, while as residual crop (pea) was immediately raised after the harvest of okra during rabi 2004-2005 and rabi 2005-2006. The fields are located at 34.1° North latitude and 74.89° East longitude at an elevation of 1587 meters above sea level. The climate is temperate and mean rainfall and relative humidity during kharif 2004-2005 was 31.31 mm, 67.27 per cent and 47.16 mm, 67.32 per cent, respectively. While as during rabi 2004-2004 and rabi 2005-2006 mean rainfall and relative humidity was 95.55 mm, 74.29 per cent, 95.55 mm and 54.82 mm, 73.68 per cent, respectively. Total sunshine hours during the period of experimentation was 4,269.40 hours. The mean monthly meteorological data pertaining to period of experimentation was recorded at agro-meteorological observatory of SKUAST-K, Shalimar Campus and is given in Appendix-I. The details of the materials used and the method adopted are given below:

#### 3.1 Experimental materials

The organic manures viz., farm yard manure (FYM), sheep manure (SM), poultry manure (PM), vermi compost (VC), biofertilizers (*Azospirillum*, *Phosphobacteria*) and chemical fertilizers (urea, super phosphate single and muriate of potash) were used as source of plant nutrients. Organic manures and chemical fertilizers were obtained from authorized sources, while as biofertilizers were provided by Division of Environmental Sciences, SKUAST-K, Shalimar. The seeds of okra SKBS-11 and pea cv. Bonevilla were provided by Division of Olericulture.

### **3.2 Experimental methods**

#### **3.2.1 Experimental details**

The experiment was laid out in lattice square design with 25 treatments and two replications as detailed below:

- |                                     |                                 |
|-------------------------------------|---------------------------------|
| a) Design                           | : Simple square lattice design  |
| b) Treatments                       | : 25                            |
| c) Replications                     | : 2                             |
| d) Total number of plots            | : 50                            |
| e) Plot size                        | : $3.0^m \times 3.0^m = 9.0m^2$ |
| f) Spacing                          | : 50 x 30 cm                    |
| g) No. of plants plot <sup>-1</sup> | : 60                            |
| h) Crop                             | : Okra-SKBS-11                  |
| i) No. of observational plants      | : 10                            |

- j) Plot size for residual crop :  $3.0^m \times 3.0^m = 9.0m^2$   
pea cv. Bonevilla
- k) Spacing : 30 x 10 cm
- l) No. of plants plot<sup>-1</sup> : 300
- m) No. of observational plants : 10
- n) Date of sowing of okra : 20.05.2004  
kharif 2004
- o) Date of sowing of residual : 11.11.2004  
crop pea rabi 2004-2005
- p) Date of sowing of okra, 09.06.2005  
kharif 2005
- q) Date of sowing of residual : 15.11.2005  
crop pea rabi 2005-2006

### 3.2.2 Treatment details

Symbol	Treatment	
T <sub>1</sub>	RFD (100%)	120:60:60 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup>
T <sub>2</sub>	FYM	30 t ha <sup>-1</sup>
T <sub>3</sub>	SM	20 t ha <sup>-1</sup>
T <sub>4</sub>	PM	6 t ha <sup>-1</sup>
T <sub>5</sub>	VC	6 t ha <sup>-1</sup>
T <sub>6</sub>	BF 7 kg ha <sup>-1</sup> ( <i>Azospirillum</i> + <i>Phosphobacteria</i> )	(both as seed inoculant @ 1.0 kg ha <sup>-1</sup> and as soil inoculant @ 2.5 kg ha <sup>-1</sup> )

T <sub>7</sub>	MoO (FYM+SM+PM+VC+ BF)	6 t + 4 t + 1 t + 1 t + 7.0 kg ha <sup>-1</sup>
T <sub>8</sub>	FYM + SM	15 t + 10 t ha <sup>-1</sup>
T <sub>9</sub>	FYM + PM	15 t + 3 t ha <sup>-1</sup>
T <sub>10</sub>	FYM + VC	15 t + 3 t ha <sup>-1</sup>
T <sub>11</sub>	FYM + BF	15 t + 7.0 kg ha <sup>-1</sup>
T <sub>12</sub>	SM + PM	10 t + 3 t ha <sup>-1</sup>
T <sub>13</sub>	SM + VC	10 t + 3 t ha <sup>-1</sup>
T <sub>14</sub>	SM + BF	10 t + 7.0 kg ha <sup>-1</sup>
T <sub>15</sub>	PM + VC	3 t + 3 t ha <sup>-1</sup>
T <sub>16</sub>	PM + BF	3 t + 7.0 kg ha <sup>-1</sup>
T <sub>17</sub>	VC + BF	3 t + 7.0 kg ha <sup>-1</sup>
T <sub>18</sub>	RFD 50%	60:30:30 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup>
T <sub>19</sub>	FYM + RFD 50%	15 t + 60:30:30 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup>
T <sub>20</sub>	SM + RFD 50%	10 t + 60:30:30 N P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup>
T <sub>21</sub>	PM + RFD 50%	3 t + 60:30:30 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup>
T <sub>22</sub>	VC + RFD 50%	3 t + 60:30:30 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup>
T <sub>23</sub>	BF + RFD 50%	7.0 kg + 60:30:30 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup>
T <sub>24</sub>	MoO (FYM + SM + PM + VC + BF + RFD 50 %)	3 t + 2 t + 0.5 t + 0.6 t + 7.0 kg + 60:30:30 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup>
T <sub>25</sub>	Control	No OM/VC/BF/RFD

OM = Organic manures, VC = Vermi compost, BF = Biofertilizers,

RFD =

The nutrient composition of organics and inorganic fertilizers are presented in Appendix-II.

### **3.3 Experimental site and preparatory tillage**

The site selected for the experiment was well leveled, with uniform soil fertility and good drainage. Land was prepared by ploughing, clod breaking and was brought to fine tilth. Fifty plots of 3.0 x 3.0 meter size were prepared as per lay out specifications to accommodate 60 plants plot<sup>-1</sup>, planted in 6 rows with 10 plants row<sup>-1</sup> in okra and 300 plants plot<sup>-1</sup> planted in 10 rows with 30 plants row<sup>-1</sup> in pea. Three irrigation channels 80 cm wide were prepared for irrigation purpose in each replication. Organic manures and vermi compost were applied as basal dose and thoroughly incorporated in the soil. Biofertilizers were applied as seed treatment, wherein okra seeds were dressed with biofertilizer slurry prepared in 10 per cent sugar solution and dried in shade. In case of soil treatment, biofertilizers were mixed with 30 kg fine soil and incorporated in the soil prior to sowing. However, in treatments, where conjugation with chemical fertilizers was practiced, biofertilizers were applied in the soil 48 hours before applying chemical fertilizer. In case of chemical fertilizers both in 100 per cent, 50 per cent and integration with organic sources, half of nitrogen, full phosphorus and potassium was applied as basal dose,

while as remaining 50 per cent nitrogen was applied as top dose one month after sowing. In case of residual crop pea, no manure or chemical fertilizer was applied. The plan of the layout is given in Fig. 1.

### **3.4 Sowing of seeds**

Seed sowing of okra-SKBS-11 in kharif 2004 and 2005 was carried on 20.05.2004 and 09.06.2005, respectively. While that of residual crop pea cv. Bonneville was done on 11.11.2004 and 15.11.2005 in rabi 2004-2005 and 2005-2006, respectively. For sowing of okra seeds shallow furrows 50 cm wide were opened and two seeds hill<sup>-1</sup> were dibbled at a distance of 30 cm. After germination, one healthy seedling was retained hill<sup>-1</sup>. In case of pea, 30 cm wide furrows were opened and two seeds hill<sup>-1</sup> were dibbled at a distance of 10 cm and after germination only one healthy seedling hill<sup>-1</sup> was retained. In both crops during both seasons, plant population was maintained by gap filling.

### **3.5 Cultural practices**

Cultural practices like weeding, hoeing was practised in both crops as and when needed. Irrigation in okra was given at an interval of 10-12 days, while in pea, occasional irrigations were given as and when required.

### **3.6 Harvesting**

Harvesting of okra fruits was started in August and continued up to September during both the years. Picking of fruits in okra was

performed at tender edible stage at an interval of 3-5 days, in all twelve pickings were made during productive period. In case of residual crop pea, harvesting of light green and tightly filled pods started in early May and continued up to ending May during both the seasons. Three pickings were carried out during productive period.

### **3.7 Observations recorded**

During the course of investigation, observations were recorded on various aspects like growth, yield and quality attributes of both crops, seed related attributes of okra, nutrient uptake by okra plants, physico-chemical properties of soil and rhizosphere microbial population. Observations regarding soil health related characters were recorded before the start of experiment, as well as after the harvest of each crop. However, in case of mechanical components, observations were recorded before the experiment and after the end of experiment i.e. after the harvest of residual crop pea 2005-2006.

#### **Observations on growth related characters of okra**

##### **3.7.1 Plant height (cm)**

The height at final harvest of the plant from ground level to growing point was taken for 10 random plants and the mean was calculated and expressed in centimeters.

##### **3.7.2 Number of branches plant<sup>-1</sup>**

At the final harvest stage, the number of branches for 10 random plants were counted and the mean was calculated.

### **3.7.3 Internodal distance (cm)**

The height of the plant was divided by the number of nodes on main stem and the mean for average internodal distance was calculated and expressed in centimeters.

## **Observations on yield related characters of okra**

### **3.7.4 Number of nodes plant<sup>-1</sup>**

The number of nodes on the main stem for 10 random plants were counted at final harvest and mean was calculated.

### **3.7.5 Fruit length (cm)**

The length of fruits in each picking from each treatment was measured from the base of the fruit to apex and average was calculated and expressed in centimeters.

### **3.7.6 Fruit diameter (cm)**

The diameter of fruits in each picking from each treatment was measured by Vernier Calliper at middle portion of the fruit and average was calculated and expressed in centimeters.

### **3.7.7 Number of fruits plant<sup>-1</sup>**

Total number of fruits harvested from 10 random plants in each treatment from different pickings was added to work out the total number of fruits plant<sup>-1</sup>.

### **3.7.8 Average fruit weight (g)**

Fresh weight of okra fruits at each picking from each treatment for 10 random plants was recorded and an average was calculated and expressed in grams.

### **3.7.9 Fruit yield plot<sup>-1</sup> (kg)**

Fresh weight of okra fruits at each picking from each treatment for 10 random plants was added to work out the total weight of fruits for 10 plants and converted depending upon number of plants in a plot to estimate the yield plot<sup>-1</sup> in kilograms.

### **3.7.10 Fruit yield ha<sup>-1</sup> (q)**

The yield plot<sup>-1</sup> (kg) was converted into quintals ha<sup>-1</sup> for each treatment.

## **Observation on seed yield related characters of okra**

### **3.7.11 Number of seeds pod<sup>-1</sup>**

Seeds from 10 random fruits at fully mature stage were extracted, counted to work out the average number of seeds pod<sup>-1</sup>.

### **3.7.12 Number of seed pods plant<sup>-1</sup>**

Number of seed pods from 10 random plants were counted to work out the average number of seed pods plant<sup>-1</sup>.

### **3.7.13 Seed yield plant<sup>-1</sup>(g)**

Seed yield plant<sup>-1</sup> in grams was worked out by multiplying the average number seed pods plant<sup>-1</sup> with average weight of seeds pod<sup>-1</sup>.

### **3.7.14 Seed yield ha<sup>-1</sup> (q)**

Seed yield plant<sup>-1</sup> (g) was converted first into seed yield plot<sup>-1</sup> and further into seed yield ha<sup>-1</sup> in quintals for each treatment.

### **3.7.15 100 seed weight (g)**

A random sample of 100 seeds from each treatment was weighed to work out 100 seed weight in grams.

## **Observations on quality related characters of okra**

### **3.7.16 Protein content of fresh fruits (%)**

Protein content in fresh fruits at palatable stage from each treatment was worked out by estimating the percentage of N in fresh fruits by Kjeldhals method – Tandon (1993). The per cent N was multiplied by factor 6.25, to estimate the protein content in fresh fruits in per cent.

### **3.7.17 Protein content of dry seeds (%)**

Protein content of dry okra seeds from each treatment was worked out by estimating the percentage of N in seeds by Kjeldhals method – Tandon (1993). The per cent N was multiplied by the factor 6.25 to estimate the protein content in dry seeds.

#### **3.7.18 Fibre content in green fruits (%)**

Fibre content in fresh okra fruits at edible stage from each treatment was estimated by the method outlined by Saini *et al.* (2001) and results were expressed in per cent.

#### **3.7.19 Vitamin C content (mg 100g<sup>-1</sup>)**

Vitamin C content of fresh okra fruits at palatable stage from each treatment was estimated by 2,6-dichlorophenol indophenol visual titration method (AOAC, 1975) and expressed in milligrams 100 gram<sup>-1</sup> of fresh weight.

#### **3.7.20 Dry matter (%)**

100 grams of fresh okra fruits at edible stage from each treatment were cut into small pieces and subjected to sun drying followed by oven drying at 60°C till the material recorded a constant weight. The dried material was weighed and expressed at dry matter content in per cent.

### **Plant nutrient analysis**

Five plants out of 10 observational plants and a representative sample of okra fruits were selected randomly from each treatment at

final harvest stage to serve as a substrate for plant nutrient analysis. The selected samples were cleaned with 0.2 per cent liquid detergent, HCL solution (8 ml litre<sup>-1</sup> of water) and distilled water. The cleaned plant material was cut into small pieces, air-dried and finally subject to oven drying at 65°C, till the material exhibited a constant weight. The dried material was grinded to powder in Wiley grinding mill.

For estimating N concentration, the powdered material (one gram) was digested in concentrated H<sub>2</sub> SO<sub>4</sub> + sulphate mixture in the ratio of 20 parts of K<sub>2</sub>SO<sub>4</sub> + 20 parts of Cu SO<sub>4</sub> + 1 part of selenium power. The digest was cooled and diluted with distil water 10 ml of the digest was taken for N estimation. For estimating the concentration of P, K, S, Ca, and Mg, the powdered material (1 g) was digested in di-acid (HNO<sub>3</sub> and HClO<sub>4</sub>) in the ratio 10:4. The digested material was filtered and the volume was made upto 100 ml with distil water and 5', 10 ml of the digest was used for P, K, S, Ca and Mg estimation, respectively.

### **Methods used for plant nutrient analysis**

#### **3.7.21 Nitrogen (kg ha<sup>-1</sup>)**

Total nitrogen in okra plants was determined by Kjeldhals methods as outlined by Tandon (1993).

#### **3.7.22 Potassium (kg ha<sup>-1</sup>)**

Total potassium in okra plants was estimated by flame photometer as per the procedure given by Piper (1966).

### **3.7.23 Phosphorus ( $\text{kg ha}^{-1}$ )**

Total phosphorus in okra plants was estimated by Vanadate molybdate yellow colour method as described by Tandon (1993).

### **3.7.24 Sulphur ( $\text{kg ha}^{-1}$ )**

Total sulphur was estimated by barium sulphate turbidimetry method of Chesnin and Yien (1950).

### **3.7.25 Calcium and magnesium ( $\text{kg ha}^{-1}$ )**

Total calcium and magnesium was estimated by Versenate method as described by Tandon (1993).

## **Soil nutrient analysis**

Representative soil samples of the experimental site before the start of experiment as well as after the harvest of each crop from each treatment were taken from a depth of 0-15 cm and analyzed for physical/ chemical/ microbial/characteristics of soil and availability of N, P, K, S, Ca, and Mg using standard procedures. The initial status of experimental site with respect to above characteristics is given in the Table 1.

## **Physical characteristics**

### **3.7.26 Mechanical components (%)**

Mechanical components, per cent sand silt and clay was determined by international pipette method – Black (1965) before the

experiment as well as after the harvest of residual crop pea (rabi 2005-2006) from each treatment.

### 3.7.27 Bulk density (g cm<sup>3</sup>)

Bulk density was estimated by taking a moist soil sample from undisturbed soil core, adopting excavation method, as outlined by Jaiswal (2003).

### 3.7.28 Particle density (g cm<sup>3</sup>)

Particle density was estimated by use of 100 ml graduated cylinder as outlined by Jaiswal (2003).

### 3.7.29 Porosity (%)

It was estimated by subtracting the per cent solid space from 100.

$$\begin{aligned} \% \text{ solid space} &= \frac{\text{Bulk density}}{\text{Particle density}} \times 100 \\ \text{Porosity \%} &= 100 - \% \text{ solid space} \end{aligned}$$

**Table 1: Initial status of experimental field with respect to physical, chemical and rhizosphere microbial population characteristics**

<b>Character</b>	<b>Value</b>	<b>Rating</b>
<b><u>PHYSICAL CHARACTERISTICS</u></b>		
<b><u>Mechanical components</u></b>		
Sand %	21.90	Clay loam

a) Fine sand	3.75
b) Coarse sand	18.15
Silt %	41.80
Clay %	33.70
Bulk density g cm <sup>3</sup>	1.450
Particle density g cm <sup>3</sup>	2.450
Porosity %	40.82

### **Chemical characteristics**

P <sub>H</sub>	7.25	Near neutral
Organic carbon %	1.08	Medium
Electrical conductivity dsm <sup>-1</sup>	0.090	Normal
Available N kg ha <sup>-1</sup>	206.95	Low
Available P kg ha <sup>-1</sup>	28.00	High
Available K kg ha <sup>-1</sup>	172.48	Medium
Available S kg ha <sup>-1</sup>	20.16	Low
Available Ca kg ha <sup>-1</sup>	3451.84	
Available Mg kg ha <sup>-1</sup>	1008.00	
Calcium carbonate %	1.2	Low
Rhizosphere microbial population		
Bacterial No. g <sup>-1</sup> of soil	15 x 10 <sup>5</sup>	
Fungal No. g <sup>-1</sup> of soil	4 x 10 <sup>5</sup>	

---

### **Chemical characteristics**

#### **3.7.30 pH**

The pH of the soil samples was determined by digital pH meter in 1:25 ratio of soil water suspension – Jackson (1973).

#### **3.7.31 Organic carbon (%)**

The organic carbon content was estimated by Walkley and Blacks method (1934).

#### **3.7.32 Electrical conductivity ( $E \text{ cd sm}^{-1}$ )**

Electrical conductivity was estimated by solubridge conductivity meter – Jackson (1973).

#### **3.7.33 Available nitrogen ( $\text{kg ha}^{-1}$ )**

Available nitrogen was determined by alkaline per manganate method as described by Subbiah and Asija (1956).

#### **3.7.34 Available phosphorus ( $\text{kg ha}^{-1}$ )**

Available phosphorus was determined by Olsen method (1954) as described by Jackson (1973).

#### **3.7.35 Available potassium ( $\text{kg ha}^{-1}$ )**

Available potassium was determined by extracting it with neutral normal ammonium acetate (Merwin and Peech, 1950) and determined by flame photometer as outlined by Jackson (1973).

#### **3.7.36 Available sulphur ( $\text{kg ha}^{-1}$ )**

Available sulphur was determined by turbidimetrically of Chesnin and Yien (1950) as described by Jackson (1973).

#### **3.7.37 Available calcium and magnesium ( $\text{kg ha}^{-1}$ )**

It was estimated by Versenate titration method – Black (1965).

### **3.7.38 Rhizosphere microbial population (No. g<sup>-1</sup> of soil)**

Rhizosphere microbial population was estimated by adopting serial dilution method as outlined by Aneja (1996).

### **Observations on growth and yield related attributes of residual crop pea cv. Bonevilla**

#### **3.7.39 Plant height (cm)**

The height at final harvest from ground level to growing point from 10 random plants was taken and the mean was calculated and expressed in centimeters.

#### **3.7.40 Number of pods plant<sup>-1</sup>**

Total number of pods harvested in 3 pickings from 10 random plants in each treatment were recorded to work out the average number of pods plant<sup>-1</sup>.

#### **3.7.41 Pod yield plant<sup>-1</sup> (g)**

Fresh weight of total pods harvested from 10 random plants was recorded to work out the average pod yield plant<sup>-1</sup> in grams.

#### **3.7.42 Pod yield ha<sup>-1</sup> (q)**

Pod yield plant<sup>-1</sup> (g) was converted into pod yield plot<sup>-1</sup> (kg) and pod yield ha<sup>-1</sup> (q) from each treatment.

### 3.7.43 Nodule number plant<sup>-1</sup>

Nodule number from 10 random plants was recorded just before flowering to work out the average nodule number plant<sup>-1</sup> from each treatment.

## Economics of production statistical analysis

### 3.7.44 Economics of production

Tabular analysis was performed to assess the economics of production of main crop okra and residual crop pea. Functional distribution income i.e. relative factor shares reflecting the proportion of total income that improves various factors of production employed in production process were estimated as:

Wb	:	Total wage bill
Kb	:	Total capital bill
Py	:	Total income from okra and pea crop, then shares of various factors of production arc.
Wb/Py	:	Share of labour in total income
Kb/Py	:	Share of capital in total income
T	:	Land share is treated as residual and is computed as per the method given by Chandra and Singh, 1999

$$1 - \frac{Wb}{Py} + \frac{Kb}{Py}$$

### 3.7.45 Break even analysis

Break even analysis indicates cost volume profit relations in short run. This analysis relies on the assumption of constant factor prices, constant technology and constant selling prices. Break even analysis is very important because in the short run, the cost and revenue structure is reasonably stable. The point at which the two curves i.e. total cost curve and total revenue curve intersect is called the break even point (BEP) which indicates the level of production at which the producer neither loses money nor makes profit. It is a point of no profit and no loss.

#### Estimation of Break even point

Algebraically, break even point can be estimated by using the formula:

$$\text{BEP} = \frac{F}{P-V}$$

Where BEP = Break even point

F = Fixed cost in Rs. ha<sup>-1</sup>

P = Price q<sup>-1</sup> in Rs.

V = Variable cost q<sup>-1</sup> in Rs.

### 3.7.46 Margin of safety

The excess of production over the break even point is called the margin of safety. It indicates the strength of the enterprise. A high

margin of safety indicates that the enterprise will make profits even if there is a fall in the output. Margin of safety is estimated as:

$$\text{Margin of safety } q \text{ ha}^{-1} = \text{Total output} - \text{output at BEP}$$

The purchase rates of organics and inorganic fertilizers are presented in Appendix-III. While as whole sale rates of okra and pea are presented in Appendix-IV.

#### **3.7.47 Statistical analysis**

The treatments under investigation were extremely large to accommodate in a single block, so simple square lattice design (partially balanced incomplete block design) was adopted to carry out the experiment. The data recorded was subjected to analysis of variance technique as per the method given by Darmaraju and Raghavarao (1987). The design generates two types of CD's for comparing treatments within block and among blocks. Selection out of two CD's was made, the one with higher value was used to compare all the treatment effects. For pooling of data over seasons, an efficient procedure called nested classification procedure, as discussed by Gupta and Prasad (2006) was adopted which ensures more precise estimate of treatment effects.

## Chapter 4

### EXPERIMENTAL FINDINGS

#### Influence of organic manures and inorganic fertilizers on growth attributes of okra

##### 4.1 Plant height (cm)

Perusal of Table 2 revealed significant effect of various treatments on plant height. Integration of organic with inorganic sources and RFD proved superior over sole applications as well as integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a maximum plant height of 188.47 and 186.58 cm during kharif 2004 and 2005, respectively and was found significantly superior to all other treatments but exhibited at par results with T<sub>1</sub> (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). However during kharif 2004, T<sub>24</sub> was also statistically at par with T<sub>4</sub> (PM 6 t ha<sup>-1</sup>), T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) and T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>). Pooled analysis revealed the significance of T<sub>24</sub>, recording a plant height of 186.82 cm and was found significantly superior to all other treatments (Table 2 and Fig. II).

Among sole application of organics, treatment T<sub>4</sub> (PM 6t ha<sup>-1</sup>) recorded a plant height of 177.43 cm during kharif 2004 and was found significantly superior to T<sub>2</sub> (FYM 30t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e.50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but exhibited at par results with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub>(VC 6t ha<sup>-1</sup>). During kharif 2005, T<sub>4</sub> recorded a plant height of 156.81 cm which was significantly superior to T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited statistically at par results with T<sub>2</sub>, T<sub>3</sub> and T<sub>5</sub>. Pooled analysis revealed that T<sub>4</sub> recorded a plant height of 165.89 cm which was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub>. However, during kharif 2005 and pooled over seasons, T<sub>4</sub> recorded significantly lower plant height than T<sub>1</sub> i.e. 100% RFD (Table 2 and Fig. II).

Integration of organic sources exhibited an increase in plant height over sole application of organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a plant height of 185.89 cm during kharif 2004 and was significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>1</sub>, T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub>. During kharif 2005, T<sub>7</sub> recorded a plant height of 167.14 cm which was significantly superior to T<sub>8</sub>, T<sub>11</sub>, T<sub>14</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>1</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>12</sub>, T<sub>13</sub> and T<sub>15</sub>. Pooled analysis

revealed the significance of T<sub>7</sub>, recording a plant height of 176.61 cm which was significantly superior to all organic integration treatments, T<sub>18</sub> and T<sub>25</sub> but was found at par with T<sub>1</sub> (Table 2 and Fig. II).

**Table 2: Influence of organic manures and inorganic fertilizers on mean plant height (cm) and number of branches plant<sup>-1</sup> in okra**

Treatment	Plant height			Mean of main treatments*	Number of branches plant <sup>-1</sup>			Mean of main treatments*
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	<b>184.49</b>	<b>173.00</b>	<b>178.64</b>	<b>178.71</b>	<b>2.98</b>	<b>2.86</b>	<b>2.92</b>	<b>2.92</b>
T <sub>2</sub>	155.06	142.77	149.48		1.81	1.64	1.72	
T <sub>3</sub>	165.23	146.74	155.65		1.96	1.88	1.90	
T <sub>4</sub>	177.43	156.81	165.98		2.30	2.16	2.22	
T <sub>5</sub>	169.87	152.37	161.19		2.20	2.01	2.08	
T <sub>6</sub>	101.16	97.22	99.12		1.51	1.34	1.43	
<b>Mean</b>	<b>153.75</b>	<b>139.18</b>	<b>146.28</b>	<b>146.40</b>	<b>1.95</b>	<b>1.80</b>	<b>1.87</b>	<b>1.87</b>
T <sub>7</sub>	185.89	167.14	176.61		2.84	2.42	2.63	
T <sub>8</sub>	160.06	150.51	154.98		1.89	1.76	1.81	
T <sub>9</sub>	170.66	156.53	162.48		2.13	2.04	2.08	
T <sub>10</sub>	166.60	155.69	161.24		2.13	1.89	1.99	
T <sub>11</sub>	162.33	144.89	153.84		1.86	1.68	1.79	
T <sub>12</sub>	172.41	158.81	166.01		2.49	2.16	2.34	
T <sub>13</sub>	168.93	156.03	162.48		2.24	1.90	2.07	
T <sub>14</sub>	169.13	148.30	157.90		2.18	1.88	2.04	
T <sub>15</sub>	175.57	164.77	170.56		2.78	2.23	2.50	
T <sub>16</sub>	174.73	160.01	167.91		2.40	2.26	2.34	
T <sub>17</sub>	173.86	156.53	165.90		2.33	2.04	2.19	
<b>Mean</b>	<b>170.92</b>	<b>156.29</b>	<b>163.62</b>	<b>163.61</b>	<b>2.29</b>	<b>2.02</b>	<b>2.16</b>	<b>2.15</b>
T <sub>18</sub>	<b>114.68</b>	<b>115.05</b>	<b>115.17</b>	<b>114.96</b>	<b>1.58</b>	<b>1.28</b>	<b>1.42</b>	<b>1.42</b>
T <sub>19</sub>	164.78	163.82	165.30		2.22	2.26	2.24	
T <sub>20</sub>	176.87	169.33	171.31		3.02	2.31	2.65	
T <sub>21</sub>	182.87	178.47	181.01		3.00	2.71	2.88	
T <sub>22</sub>	180.30	172.84	177.07		3.03	2.49	2.78	
T <sub>23</sub>	166.02	160.28	163.25		2.38	2.33	2.36	
T <sub>24</sub>	188.47	186.58	186.82		3.22	2.91	3.08	
<b>Mean</b>	<b>177.05</b>	<b>171.88</b>	<b>174.12</b>	<b>174.35</b>	<b>2.81</b>	<b>2.50</b>	<b>2.66</b>	<b>2.65</b>
T <sub>25</sub>	<b>70.66</b>	<b>68.10</b>	<b>69.88</b>	<b>69.54</b>	<b>1.12</b>	<b>0.96</b>	<b>1.04</b>	<b>1.04</b>
CD at 5%	13.41	15.77	3.58		0.37	0.39	0.14	

\* Mean of main treatments namely RFD, organics, integration of organics, 50% RFD, integration of organics & inorganics and control.

Integration of different organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in plant height over sole applications as well as integration of organics. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a plant height of 182.87 and 178.47 cm during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>18</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> but was statistically at par with T<sub>1</sub>, T<sub>7</sub>, T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). However, T<sub>21</sub> exhibited at par results with T<sub>19</sub> during kharif 2005. Pooled analysis revealed the significance of T<sub>21</sub>, recording a plant height of 181.01 cm which was significantly superior to T<sub>7</sub>, T<sub>18</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub> and T<sub>25</sub> but was statistically at par with T<sub>1</sub> (Table 2).

#### **4.2 Number of branches plant<sup>-1</sup>**

Perusal of Table 2 indicated that different treatments significantly effected number of branches plant<sup>-1</sup>. Integration of organic sources with chemical fertilizer and RFD proved superior to sole applications of organic sources as well as their integration.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t +PM 0.5t +VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded maximum number of branches plant<sup>-1</sup> (3.22 and 2.91) during kharif 2004 and 2005, respectively and was found significantly superior to all treatments but statistically at par with T<sub>21</sub> (PM 3t + 60:30:30 N:

P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>1</sub> (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis revealed that T<sub>24</sub> recorded significantly maximum number of branches plant<sup>-1</sup> 3.08 as compared to rest of the treatments but was statistically at par with T<sub>1</sub> (Table 2).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded significantly maximum number of branches plant<sup>-1</sup> 2.30 and 2.16 during kharif 2004 and 2005, respectively as compared to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6 t ha<sup>-1</sup>). However, T<sub>4</sub> registered significantly lower values as compared to T<sub>1</sub>. Pooled analysis also revealed the significant effect of T<sub>4</sub>, recording 2.22 number of branches plant<sup>-1</sup> which was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>5</sub>. However, T<sub>4</sub> exhibited significantly lower value as compared to T<sub>1</sub> i.e. 100% RFD (Table 2).

Integration of organic source however, depicted an increase in number of branches plant<sup>-1</sup> over sole application of organics. During kharif 2004, 2005 and pooled over seasons, treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded maximum number of branches plant<sup>-1</sup>, 2.84, 2.42 and 2.63 respectively and was found significantly superior to treatment combinations of T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>)

<sup>1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>1</sub>. However, T<sub>7</sub> recorded significantly lower values as compared to T<sub>1</sub>

during kharif 2005. Pooled analysis also revealed the significant effect of T<sub>7</sub> recording maximum number of branches plant<sup>-1</sup> (2.63) which was statistically at par with T<sub>15</sub> but recorded significantly lower values as compared to T<sub>1</sub> (Table 3). Conjugation of different organic sources with recommended fertilizer dose in equal proportions (50:50) increased the number of branches plant<sup>-1</sup> over sole as well as combined application of organic sources. Conjugation of PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) recorded significantly maximum number of branches plant<sup>-1</sup> 3.00, 2.71 and 2.88 during kharif 2004, 2005 and pooled over seasons, respectively as compared to T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub> and T<sub>1</sub> (Table 2).

### **4.3 Internodal distance (cm)**

Perusal of Table 3 indicated significant variation due to various treatments in respect of internodal distance. Integration of organic sources with inorganic sources and RFD registered an increase in internodal distance over sole application of organics as well as their integration and control.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>)

recorded an internodal distance of 7.01 and 7.00 cm during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but exhibited at par results with rest of the treatments. However, T<sub>24</sub> exhibited significant superiority over T<sub>6</sub> (BR 7 kg ha<sup>-1</sup>) during kharif 2005. Pooled analysis revealed that T<sub>24</sub> recorded an internodal distance of 6.99 cm which was significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was found statistically at par with rest of the treatments (Table 3).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded an internodal distance of 6.89, 6.87 and 6.82 cm during kharif 2004, 2005 and pooled over seasons, respectively and was found significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>1</sub> (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub>, T<sub>3</sub> and T<sub>25</sub>. However, T<sub>4</sub> exhibited at par results with T<sub>6</sub> and T<sub>18</sub> during kharif 2004 ad 2005, respectively and significant superiority over T<sub>6</sub> during pooled over seasons (Table 3).

Organic integrations increased the internodal distance over sole application of organics, treatment T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) recorded an internodal distance of 6.84 and 6.92 cm during kharif 2004 and 2005, respectively and was significantly superior to T<sub>18</sub> and T<sub>25</sub> but was at par with rest of the organic integration treatments viz. T<sub>7</sub>, T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>12</sub>,

T<sub>13</sub>, T<sub>14</sub>, T<sub>15</sub>, T<sub>17</sub> and T<sub>1</sub>. However, T<sub>16</sub> exhibited at par results with T<sub>18</sub> during kharif 2005. Pooled analysis also revealed that T<sub>16</sub> recorded an internodal distance of 6.93 cm which was significantly superior to T<sub>8</sub>, T<sub>9</sub>, T<sub>18</sub> and T<sub>25</sub> but was found statistically at par with rest of the organic integration treatments and T<sub>1</sub> (Table 3).

**Table 3: Influence of organic manures and inorganic fertilizers on mean internodal distance (cm) and number of nodes plant<sup>-1</sup> (main stem) in okra**

Treatment	Internodal distance			Mean of main treatments	Number of nodes plant <sup>-1</sup>			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	<b>6.97</b>	<b>7.03</b>	<b>7.00</b>	<b>7.00</b>	<b>26.40</b>	<b>24.74</b>	<b>25.57</b>	<b>25.57</b>
T <sub>2</sub>	6.71	6.62	6.71		23.24	21.55	22.26	
T <sub>3</sub>	6.76	6.78	6.77		24.44	21.67	22.98	
T <sub>4</sub>	6.89	6.87	6.82		25.73	22.85	24.29	
T <sub>5</sub>	6.80	6.83	6.80		24.94	22.34	23.58	
T <sub>6</sub>	6.63	6.10	6.32		15.24	15.95	15.73	
<b>Mean</b>	<b>6.75</b>	<b>6.64</b>	<b>6.68</b>	<b>6.69</b>	<b>22.71</b>	<b>20.87</b>	<b>21.76</b>	<b>21.78</b>
T <sub>7</sub>	6.97	6.73	6.85		26.68	24.66	25.67	
T <sub>8</sub>	6.76	6.70	6.69		23.68	22.38	23.09	
T <sub>9</sub>	6.78	6.76	6.67		25.17	23.06	24.25	
T <sub>10</sub>	6.82	6.70	6.71		24.38	23.15	23.84	
T <sub>11</sub>	6.75	6.79	6.77		24.04	21.37	22.78	
T <sub>12</sub>	6.84	6.76	6.84		25.18	23.38	24.22	
T <sub>13</sub>	6.82	6.78	6.80		24.78	23.00	23.89	
T <sub>14</sub>	6.77	6.80	6.73		24.97	21.78	23.45	
T <sub>15</sub>	6.97	6.84	6.89		25.18	24.07	24.64	
T <sub>16</sub>	6.84	6.92	6.93		25.53	23.15	24.34	
T <sub>17</sub>	6.82	6.76	6.88		25.47	23.06	24.13	
<b>Mean</b>	<b>6.83</b>	<b>6.77</b>	<b>6.79</b>	<b>6.79</b>	<b>25.00</b>	<b>23.00</b>	<b>24.02</b>	<b>24.00</b>
T <sub>18</sub>	<b>6.39</b>	<b>6.39</b>	<b>6.45</b>	<b>6.41</b>	<b>17.97</b>	<b>17.98</b>	<b>17.90</b>	<b>17.95</b>
T <sub>19</sub>	6.82	6.89	6.86		24.66	23.76	24.21	
T <sub>20</sub>	6.90	6.90	6.94		25.57	24.55	25.00	
T <sub>21</sub>	7.01	6.97	7.01		26.04	25.64	25.90	
T <sub>22</sub>	6.94	6.80	6.93		25.88	25.35	25.54	
T <sub>23</sub>	6.86	6.85	6.87		24.18	23.37	23.76	
T <sub>24</sub>	7.01	7.00	6.99		26.87	26.65	26.82	
<b>Mean</b>	<b>6.92</b>	<b>6.90</b>	<b>6.93</b>	<b>6.91</b>	<b>25.53</b>	<b>24.88</b>	<b>25.20</b>	<b>25.20</b>
T <sub>25</sub>	<b>5.81</b>	<b>6.13</b>	<b>5.97</b>	<b>5.97</b>	<b>12.08</b>	<b>11.04</b>	<b>11.56</b>	<b>11.56</b>
CD at 5%	0.40	0.54	0.20		2.65	2.03	0.62	

Integration of different organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in internodal distance. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an internodal distance of 7.01, 6.97 and 7.01 cm during kharif 2004, 2005 and pooled over seasons and was found significantly superior to T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>1</sub> and T<sub>16</sub> (Table 3).

#### **4.4 Number of nodes plant<sup>-1</sup> (main stem)**

Perusal of Table 3 revealed significant difference due to various treatments in respect of number of nodes plant<sup>-1</sup> (main stem). Integration of organic with inorganic sources proved comparable to recommended fertilizer dose and superior to sole as well as integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded maximum number of nodes plant<sup>-1</sup> 26.87 and 26.65 during kharif 2004 and 2005, respectively and was significantly superior to T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with the rest of the treatments. However, T<sub>24</sub> also exhibited significant increase over T<sub>19</sub> (FYM 15t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>20</sub> (SM 10t + 60: 30: 30:

N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during kharif 2005. Pooled analysis revealed that T<sub>24</sub> recorded significantly maximum number of nodes plant<sup>-1</sup> 26.82 as compared to other treatments (Table 3).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6t ha<sup>-1</sup>) recorded a node number of 25.73 and 22.85 plant<sup>-1</sup> during kharif 2004 and 2005, respectively which was significantly superior to T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>3</sub> (SM 20t ha<sup>-1</sup>), T<sub>2</sub> (FYM 30t ha<sup>-1</sup>) and T<sub>1</sub> (120: 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis also depicted that treatment T<sub>4</sub> recorded significantly superior number of nodes plant<sup>-1</sup> 24.29 as compared to T<sub>6</sub>, T<sub>5</sub>, T<sub>3</sub>, T<sub>2</sub>, T<sub>18</sub> and T<sub>25</sub> but recorded significantly lower values as compared to T<sub>1</sub> (Table 3).

Integration of organic sources depicted an increase in node number plant<sup>-1</sup> over sole application of organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) registered a node number of 26.68 and 24.66 plant<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic treatment combinations and recommended fertilizer doze. However, T<sub>7</sub> exhibited its significance over treatment combinations of T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>) and T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>) during kharif 2005. Pooled analysis also revealed the significance of T<sub>7</sub>, recording a node number of 25.67 plant<sup>-1</sup> which was significantly superior to all organic treatment

combinations viz. T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>12</sub>, T<sub>13</sub>, T<sub>14</sub>, T<sub>15</sub>, T<sub>16</sub> and T<sub>17</sub> but was statistically at par with T<sub>1</sub> (Table 3).

Integration of different organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in node number plant<sup>-1</sup> (main stem) over sole application as well as combined application of organic sources. Treatment T<sub>21</sub> (PM 3t +60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded maximum number of nodes 26.04 and 25.64 plant<sup>-1</sup> during kharif 2004 and 2005, respectively and was significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub>, T<sub>7</sub> and T<sub>1</sub>. Pooled analysis revealed the significance of T<sub>21</sub> with a node number of 25.90 plant<sup>-1</sup>, over that of T<sub>19</sub>, T<sub>20</sub>, T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>22</sub> (VC 3t +60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub> and T<sub>1</sub> (Table 3).

### **Influence of organic manures and inorganic fertilizers on yield attributes of okra**

#### **4.5 Number of fruits plant<sup>-1</sup>**

Perusal of Table 4 indicated significant influence of various treatments on number of fruits plant<sup>-1</sup>. Integration of organic sources with chemical fertilizers and RFD proved superior than sole application of organic as well as their integration.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t +PM 0.5t +VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered maximum number of fruits 28.75 and 29.20 plant<sup>-1</sup> during

kharif 2004 and 2005, respectively and was significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) and T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis also revealed that T<sub>24</sub> recorded significantly maximum number of nodes 28.93 plant<sup>-1</sup> as compared to all other treatments, except that of T<sub>1</sub> where it exhibited at par results (Table 4 and Fig.III).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded maximum number of fruits 26.80 and 26.37 plant<sup>-1</sup> during kharif 2004 and 2005, respectively and was significantly superior to T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but was found statistically at par with T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>1</sub>. Pooled analysis further revealed the significant influence of T<sub>4</sub>, recording maximum number of fruits 26.50 as compared to T<sub>2</sub>, T<sub>3</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but recorded at par results with T<sub>5</sub> and significantly lower values than T<sub>1</sub> (Table 4 and Fig. III).

Combined application of organic sources exhibited an increase in number of fruits plant<sup>-1</sup> over sole application of organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a fruit number of 28.28 and 27.40 during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par

with rest of the organic treatment combinations and recommended fertilizer dose. However during kharif 2005, T<sub>7</sub> exhibited its significance over T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>) and T<sub>14</sub>

**Table 4: Influence of organic manures and inorganic fertilizers on mean number of fruits plant<sup>-1</sup> and fruit length (cm) in okra**

Treatment	Number of fruits plant <sup>-1</sup>			Mean of main treatments	Fruit length			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	<b>29.34</b>	<b>27.56</b>	<b>28.45</b>	<b>28.48</b>	<b>14.69</b>	<b>14.02</b>	<b>14.35</b>	<b>14.35</b>
T <sub>2</sub>	24.71	23.68	24.18		13.62	13.65	13.64	
T <sub>3</sub>	25.71	25.10	25.31		14.03	13.79	13.92	
T <sub>4</sub>	26.80	26.37	26.50		14.13	13.82	13.94	
T <sub>5</sub>	26.09	25.89	25.95		13.99	13.82	13.92	
T <sub>6</sub>	17.21	19.88	18.56		13.43	13.76	13.59	
<b>Mean</b>	<b>24.10</b>	<b>24.18</b>	<b>24.10</b>	<b>24.12</b>	<b>13.84</b>	<b>13.76</b>	<b>13.80</b>	<b>13.80</b>
T <sub>7</sub>	28.28	27.40	27.84		14.51	13.90	14.20	
T <sub>8</sub>	25.48	25.12	25.22		13.81	13.72	13.76	
T <sub>9</sub>	27.57	26.29	26.86		13.89	13.81	13.80	
T <sub>10</sub>	26.66	25.81	26.21		13.87	13.78	13.83	
T <sub>11</sub>	25.21	24.10	24.75		13.73	13.74	13.73	
T <sub>12</sub>	27.98	26.52	27.25		14.09	13.93	14.01	
T <sub>13</sub>	27.28	24.84	26.06		14.25	13.91	14.08	
T <sub>14</sub>	25.97	24.91	25.45		14.13	13.79	13.91	
T <sub>15</sub>	27.86	26.63	27.30		14.29	14.00	14.15	
T <sub>16</sub>	27.90	25.87	26.97		14.18	13.93	14.09	
T <sub>17</sub>	26.97	25.89	26.50		14.11	13.79	13.99	
<b>Mean</b>	<b>27.01</b>	<b>25.76</b>	<b>26.40</b>	<b>26.93</b>	<b>14.07</b>	<b>13.84</b>	<b>13.95</b>	<b>13.95</b>
T <sub>18</sub>	<b>19.97</b>	<b>19.91</b>	<b>19.93</b>	<b>19.93</b>	<b>13.55</b>	<b>13.49</b>	<b>13.57</b>	<b>13.53</b>
T <sub>19</sub>	26.86	26.88	26.87		14.13	13.86	14.00	
T <sub>20</sub>	27.75	27.40	27.62		14.16	14.20	14.23	
T <sub>21</sub>	28.49	27.39	27.98		14.56	14.58	14.56	
T <sub>22</sub>	27.86	27.81	27.86		14.27	14.22	14.24	
T <sub>23</sub>	26.86	26.03	26.39		13.80	14.09	13.94	
T <sub>24</sub>	28.75	29.20	28.93		14.96	14.63	14.74	
<b>Mean</b>	<b>27.76</b>	<b>27.45</b>	<b>27.60</b>	<b>27.60</b>	<b>14.31</b>	<b>14.26</b>	<b>14.28</b>	<b>14.28</b>
T <sub>25</sub>	<b>13.14</b>	<b>11.72</b>	<b>12.43</b>	<b>12.43</b>	<b>13.06</b>	<b>12.99</b>	<b>13.02</b>	<b>13.02</b>
CD at 5%	3.06	2.32	0.63		1.01	0.49	0.24	

(SM 10t + BF 7 kg ha<sup>-1</sup>). Pooled analysis also revealed the significance of T<sub>7</sub>, recording a fruit number of 27.84 plant<sup>-1</sup>, which was significantly superior to all organic treatment combinations viz. T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>13</sub>, T<sub>14</sub>, T<sub>15</sub>, T<sub>16</sub>, T<sub>17</sub> except that of T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>1</sub> (Table 4 and Fig. III).

Combined application of different organic sources with recommended fertilizer dose in equal proportion (50:50) depicted an increase in fruit number over respective sole applications as well as combined application of organic sources. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a fruit number of 28.49 and 27.39 plant<sup>-1</sup> during both the seasons respectively and was found statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>1</sub> (100% RFD) but was significantly superior to T<sub>18</sub> and T<sub>25</sub>. Pooled analysis indicated that T<sub>21</sub> recorded a fruit number of 27.98 plant<sup>-1</sup> which was significantly superior to T<sub>18</sub>, T<sub>19</sub>, T<sub>23</sub> and T<sub>25</sub> but was statistically at par with T<sub>20</sub>, T<sub>22</sub>, T<sub>7</sub> and T<sub>1</sub> (Table 4 and Fig. III).

#### **4.6 Fruit length (cm)**

Perusal of Table 4 revealed significant variations due to various treatments for fruit length. Integration of organic with inorganic sources and RFD proved superior over sole application of organic sources as well as their integration.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded maximum fruit length of 14.96 cm during kharif 2004 and was significantly superior to T<sub>2</sub> (FYM 30t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + PM 10 t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15 t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with rest of the treatments. During kharif 2005, T<sub>24</sub> recorded a fruit length of 14.63 cm and was found significantly superior to the values recorded with all treatments but exhibited at par values with T<sub>20</sub> (SM 10t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t ha<sup>-1</sup> + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t ha<sup>-1</sup> + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis further revealed that T<sub>24</sub>, recorded maximum fruit length of 14.74 cm which was significantly superior to all other treatments but was statistically at par with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a fruit length of 14.13 and 13.82 cm during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>25</sub> but statistically at par with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis depicted that T<sub>4</sub> recorded a fruit length of 13.94 cm which was significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>).

<sup>1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and recorded significantly lesser fruit length as compared to T<sub>1</sub> (Table 4).

Combined application of organic sources exhibited an increase in fruit length over sole application of organics. Treatment combination of FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup> (T<sub>7</sub>) recorded a fruit length of 14.51 and 13.90 cm during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>25</sub> (control) but statistically at par with all organic treatment combinations viz. T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>12</sub>, T<sub>13</sub>, T<sub>14</sub>, T<sub>15</sub>, T<sub>16</sub>, T<sub>17</sub> and T<sub>1</sub>. Pooled analysis revealed the significance of T<sub>7</sub> recording a fruit length of 14.20 cm which was significantly superior to T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic treatment combinations and T<sub>1</sub> (Table 4).

Integration of different organic sources with recommended fertilizer dose in equal proportions (50:50) recorded increased fruit length as compared to sole application as well as combined application of organic sources. Integration of PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) recorded a fruit length of 14.56 during kharif 2004 and was significantly superior to T<sub>25</sub> but was statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub> and T<sub>1</sub>. However, during kharif 2005, T<sub>21</sub> recorded a fruit length of 14.58 cm which was significantly superior to T<sub>1</sub>, T<sub>7</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>20</sub>, T<sub>22</sub> and T<sub>23</sub>. Pooled analysis

indicated that T<sub>21</sub> recorded a fruit length of 14.56 cm which was significantly superior to T<sub>7</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>1</sub> i.e. 100% RFD (Table 4).

#### **4.7 Fruit diameter (cm)**

Perusal of Table 5 revealed significant differences for fruit diameter due to various treatments. Conjugation of organic and inorganic sources of nutrients exhibited superiority over that of sole application of organic sources as well as their integration but comparable to RFD.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a fruit diameter of 1.40 cm during kharif 2004 and was found significantly superior to all treatments but statistically at par with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). During kharif 2005, T<sub>24</sub> recorded a fruit diameter of 1.40 cm which was significantly superior to all other treatments but statistically at par with T<sub>21</sub>. However, pooled analysis revealed the significance of T<sub>24</sub> over all other treatments recording a maximum fruit diameter of 1.41 cm (Table 5).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a fruit diameter of 1.34 cm during kharif 2004 and was found significantly superior to T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was at par with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>). However, the value were significantly lower as compared to 1.40 cm recorded with T<sub>1</sub>. During kharif 2005, T<sub>4</sub> recorded a fruit diameter of 1.33 cm which was significantly superior to T<sub>2</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but was found at par with T<sub>1</sub>, T<sub>3</sub> and T<sub>5</sub>. Pooled analysis revealed that T<sub>4</sub> recorded a fruit diameter of 1.33 cm which was significantly lower than the fruit diameter 1.37 cm recorded with T<sub>1</sub> but was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub>. However, exhibited at part results with T<sub>5</sub> (Table 5).

Integration of organic sources as well as sole application of organics exhibited similar values for fruit diameter. During kharif 2004, treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a fruit diameter of 1.35 cm which was significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic treatment combinations (T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>12</sub>, T<sub>13</sub>, T<sub>14</sub>, T<sub>15</sub>, T<sub>16</sub> and T<sub>17</sub>). However, T<sub>7</sub> recorded significantly lower values as compared to T<sub>1</sub>. During kharif 2005, T<sub>7</sub> recorded a fruit T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) diameter of 1.35 cm which was statistically at par with T<sub>1</sub> and T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) but was significantly superior to rest of the organic treatment combinations, T<sub>18</sub> and T<sub>25</sub>. Pooled analysis indicated that T<sub>7</sub> recorded a

fruit diameter of 1.35 cm which was significantly superior to all organic treatment combinations, T<sub>18</sub> and T<sub>25</sub> but exhibited significantly lower values as compared to T<sub>1</sub> (Table 5).

Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) recorded higher values for fruit diameter as compared to sole application of organic sources as well as their integration. Treatment T21 (PM 3t + 60:30:30 N: P2O5: K2O kg ha<sup>-1</sup>) recorded a fruit diameter of 1.39 cm during kharif 2004 and was significantly superior to T19 (FYM 15t + 60:30:30 N: P2O5: K2O kg

**Table 5: Influence of organic manures and inorganic fertilizers on mean fruit diameter (cm) and average fruit weight (g) in okra**

Treatment	Fruit diameter			Mean of main treatments	Average fruit weight			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	1.40	1.34	1.37	1.37	14.15	13.34	13.75	13.75
T <sub>2</sub>	1.31	1.29	1.30		13.08	12.70	12.89	
T <sub>3</sub>	1.31	1.30	1.31		13.28	12.83	13.07	
T <sub>4</sub>	1.34	1.33	1.33		13.73	13.07	13.40	
T <sub>5</sub>	1.33	1.32	1.33		13.71	12.88	13.33	
T <sub>6</sub>	1.31	1.29	1.30		12.73	12.41	12.57	
<b>Mean</b>	<b>1.32</b>	<b>1.30</b>	<b>1.31</b>	<b>1.31</b>	<b>13.30</b>	<b>12.77</b>	<b>13.05</b>	<b>13.04</b>
T <sub>7</sub>	1.35	1.35	1.35		14.16	13.26	13.71	
T <sub>8</sub>	1.31	1.29	1.30		13.29	12.97	13.14	
T <sub>9</sub>	1.32	1.31	1.32		13.41	13.01	13.21	
T <sub>10</sub>	1.32	1.30	1.31		13.36	12.94	13.18	
T <sub>11</sub>	1.32	1.30	1.31		13.14	12.85	12.99	
T <sub>12</sub>	1.34	1.31	1.32		13.95	13.04	13.48	
T <sub>13</sub>	1.33	1.30	1.31		13.74	13.05	13.39	
T <sub>14</sub>	1.32	1.29	1.31		13.48	12.95	13.19	
T <sub>15</sub>	1.35	1.32	1.34		14.04	13.20	13.64	
T <sub>16</sub>	1.33	1.31	1.32		13.98	13.08	13.54	
T <sub>17</sub>	1.33	1.31	1.31		14.01	13.10	13.56	
<b>Mean</b>	<b>1.32</b>	<b>1.30</b>	<b>1.31</b>	<b>1.31</b>	<b>13.68</b>	<b>13.04</b>	<b>13.36</b>	<b>13.36</b>
T <sub>18</sub>	1.29	1.28	1.28	1.28	12.93	12.77	12.87	12.85
T <sub>19</sub>	1.35	1.32	1.34		14.02	13.23	13.62	
T <sub>20</sub>	1.37	1.34	1.36		14.17	13.46	13.85	
T <sub>21</sub>	1.39	1.39	1.39		14.30	13.66	13.95	
T <sub>22</sub>	1.37	1.35	1.36		14.31	13.44	13.84	
T <sub>23</sub>	1.34	1.31	1.33		13.84	13.22	13.51	
T <sub>24</sub>	1.40	1.40	1.41		14.95	13.86	14.14	
<b>Mean</b>	<b>1.37</b>	<b>1.35</b>	<b>1.36</b>	<b>1.36</b>	<b>14.26</b>	<b>13.47</b>	<b>13.81</b>	<b>13.84</b>
T <sub>25</sub>	1.24	1.22	1.23	1.23	12.06	11.67	11.87	11.86
CD at 5%	0.03	0.03	0.01		0.56	0.34	0.13	

ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>20</sub>, T<sub>22</sub> and T<sub>1</sub>. However during kharif 2005 and pooled over season, T<sub>21</sub> recorded significantly higher fruit diameter of 1.39 and 1.39 cm respectively as compared to T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub>, T<sub>7</sub>, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 5).

#### **4.8 Average fruit weight (g)**

Perusal of Table 5 revealed significant differences for average fruit weight due various treatments. Integration of organic with inorganic sources of nutrients, exhibited superiority over sole application of chemical fertilizers, organic sources as well as the integration of various organic sources. Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t +PM 0.5t +VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a fruit weight of 14.95, 13.86 and 14.14 g during kharif 2004, 2005 and pooled over seasons respectively and was found significantly superior to all treatments. However, during kharif 2005, the value recorded with T<sub>24</sub> was at par with the value 13.66 recorded with T<sub>21</sub> (Table 5).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a fruit weight of 13.73 and 13.07 g during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis revealed that T<sub>4</sub> registered a fruit

weight of 13.40 g, which was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>6</sub>, T<sub>18</sub> (50% RFD) and T<sub>25</sub> but was statistically at par with T<sub>5</sub>. However, the fruit weight recorded with T<sub>4</sub> was significantly lower as compared to 13.75 g recorded with T<sub>1</sub> (Table 5).

Integration of organic sources resulted an increase in fruit weight over sole application of organics. During kharif 2004, treatment combination of FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup> (T<sub>7</sub>) recorded a fruit weight of 14.16 g which was significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> but was statistically at par with T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>1</sub>. However, during kharif 2005, T<sub>7</sub> recorded a fruit weight of 13.26 g, which was significantly superior to T<sub>11</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>12</sub>, T<sub>13</sub>, T<sub>14</sub>, T<sub>15</sub>, T<sub>16</sub>, T<sub>17</sub> and T<sub>1</sub>. Pooled analysis revealed that T<sub>7</sub>, recorded a fruit weight of 13.71 g which was statistically at par with T<sub>15</sub> and T<sub>1</sub> but significantly superior to rest of organic combination, T<sub>18</sub> and T<sub>25</sub> (Table 5).

Integration of different organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in fruit weight over sole application of chemical fertilizers, organics as well as the integration of organic sources. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N:

$P_2O_5: K_2O$  kg ha<sup>-1</sup>) registered a fruit weight of 14.30 g during kharif 2004 which was significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N:  $P_2O_5: K_2O$  kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N:  $P_2O_5: K_2O$  kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N:  $P_2O_5: K_2O$  kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N:  $P_2O_5: K_2O$  kg ha<sup>-1</sup>), T<sub>7</sub> and T<sub>1</sub>. During kharif 2005, T<sub>21</sub> recorded a fruit weight of 13.66 g and was significantly superior to T<sub>19</sub>, T<sub>23</sub>, T<sub>7</sub>, T<sub>18</sub>, T<sub>25</sub> but was statistically at par with T<sub>20</sub>, T<sub>22</sub> and T<sub>1</sub>. Pooled analysis revealed that T<sub>21</sub> recorded a fruit weight of 13.95 g which was significantly superior to T<sub>19</sub>, T<sub>23</sub>, T<sub>7</sub>, T<sub>18</sub>, T<sub>25</sub> and T<sub>1</sub> but was statistically at par with T<sub>20</sub> and T<sub>22</sub> (Table 5).

#### 4.9 Fruit yield plot<sup>-1</sup> (kg)

Perusal of Table 6 revealed significant effect if different treatments on fruit yield plot<sup>-1</sup>. Among various treatments, integration of organic with inorganic sources of nutrients and RFD proved superior than combined application of organic sources as well as sole application of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t +PM 0.5t +VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N:  $P_2O_5: K_2O$  kg ha<sup>-1</sup>) recorded a fruit yield of 24.95 and 24.25 kg during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N:  $P_2O_5: K_2O$  kg ha<sup>-1</sup>) and

T<sub>25</sub> (control) but was statistically at par with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis also depicted treatment T<sub>24</sub>, to be significantly superior with maximum fruit yield of 24.53 kg plot<sup>-1</sup> as compared to rest of the treatments (Table 6).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a fruit yield of 22.32 and 20.68 kg plot<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>1</sub>, T<sub>3</sub> and T<sub>5</sub>. Pooled analysis depicted that T<sub>4</sub> recorded a fruit yield of 21.48 kg plot<sup>-1</sup> which was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but recorded significantly lower values as compared to 23.31 kg plot<sup>-1</sup> recorded with T<sub>1</sub> (Table 6).

Combined application of organic sources in equal proportions, enhanced the fruit yield plot<sup>-1</sup> over sole applications of organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) registered a fruit yield of 24.07 and 21.82 kg plot<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>8</sub>, T<sub>11</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub>, T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>1</sub>. Pooled analysis exhibited significant

superiority of T<sub>7</sub>, recording a fruit weight of 22.95 kg plot over rest of the organic combinations, T<sub>18</sub> and T<sub>25</sub> but was at par with T<sub>1</sub> (Table 6).

Integration of different organic sources with recommended fertilizers enhanced the fruit yield plot<sup>-1</sup> over sole application of organics as well as their integration. Integration of PM 3 t + 60: 30: 30 N: P<sub>2</sub>O<sub>5</sub>:

**Table 6: Influence of organic manures and inorganic fertilizers on mean fruit yield plot<sup>-1</sup> (kg) and fruit yield ha<sup>-1</sup> (q) in okra**

Treatment	Fruit yield plot <sup>-1</sup>			Mean of main treatments	Fruit yield ha <sup>-1</sup>			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	24.55	22.08	23.31	23.31	272.78	245.86	259.08	259.24
T <sub>2</sub>	19.45	18.07	18.81		216.17	200.86	209.00	
T <sub>3</sub>	20.52	19.32	19.90		227.95	214.74	221.14	
T <sub>4</sub>	22.32	20.68	21.48		248.05	229.81	238.78	
T <sub>5</sub>	21.50	20.01	20.80		238.90	222.34	231.19	
T <sub>6</sub>	13.18	14.82	13.96		146.46	164.75	155.13	
<b>Mean</b>	<b>19.39</b>	<b>18.58</b>	<b>18.99</b>	<b>18.98</b>	<b>215.50</b>	<b>206.50</b>	<b>211.04</b>	<b>211.01</b>
T <sub>7</sub>	24.07	21.82	22.95		267.46	242.53	254.99	
T <sub>8</sub>	20.34	19.57	19.98		226.06	217.45	221.08	
T <sub>9</sub>	22.18	20.53	21.29		246.44	228.14	236.67	
T <sub>10</sub>	21.38	20.07	20.73		237.73	223.00	230.37	
T <sub>11</sub>	19.93	18.57	19.27		221.45	206.40	214.13	
T <sub>12</sub>	23.45	20.77	22.17		260.56	230.84	246.38	
T <sub>13</sub>	22.50	19.44	20.97		250.00	215.99	233.00	
T <sub>14</sub>	20.97	19.32	20.15		233.05	214.73	223.95	
T <sub>15</sub>	23.44	21.08	22.33		260.51	234.32	248.18	
T <sub>16</sub>	23.74	20.29	22.03		263.77	225.48	244.77	
T <sub>17</sub>	22.67	20.11	21.45		251.89	223.47	238.30	
<b>Mean</b>	<b>22.24</b>	<b>20.14</b>	<b>21.21</b>	<b>21.19</b>	<b>247.17</b>	<b>223.85</b>	<b>235.62</b>	<b>235.54</b>
T <sub>18</sub>	15.47	15.22	15.34	15.34	171.93	169.18	170.50	170.53
T <sub>19</sub>	22.53	21.29	21.91		250.37	236.31	243.34	
T <sub>20</sub>	23.54	22.10	22.89		261.61	245.62	254.33	
T <sub>21</sub>	24.46	22.45	23.40		271.85	249.45	260.08	
T <sub>22</sub>	23.93	22.44	23.18		265.96	249.34	257.56	
T <sub>23</sub>	22.29	20.64	21.40		247.73	229.37	237.79	
T <sub>24</sub>	24.95	24.25	24.53		277.33	269.50	272.71	
<b>Mean</b>	<b>23.61</b>	<b>22.19</b>	<b>22.88</b>	<b>22.89</b>	<b>262.47</b>	<b>246.59</b>	<b>254.30</b>	<b>254.45</b>
T <sub>25</sub>	9.49	8.24	8.87	8.86	105.52	91.59	98.56	98.55
CD at 5%	3.18	2.19	0.59		35.37	24.45	6.59	

K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) recorded a fruit yield of 24.46 and 22.45 kg plot<sup>-1</sup> during kharif 2004 and 2005, respectively and was found statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub> and T<sub>1</sub> but was significantly superior to T<sub>18</sub> and T<sub>25</sub>. Pooled analysis revealed that T<sub>21</sub> registered significantly superior fruit yield of 23.40 kg plot<sup>-1</sup> over that of T<sub>19</sub>, T<sub>23</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>20</sub>, T<sub>22</sub> T<sub>7</sub> and T<sub>1</sub> (Table 6).

#### 4.10 Fruit yield ha<sup>-1</sup> (q)

Perusal of Table 6 depicted significant effect of treatments on fruit yield ha<sup>-1</sup>. Among various treatments, integration of organic with inorganic sources and RFD proved superior to combined application of organic sources as well as their sole applications.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t +PM 0.5t +VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a fruit yield of 277.33 q ha<sup>-1</sup> during kharif 2004 which was significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with rest of the treatments. During kharif 2005, T<sub>24</sub> registered a fruit yield of 269.50 q ha<sup>-1</sup> which was statistically at par with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but was

significantly superior over rest of the treatments. Pooled analysis revealed the significance of T<sub>24</sub> over rest of the treatments, recording a fruit yield of 272.71 q ha<sup>-1</sup> (Table 6 and Fig. IV).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a fruit yield of 248.05 and 229.81 q ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was significantly superior to T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>3</sub>, T<sub>5</sub> and T<sub>1</sub>. Pooled analysis revealed that T<sub>4</sub> registered a fruit yield of 238.78 q ha<sup>-1</sup> which was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but recorded significantly lower values as compared to T<sub>1</sub> (Table 6 and Fig. IV).

Integration of organic sources exhibited an increase in fruit yield ha<sup>-1</sup> over sole application of organics. Treatment combination of FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup> (T<sub>7</sub>) recorded a fruit yield of 267.46 and 242.53 q ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was significantly superior to T<sub>8</sub>, T<sub>11</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub>, T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>1</sub>. Pooled analysis exhibited significant superiority of T<sub>7</sub> recording a fruit yield of 254.99 q ha<sup>-1</sup> over rest of the organic combinations, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>1</sub> (Table 6 and Fig. IV).

Conjugation of organic sources with recommended fertilizer dose in equal proportions (50:50) enhanced the fruit yield ha<sup>-1</sup> over sole applications of organics as well as integration of organics.

Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), recorded a fruit yield of 271.85 and 249.45 q ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub>, T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub> and T<sub>1</sub>. Pooled analysis revealed that T<sub>21</sub> registered significantly superior fruit yield of 260.08 q ha<sup>-1</sup> over that of T<sub>19</sub>, T<sub>23</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>20</sub>, T<sub>22</sub>, T<sub>7</sub> and T<sub>1</sub> (Table 6 and Fig. IV).

#### **Influence of organic manure and inorganic fertilizers on seed production attributes of okra**

##### **4.11 Number of seed pods plant<sup>-1</sup>**

Perusal of Table 7 revealed significant variation for number of seed pods plant<sup>-1</sup>. Among various treatments, integration of organic with inorganic sources and RFD proved superior than integration of organics as well as sole application of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded 12.76 seed pods plant<sup>-1</sup> during kharif 2004 and was found statistically at par with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but was significantly superior to rest of the treatments. During kharif 2005, T<sub>24</sub> again registered 10.72 seed pods

plant<sup>-1</sup> which was statistically at par with T<sub>1</sub>, T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but was significantly superior to rest of the treatments. Pooled analysis revealed that T<sub>24</sub> recorded 11.76 seed pods plant<sup>-1</sup> which was statistically at par with T<sub>21</sub> T<sub>22</sub> and was significantly superior to rest of the treatments (Table 7).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded 11.01, 9.41 and 10.20 seed pods plant<sup>-1</sup> during kharif 2004, 2005 and pooled over seasons respectively and was significantly superior to T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) and also T<sub>18</sub> i.e. 50% RFD and T<sub>25</sub> (control) but was statistically at par with T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>1</sub>. However, the number of seed pods plant<sup>-1</sup> recorded with T<sub>4</sub> during kharif 2004 and pooled over seasons was significantly lower than T<sub>1</sub> (Table 7).

Integration among organic sources exhibited an increase in number of seed pods plant<sup>-1</sup>. During kharif 2004, treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded 11.52 seed pods plant<sup>-1</sup> which was significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic treatment combinations viz. T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>12</sub>, T<sub>13</sub>, T<sub>14</sub>, T<sub>15</sub>, T<sub>16</sub>, T<sub>17</sub>. T<sub>7</sub>. During kharif 2005, T<sub>7</sub> recorded 10.44 seed pods

plant<sup>-1</sup> which was statistically at par with T<sub>1</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>12</sub>, T<sub>13</sub> and T<sub>15</sub> but was significant with rest of organic combinations (T<sub>8</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>13</sub>, T<sub>14</sub>, T<sub>16</sub> and T<sub>17</sub>). Pooled analysis revealed that T<sub>7</sub> recorded 10.98 seed pods plant<sup>-1</sup> which was statistically at par with T<sub>12</sub> and T<sub>15</sub> but was significantly superior to rest of the

**Table 7: Influence of organic manures and inorganic fertilizers on mean number of seed pods plant<sup>-1</sup> and number of seeds pod<sup>-1</sup> in okra**

Treatment	Number of seed pods plant <sup>-1</sup>			Mean of main treatments	Number of seeds pod <sup>-1</sup>			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	12.44	10.28	11.36	11.36	42.88	42.00	42.44	42.44
T <sub>2</sub>	9.73	8.46	9.12		36.76	36.70	38.82	
T <sub>3</sub>	9.98	8.60	9.30		38.46	39.05	38.41	
T <sub>4</sub>	11.01	9.41	10.20		40.20	41.06	40.38	
T <sub>5</sub>	10.59	8.99	9.76		39.10	39.69	39.38	
T <sub>6</sub>	7.33	6.66	6.97		28.26	29.70	28.89	
<b>Mean</b>	<b>9.72</b>	<b>8.42</b>	<b>9.07</b>	<b>9.07</b>	<b>36.55</b>	<b>37.24</b>	<b>37.17</b>	<b>36.98</b>
T <sub>7</sub>	11.52	10.44	10.98		42.00	41.00	41.50	
T <sub>8</sub>	10.47	8.98	9.71		39.04	37.75	37.96	
T <sub>9</sub>	11.20	10.09	10.61		39.58	38.26	38.58	
T <sub>10</sub>	10.78	9.47	10.07		39.28	38.29	38.68	
T <sub>11</sub>	9.98	8.70	9.33		37.76	37.55	38.00	
T <sub>12</sub>	11.27	10.08	10.69		40.84	39.75	40.73	
T <sub>13</sub>	11.22	9.43	10.32		40.04	39.10	39.57	
T <sub>14</sub>	10.65	9.13	9.87		39.28	38.11	38.79	
T <sub>15</sub>	11.53	10.22	10.83		40.98	41.24	41.44	
T <sub>16</sub>	10.91	9.41	10.17		40.20	39.56	40.13	
T <sub>17</sub>	10.90	9.39	10.18		39.58	39.26	39.76	
<b>Mean</b>	<b>10.94</b>	<b>9.57</b>	<b>10.25</b>	<b>10.25</b>	<b>39.87</b>	<b>39.07</b>	<b>39.55</b>	<b>39.49</b>
T <sub>18</sub>	8.45	7.43	7.96	7.94	32.28	32.11	32.10	32.16
T <sub>19</sub>	11.38	10.24	10.81		40.52	40.62	40.57	
T <sub>20</sub>	11.56	10.52	11.02		41.22	41.58	41.77	
T <sub>21</sub>	12.39	10.59	11.52		42.90	42.69	42.81	
T <sub>22</sub>	12.28	10.57	11.48		41.78	41.89	41.94	
T <sub>23</sub>	11.23	10.17	10.74		40.48	40.24	40.03	
T <sub>24</sub>	12.76	10.72	11.76		44.22	43.75	43.75	
<b>Mean</b>	<b>11.93</b>	<b>10.46</b>	<b>11.22</b>	<b>11.20</b>	<b>41.85</b>	<b>41.79</b>	<b>41.81</b>	<b>41.81</b>
T <sub>25</sub>	5.54	5.21	5.37	5.37	27.42	25.38	26.40	26.40
CD at 5%	1.11	0.97	0.34		3.35	2.38	0.90	

organic combinations. However, the value recorded with T<sub>7</sub> was significantly lower than T<sub>1</sub> (Table 7).

Integration of different organic sources with recommended fertilizer dose in equal proportions (50:50) enhanced the number of seed pods plant<sup>-1</sup> over integration of organics as well as sole application of organic sources. Integration of PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) recorded 12.39 and 10.59 seed pods plant<sup>-1</sup> during kharif 2004 and 2005 respectively and was significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub>, T<sub>7</sub> and T<sub>1</sub>. Pooled analysis also depicted significance of T<sub>21</sub>, recording 11.52 number of seed pods plant<sup>-1</sup> and was significantly superior to T<sub>19</sub>, T<sub>20</sub>, T<sub>23</sub>, T<sub>18</sub> and T<sub>25</sub> but statistically at par with T<sub>22</sub> and T<sub>1</sub> (Table 7).

#### **4.12 Number of seeds pod<sup>-1</sup>**

Perusal of Table 7 depicted significant variation for number of seeds pod<sup>-1</sup>. Among various treatments, integration of organic and inorganic sources and RFD proved better than integration among organics as well as sole application of organics.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded 44.22 and 43.75 seeds pod<sup>-1</sup> during kharif 2004 and 2005, respectively and was statistically at par with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N:

$P_2O_5$ :  $K_2O$  kg ha<sup>-1</sup>) but was significantly superior to rest of the treatments. However, T<sub>24</sub> during kharif 2004, exhibited at par results with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) and T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>). Pooled analysis depicted that T<sub>24</sub> recorded significantly maximum number of seeds 43.75 pod<sup>-1</sup> over all treatments (Table 7).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded 40.20 and 41.06 seeds pod<sup>-1</sup> during kharif 2004 and 2005, respectively and was significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N:  $P_2O_5$ :  $K_2O$  kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>1</sub>, T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). Pooled analysis revealed that T<sub>4</sub> recorded 40.38 seeds pod<sup>-1</sup> which was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but was significantly lower than T<sub>1</sub> (Table 7).

Integration of organic sources exhibited an increase in seed number pod<sup>-1</sup> over sole application of organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded 42.00, 41.00 and 41.50 seeds pod<sup>-1</sup> during kharif 2004, 2005 and pooled over seasons, respectively and was found significantly superior to T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>1</sub>. However, during pooled over season, T<sub>7</sub> recorded significantly lower values as compared to T<sub>1</sub> (Table 7).

Combined application of different organic sources with recommended fertilizer dose in equal proportions (50:50) enhanced the number of seeds pod<sup>-1</sup> over sole application of organics as well as integration of organic sources. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered 42.90 and 42.69 seed pod<sup>-1</sup> during kharif 2004 and 2005, respectively and was significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub>, T<sub>22</sub>, T<sub>7</sub> and T<sub>1</sub>. However, T<sub>21</sub> exhibited significant superiority over T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during kharif 2005. Pooled analysis revealed significance of T<sub>21</sub>, recording 42.81 seed pod<sup>-1</sup> over T<sub>19</sub>, T<sub>20</sub>, T<sub>23</sub>, T<sub>7</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>22</sub> and T<sub>1</sub> (Table 7).

#### **4.13 Seed yield plant<sup>-1</sup> (g)**

Perusal of Table 8 revealed significant variation for seed yield plant<sup>-1</sup>. Among various treatments, integration of organic and inorganic sources proved superior over integration of organics as well as sole application of organic and inorganic fertilizers.

Among 25 treatment under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a seed yield of 41.84 g plant<sup>-1</sup> during kharif 2004 and was significantly superior to all other treatments except T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t +

60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) where it was statistically at par. However, during kharif 2005 and pooled over seasons T<sub>24</sub>, recorded a seed yield of 37.72 and 39.94 g plant<sup>-1</sup> and was significantly superior to all other treatments (Table 8).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a seed yield of 33.06 and 29.32 g plant<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>1</sub>, T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). However, during kharif 2004, T<sub>4</sub> recorded significantly lower values than T<sub>1</sub>. Pooled analysis revealed the significant superiority of T<sub>4</sub> recording a seed yield of 31.09 g plant<sup>-1</sup> over T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but recorded significantly lower seed yield values as compared to T<sub>1</sub> (Table 8).

Integration of different organics increased the seed yield plant<sup>-1</sup> over sole application of organics. Integration of FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup> (T<sub>7</sub>) recorded a seed yield of 36.69 and 31.49 g plant<sup>-1</sup> during kharif 2004 and 2005, respectively and was significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic combinations viz. T<sub>9</sub>, T<sub>10</sub>, T<sub>12</sub>, T<sub>13</sub>, T<sub>15</sub>, T<sub>16</sub>, T<sub>17</sub> and T<sub>1</sub>. Pooled analysis revealed that T<sub>7</sub> recorded a seed yield of 34.09 g plant<sup>-1</sup> which was significantly superior to T<sub>8</sub>, T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub>

(FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub>, T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>1</sub> (Table 8).

**Table 8: Influence of organic manures and inorganic fertilizers on mean seed yield plant<sup>-1</sup> (g) and seed yield ha<sup>-1</sup> (q) in okra**

Treatment	Seed yield plant <sup>-1</sup>			Mean of main treatments	Seed yield ha <sup>-1</sup>			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	<b>38.38</b>	<b>31.29</b>	<b>34.83</b>	<b>34.83</b>	<b>25.67</b>	<b>20.85</b>	<b>23.26</b>	<b>23.26</b>
T <sub>2</sub>	26.93	24.56	25.83		17.95	16.17	17.21	
T <sub>3</sub>	28.87	26.38	27.45		19.22	17.58	18.27	
T <sub>4</sub>	33.00	29.32	31.09		22.05	19.55	20.71	
T <sub>5</sub>	30.92	26.89	28.65		20.60	17.93	19.08	
T <sub>6</sub>	18.78	17.72	18.01		12.51	11.81	12.01	
<b>Mean</b>	<b>27.71</b>	<b>24.97</b>	<b>26.20</b>	<b>26.29</b>	<b>18.46</b>	<b>16.60</b>	<b>17.45</b>	<b>17.50</b>
T <sub>7</sub>	36.69	31.49	34.09		24.46	20.98	22.72	
T <sub>8</sub>	31.43	26.67	28.63		20.93	17.78	19.06	
T <sub>9</sub>	33.75	29.55	31.31		22.52	19.70	20.87	
T <sub>10</sub>	32.04	29.46	30.25		21.36	19.64	20.16	
T <sub>11</sub>	28.22	25.61	27.09		18.79	17.07	18.07	
T <sub>12</sub>	33.77	30.56	32.59		22.49	20.37	21.72	
T <sub>13</sub>	33.61	28.56	31.09		22.37	19.04	20.70	
T <sub>14</sub>	31.25	26.96	29.19		20.83	17.97	19.45	
T <sub>15</sub>	35.64	31.07	33.27		23.74	20.71	22.18	
T <sub>16</sub>	33.07	28.50	30.88		22.06	19.00	20.61	
T <sub>17</sub>	32.57	28.87	31.06		21.73	19.25	20.73	
<b>Mean</b>	<b>32.90</b>	<b>28.84</b>	<b>30.58</b>	<b>30.77</b>	<b>21.93</b>	<b>19.22</b>	<b>20.57</b>	<b>20.57</b>
T <sub>18</sub>	<b>23.29</b>	<b>20.07</b>	<b>21.60</b>	<b>21.65</b>	<b>15.32</b>	<b>13.38</b>	<b>14.30</b>	<b>14.33</b>
T <sub>19</sub>	35.07	31.00	33.03		23.41	20.66	22.04	
T <sub>20</sub>	35.62	32.84	34.07		23.77	21.89	22.73	
T <sub>21</sub>	39.36	32.90	36.39		26.23	21.93	24.26	
T <sub>22</sub>	37.61	33.11	35.87		25.07	22.07	23.91	
T <sub>23</sub>	34.15	27.25	30.78		22.74	18.16	20.49	
T <sub>24</sub>	41.84	37.72	39.94		27.91	25.14	26.62	
<b>Mean</b>	<b>37.27</b>	<b>32.47</b>	<b>35.01</b>	<b>34.91</b>	<b>24.85</b>	<b>21.64</b>	<b>23.34</b>	<b>23.27</b>
T <sub>25</sub>	<b>14.57</b>	<b>12.33</b>	<b>13.45</b>	<b>13.45</b>	<b>9.71</b>	<b>8.22</b>	<b>8.96</b>	<b>8.96</b>
CD at 5%	5.23	3.06	0.84		3.50	2.04	0.58	

Integration of individual organic sources and recommended fertilizer dose in equal proportions (50:50) enhanced the seed yield plant<sup>-1</sup> over sole application of organics, inorganic fertilizers and integration of organic sources. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a seed yield of 39.36 and 32.90 g plant<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub>, T<sub>7</sub> and T<sub>1</sub>. However, T<sub>21</sub> exhibited significant superiority over T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during kharif 2005. Pooled analysis revealed that T<sub>21</sub> recorded a seed yield of 36.39 g plant<sup>-1</sup> which was significantly superior to T<sub>18</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>23</sub>, T<sub>25</sub>, T<sub>7</sub> and T<sub>1</sub> but was statistically at par with T<sub>22</sub> (Table 8).

#### **4.14 Seed yield ha<sup>-1</sup> (q)**

Perusal of Table 8 revealed significant variation for seed yield ha<sup>-1</sup>. Among various treatments, integration of organics with recommended fertilizer dose proved comparable with RFD but superior than integration among organic sources and as well as sole application.

Among 25 treatment under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a seed yield of 27.91, 25.14 and 26.62 q ha<sup>-1</sup> during kharif 2004, 2005 and pooled over seasons respectively and was found significantly superior to all other treatments but during kharif 2004, T<sub>24</sub>

proved statistically at par with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a seed yield of 22.05 and 19.55 q ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). However, T<sub>4</sub> recorded significantly lower value than T<sub>1</sub> during kharif 2004 and at par value with T<sub>1</sub> during kharif 2005. Pooled analysis revealed the significance of T<sub>4</sub> recording a seed yield of 20.71 q ha<sup>-1</sup> over T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but recorded significantly lower seed yield as compared to T<sub>1</sub> (Table 8 and Fig. V).

Integration of organics increased the seed yield ha<sup>-1</sup>. Integration of FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup> (T<sub>7</sub>) registered a seed yield of 24.46 and 20.98 q ha<sup>-1</sup> during kharif 2004 and 2005 respectively and was found significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic combinations viz. T<sub>9</sub>, T<sub>10</sub>, T<sub>12</sub>, T<sub>13</sub>, T<sub>15</sub>, T<sub>16</sub>, T<sub>17</sub> and T<sub>1</sub>. Pooled analysis revealed that T<sub>7</sub> recorded a seed of 22.72 q ha<sup>-1</sup> which was significantly superior to rest of the organic combinations, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>1</sub> (Table 8 and Fig. V).

Integration of different organic sources with recommended fertilizer dose in equal proportions (50:50) enhanced the seed yield  $\text{ha}^{-1}$  over sole application of organics, inorganic fertilizers and integration of organic sources. Treatment  $T_{21}$  (PM 3t + 60:30:30 N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ) recorded a seed yield of 26.23 and 21.93  $\text{q ha}^{-1}$  during kharif 2004 and 2005, respectively and was significantly superior to  $T_{18}$  and  $T_{25}$  but was statistically at par with  $T_{19}$  (FYM 15t + 60:30:30 N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ),  $T_{20}$  (SM 10t + 60: 30: 30: N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ),  $T_{22}$  (VC 3t + 60:30:30 N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ),  $T_7$  and  $T_1$ . However,  $T_{21}$  exhibited significant superiority over  $T_{23}$  (BF 7  $\text{kg} + 60: 30: 30: \text{N: P}_2\text{O}_5: \text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ) during kharif 2005. Pooled analysis exhibited significant superiority of  $T_{21}$  over  $T_{18}$ ,  $T_{19}$ ,  $T_{20}$ ,  $T_{23}$ ,  $T_{25}$ ,  $T_7$  and  $T_1$  recording a seed yield of 24.26  $\text{q ha}^{-1}$  but was statistically at par with  $T_{22}$  (Table 8 and Fig. V).

#### **4.15 100 seed weight (g)**

Perusal of Table 9 revealed significant variation for 100 seed weight due to various treatments. Integration of organic with inorganic sources and RFD proved superior than integration of organics as well as sole application of organics.

Among 25 treatments under study, treatment  $T_{24}$  (FYM 3t + SM 2t +PM 0.5t +VC 0.6t + BF 7  $\text{kg ha}^{-1} + 60: 30: 30: \text{N: P}_2\text{O}_5: \text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ) recorded a 100 seed weight of 6.90 g during kharif 2004 which was significantly superior to all other treatments but was statistically at par with  $T_1$  i.e. 100% RFD (120:60:60 N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ),  $T_7$  (FYM 6t + SM

4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). However, during kharif 2005 and pooled over seasons T<sub>24</sub> recorded a 100 seed weight of 6.91 and 6.93 g respectively and was significantly superior to rest of the treatments (Table 9).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a 100 seed weight of 6.11 g during kharif 2004 and was significantly superior to T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). During kharif 2005, T<sub>4</sub> recorded a value of 6.13 g which was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>6</sub>, T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> but was at par with T<sub>1</sub> and T<sub>5</sub>. Pooled analysis depicted the significant superiority of T<sub>4</sub> over T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub>, recording a value of 6.11 g. However, T<sub>4</sub> recorded significantly lower values than T<sub>1</sub> during kharif 2004 and pooled over seasons (Table 9).

Integration of different organic sources, however exhibited an increase in 100 seed weight over sole application or organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a 100 seed weight of 6.47 and 6.24 g during kharif 2004 and 2005 respectively and was significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic combinations and T<sub>1</sub>. However, T<sub>7</sub> exhibited significance over T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>) and

T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>) during kharif 2005. Pooled analysis revealed that T<sub>7</sub> recorded a 100 seed weight of 6.36 g which was statistically at par with T<sub>12</sub>, T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>) and T<sub>15</sub> but was significantly superior to rest of

**Table 9: Influence of organic manures and inorganic fertilizers on mean 100 seed weight (g) and protein content (%) of dry seeds in okra**

Treatment	100-seed weight			Mean of main treatments	Protein content			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	<b>6.75</b>	<b>6.39</b>	<b>6.57</b>	<b>6.57</b>	<b>22.74</b>	<b>17.60</b>	<b>20.17</b>	<b>20.17</b>
T <sub>2</sub>	5.66	5.27	5.46		19.89	18.34	19.08	
T <sub>3</sub>	5.94	5.44	5.70		20.44	18.67	19.57	
T <sub>4</sub>	6.11	6.13	6.11		20.71	19.04	19.93	
T <sub>5</sub>	5.97	5.89	5.89		20.48	18.43	19.50	
T <sub>6</sub>	5.33	5.34	5.34		19.02	16.59	17.84	
<b>Mean</b>	<b>5.80</b>	<b>5.61</b>	<b>5.70</b>	<b>5.70</b>	<b>20.10</b>	<b>18.21</b>	<b>19.18</b>	<b>19.16</b>
T <sub>7</sub>	6.47	6.24	6.36		20.74	19.43	20.08	
T <sub>8</sub>	6.23	5.72	5.99		20.13	18.54	19.38	
T <sub>9</sub>	6.26	5.99	6.12		20.37	19.03	19.79	
T <sub>10</sub>	6.24	5.85	6.01		20.04	18.52	19.38	
T <sub>11</sub>	6.04	5.62	5.28		20.25	18.58	19.41	
T <sub>12</sub>	6.41	6.18	6.28		20.64	19.51	20.03	
T <sub>13</sub>	6.37	6.15	6.26		20.43	18.87	19.65	
T <sub>14</sub>	6.08	6.04	6.04		20.27	18.80	19.58	
T <sub>15</sub>	6.43	6.30	6.32		20.63	19.51	20.11	
T <sub>16</sub>	6.09	6.18	6.14		20.56	19.32	19.88	
T <sub>17</sub>	6.07	6.05	6.06		20.34	19.38	19.77	
<b>Mean</b>	<b>6.24</b>	<b>6.02</b>	<b>6.12</b>	<b>6.12</b>	<b>20.40</b>	<b>19.04</b>	<b>19.73</b>	<b>19.72</b>
T <sub>18</sub>	<b>5.69</b>	<b>5.36</b>	<b>5.55</b>	<b>5.53</b>	<b>19.15</b>	<b>17.18</b>	<b>18.12</b>	<b>18.15</b>
T <sub>19</sub>	6.30	6.36	6.33		20.84	20.18	20.51	
T <sub>20</sub>	6.35	6.37	6.33		21.52	20.56	21.03	
T <sub>21</sub>	6.80	6.43	6.76		22.98	21.08	21.98	
T <sub>22</sub>	6.50	6.41	6.49		21.67	20.73	21.12	
T <sub>23</sub>	6.36	6.24	6.35		21.34	20.19	20.73	
T <sub>24</sub>	6.90	6.91	6.93		23.64	21.66	22.65	
<b>Mean</b>	<b>6.53</b>	<b>6.45</b>	<b>6.53</b>	<b>6.50</b>	<b>21.99</b>	<b>20.73</b>	<b>21.33</b>	<b>21.35</b>
T <sub>25</sub>	<b>4.99</b>	<b>4.97</b>	<b>4.98</b>	<b>4.98</b>	<b>16.13</b>	<b>14.13</b>	<b>15.13</b>	<b>15.13</b>
CD at 5%	0.50	0.40	0.15		0.68	2.60	0.50	

the organic combinations, T<sub>18</sub> and T<sub>25</sub>. However, T<sub>7</sub> recorded significantly lower values than T<sub>1</sub> (Table 9).

Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in 100 seed weight over sole application as well as integration of organic sources. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a 100 seed weight of 6.80 and 6.43 g during kharif 2004 and 2005, respectively and was significantly superior to T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>7</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis also exhibited significant superiority of T<sub>21</sub> over T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub>, T<sub>7</sub>, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> recording a value of 6.76 g (Table 9).

### **Influence of organic manures and inorganic fertilizers on quality attributes of okra**

#### **4.16 Protein content of dry seeds (%)**

Perusal of Table 9 indicated significant variation due to various treatments in respect of protein content of dry seeds. Integration of organics with chemical fertilizer proved superior over integration of organics as well as sole application of organics and chemical fertilizers.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a protein content of 23.64 per cent during kharif 2004 and

was found significantly superior to all other treatments except T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) which exhibited at par results. During kharif 2005, T<sub>24</sub>, recorded a protein content of 21.66 per cent and was significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>4</sub> (PM 6 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but exhibited at par results with rest of the treatments (Table 9 and Fig. VI).

Among sole application of organics, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a protein content of 20.71 per cent during kharif 2004 and was found significantly superior to T<sub>2</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>3</sub> and T<sub>5</sub> and T<sub>4</sub> recorded significantly lower value than T<sub>1</sub>. During kharif 2005, T<sub>4</sub> recorded a protein content of 19.04 per cent which was statistically at par with T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub> and T<sub>6</sub> but significantly superior to T<sub>25</sub>. Pooled analysis revealed the significance of T<sub>4</sub>, recording a protein content of 19.93 per cent over T<sub>2</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>1</sub>, T<sub>3</sub> and T<sub>5</sub> (Table 9 and Fig. VI).

Integration of organic sources enhanced the protein content over sole application of organic. Treatment T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) recorded a protein content of 20.63 and 19.51 per cent during kharif 2004 and 2005 respectively and was significantly superior to T<sub>25</sub> but

statistically at par with rest of the organic combinations and T<sub>1</sub>. However, T<sub>15</sub> recorded significantly lower values than T<sub>1</sub> during kharif 2004. Pooled analysis also revealed the significance of T<sub>15</sub>, recording a protein content of 20.11 per cent and was significantly superior to T<sub>8</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>14</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with rest of the organic combinations viz. T<sub>7</sub>, T<sub>9</sub>, T<sub>12</sub>, T<sub>13</sub>, T<sub>16</sub>, T<sub>17</sub> and T<sub>1</sub> (Table 9 and Fig. VI).

Integrated use of different organics with recommended fertilizer dose in equal proportions (50:50) enhanced the protein content over sole application of nutrient sources (organic and inorganic) as well as integration of organics. Integration of PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) recorded a protein content of 22.98 per cent during kharif 2004 and was found significantly superior to T<sub>15</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>1</sub>. During kharif 2005, T<sub>21</sub>, recorded a protein content of 21.08 per cent which was significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>15</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub> and T<sub>23</sub>. Pooled analysis also revealed that T<sub>21</sub> recorded significantly higher protein content of 21.98 per cent over T<sub>1</sub>, T<sub>15</sub>, T<sub>18</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub> and T<sub>25</sub> (Table 9 and Fig. VI).

#### **4.17 Protein content of fresh fruits (%)**

Perusal of Table 10 revealed significant differences for protein content of fresh fruits due to various treatments. Integration of organic with inorganic sources proved comparable with RFD but exhibited superiority over sole application of organics as well as integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a protein content of 3.08 and 2.82 per cent during kharif 2004 and 2005 respectively and was found significantly superior to all other treatments but was statistically at par with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). During kharif 2005, T<sub>24</sub> exhibited at par values with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and significantly superior to all other treatments. Pooled analysis also revealed that T<sub>24</sub> recorded a protein content of 3.01 per cent which was significantly superior to rest of the treatments (Table 10 and Fig. VII).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a protein content of 2.54 and 2.36 per cent during kharif 2004 and 2005 respectively which was significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>1</sub>, T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). Pooled analysis revealed that T<sub>4</sub> recorded a protein content of 2.47 per cent which was significantly lower than T<sub>1</sub> but

exhibited significant superiority over T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 10 and Fig. VII).

Integration of organic sources exhibited an increase in protein content over sole application of organics. Treatment T7 (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a protein content of 2.57 and 2.32 per cent during kharif 2004 and 2005 respectively and was

**Table 10: Influence of organic manures and inorganic fertilizers on mean protein content (%) and fibre content (%) of fresh okra fruits**

Treatment	Protein content			Mean of main treatments	Fibre content			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	2.78	2.48	2.63	2.63	2.03	2.10	2.07	2.06
T <sub>2</sub>	2.16	1.88	2.01		1.78	1.84	1.81	
T <sub>3</sub>	2.31	2.07	2.19		1.67	1.70	1.69	
T <sub>4</sub>	2.54	2.36	2.47		1.57	1.58	1.58	
T <sub>5</sub>	2.30	2.05	2.13		1.34	1.42	1.38	
T <sub>6</sub>	1.96	1.70	1.84		1.56	1.60	1.58	
<b>Mean</b>	<b>2.25</b>	<b>2.01</b>	<b>2.12</b>	<b>2.12</b>	<b>1.58</b>	<b>1.62</b>	<b>1.60</b>	<b>1.60</b>
T <sub>7</sub>	2.57	2.32	2.45		1.36	1.45	1.40	
T <sub>8</sub>	2.30	2.04	2.18		1.59	1.59	1.60	
T <sub>9</sub>	2.33	2.12	2.25		1.59	1.59	1.57	
T <sub>10</sub>	2.28	2.04	2.13		1.50	1.55	1.45	
T <sub>11</sub>	2.23	2.02	2.13		1.61	1.60	1.60	
T <sub>12</sub>	2.48	2.26	2.36		1.53	1.57	1.55	
T <sub>13</sub>	2.41	2.24	2.32		1.46	1.48	1.47	
T <sub>14</sub>	2.33	2.21	2.29		1.58	1.57	1.57	
T <sub>15</sub>	2.57	2.40	2.45		1.44	1.44	1.36	
T <sub>16</sub>	2.46	2.26	2.35		1.44	1.48	1.48	
T <sub>17</sub>	2.42	2.23	2.30		1.37	1.38	1.38	
<b>Mean</b>	<b>2.39</b>	<b>2.19</b>	<b>2.29</b>	<b>2.29</b>	<b>1.49</b>	<b>1.51</b>	<b>1.49</b>	<b>1.49</b>
T <sub>18</sub>	2.03	1.87	1.93	1.94	2.01	2.04	2.03	2.02
T <sub>19</sub>	2.63	2.39	2.51		1.48	1.49	1.48	
T <sub>20</sub>	2.70	2.46	2.52		1.40	1.41	1.33	
T <sub>21</sub>	2.87	2.60	2.77		1.34	1.36	1.43	
T <sub>22</sub>	2.79	2.47	2.66		1.24	1.26	1.33	
T <sub>23</sub>	2.59	2.37	2.52		1.32	1.35	1.42	
T <sub>24</sub>	3.08	2.82	3.01		1.19	1.22	1.28	
<b>Mean</b>	<b>2.77</b>	<b>2.51</b>	<b>2.66</b>	<b>2.64</b>	<b>1.32</b>	<b>1.34</b>	<b>1.37</b>	<b>1.34</b>
T <sub>25</sub>	1.39	1.36	1.38	1.37	2.54	2.61	2.58	2.57
CD at 5%	0.33	0.33	0.13		0.28	0.31	0.12	

found significantly superior to T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but exhibited at par values with T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>) T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>1</sub>. Pooled analysis depicted that T<sub>7</sub> recorded a protein content of 2.45 per cent which was significantly superior to T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>14</sub>, T<sub>17</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>12</sub>, T<sub>13</sub>, T<sub>15</sub> and T<sub>16</sub>. However, the value recorded with T<sub>7</sub> was significantly lower than T<sub>1</sub> (Table 10 and Fig. VII).

Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in protein content over sole application of organics, inorganic fertilizers and integration of organic sources. Integration of PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) recorded a protein content of 2.87 and 2.60 per cent during kharif 2004 and 2005 respectively and was statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60:30:30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub>, T<sub>23</sub> (BF 7 kg + 60:30:30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub> and T<sub>1</sub> but was significantly superior to T<sub>18</sub> and T<sub>25</sub>. Pooled analysis revealed that T<sub>21</sub> recorded a protein content of 2.77 per cent which was significantly superior to T<sub>19</sub>, T<sub>20</sub>, T<sub>23</sub>, T<sub>7</sub>, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>22</sub> (Table 10).

#### 4.18 Fibre content of fresh fruits (%)

Perusal of Table 10 revealed that different treatments significantly effected fibre content of fresh fruits. Among various treatments, integration of organic and inorganic sources exhibited a decrease in fibre content over sole application of organics, integration of organic sources and inorganic fertilizers.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a fibre content of 1.19 and 1.22 per cent during kharif 2004 and 2005 respectively which was significantly lower than the values recorded with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>4</sub> (PM 6 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis revealed that T<sub>24</sub> recorded a fibre content of 1.28 per cent which was statistically at par with T<sub>5</sub>, T<sub>7</sub>, T<sub>15</sub>,

T<sub>17</sub>, T<sub>20</sub> and T<sub>22</sub> but exhibited significantly lower values than rest of the treatments (Table 10 and Fig. VIII).

Among sole application of organic sources, treatment T<sub>5</sub> (VC 6t ha<sup>-1</sup>) recorded a fibre content of 1.34 and 1.42 per cent during kharif 2004 and 2005 respectively which was significantly lower than T<sub>1</sub>, T<sub>2</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>4</sub> and T<sub>6</sub>. Pooled analysis depicted that T<sub>5</sub> recorded a fibre content of 1.38 per cent which was significantly lower than the values recorded with T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 10).

Integration among organic sources exhibited a decrease in fibre content over sole application of organics and inorganic fertilizers. Treatment T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) recorded a fibre content of 1.44 and 1.44 per cent during kharif 2004 and 2005 respectively which was significantly lower than the values recorded with T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic integration treatments (T<sub>7</sub>, T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>12</sub>, T<sub>13</sub>, T<sub>14</sub>, T<sub>16</sub> and T<sub>17</sub>). Pooled analysis indicated that T<sub>15</sub> recorded a fibre content of 1.36 per cent which was statistically at par with T<sub>7</sub>, T<sub>10</sub>, T<sub>13</sub>, T<sub>16</sub> and T<sub>17</sub> but recorded significantly lower fibre content than rest of organic integration treatments, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 10).

Integration of different organic sources with recommended fertilizer dose in equal proportion (50:50) exhibited a decrease in fibre content over sole application of organics, inorganic fertilizers and

integration of organics. Treatment T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a fibre content of 1.24 and 1.26 per cent during kharif 2004 and 2005, respectively which was significantly lower than T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>7</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>21</sub> and T<sub>23</sub>. Pooled analysis indicated that T<sub>22</sub> recorded a fibre content of 1.33 per cent which was significantly lower than T<sub>19</sub>, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>20</sub>, T<sub>21</sub>, T<sub>23</sub> and T<sub>7</sub> (Table 10 and Fig. VIII).

#### **4.19 Vitamin C content (mg 100 g<sup>-1</sup> of fresh weight)**

Perusal of Table 11 revealed significant variation due to various treatments in respect of vitamin C content of fresh okra fruits. Integration of organic with inorganic sources proved superior over sole application of organics and inorganic fertilizer as well as the integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a vitamin C content of 17.56 and 17.25 mg 100 g<sup>-1</sup> during kharif 2004 and 2005 respectively and was significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with rest of the treatments. However, T<sub>24</sub> exhibited significant superiority over T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during kharif 2004 and over T<sub>10</sub> (FYM 15t + VC 3t

ha<sup>-1</sup>) and T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>) during kharif 2005. Pooled analysis revealed that T<sub>24</sub> recorded significantly maximum vitamin C content of 17.59 mg as compared to all other treatments but was statistically at par with T<sub>21</sub> (Table 11 and Fig. IX).

**Table 11: Influence of organic manures and inorganic fertilizers on mean vitamin C content (mg 100g<sup>-1</sup> of fresh weight) and dry matter content (%) of okra fruits**

Treatment	Vitamin C content			Mean of main treatments	Dry matter content			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	13.38	12.98	13.18	13.18	12.43	11.46	11.95	11.94
T <sub>2</sub>	14.95	14.08	14.45		9.97	9.91	9.87	
T <sub>3</sub>	15.18	15.22	15.11		10.19	9.96	9.96	
T <sub>4</sub>	16.00	16.11	16.03		11.26	10.27	10.74	
T <sub>5</sub>	15.43	15.23	15.15		10.49	10.21	10.35	
T <sub>6</sub>	12.90	14.18	13.60		9.42	9.30	9.43	
<b>Mean</b>	<b>14.89</b>	<b>14.96</b>	<b>14.86</b>	<b>14.90</b>	<b>10.26</b>	<b>9.93</b>	<b>10.07</b>	<b>10.08</b>
T <sub>7</sub>	16.53	15.73	16.13		11.47	10.87	11.17	
T <sub>8</sub>	15.05	14.27	14.63		10.00	10.08	10.00	
T <sub>9</sub>	15.27	15.41	15.38		11.08	10.13	10.66	
T <sub>10</sub>	15.35	15.08	15.10		10.74	10.20	10.47	
T <sub>11</sub>	15.23	14.20	14.91		9.59	9.96	9.89	
T <sub>12</sub>	15.95	15.97	15.98		11.31	10.43	10.91	
T <sub>13</sub>	16.13	15.41	15.77		11.00	10.02	10.51	
T <sub>14</sub>	15.50	15.05	15.34		10.76	9.97	10.46	
T <sub>15</sub>	16.66	16.27	16.37		11.48	10.54	11.12	
T <sub>16</sub>	16.00	16.06	16.05		11.25	10.44	10.87	
T <sub>17</sub>	15.62	15.66	15.59		11.03	10.26	10.59	
<b>Mean</b>	<b>15.75</b>	<b>15.37</b>	<b>15.56</b>	<b>15.56</b>	<b>10.88</b>	<b>10.26</b>	<b>10.60</b>	<b>10.58</b>
T <sub>18</sub>	12.80	12.95	12.81	12.85	9.96	9.69	9.73	9.79
T <sub>19</sub>	15.17	15.64	15.40		11.76	11.09	11.43	
T <sub>20</sub>	15.73	15.61	15.51		12.17	11.64	11.92	
T <sub>21</sub>	16.86	16.43	16.83		12.41	12.05	12.24	
T <sub>22</sub>	16.73	15.88	16.42		12.14	11.85	11.93	
T <sub>23</sub>	16.41	15.82	16.21		11.41	10.98	10.09	
T <sub>24</sub>	17.56	17.26	17.59		13.19	12.75	12.95	
<b>Mean</b>	<b>16.41</b>	<b>16.10</b>	<b>16.32</b>	<b>16.27</b>	<b>12.18</b>	<b>11.72</b>	<b>11.92</b>	<b>11.94</b>
T <sub>25</sub>	11.78	11.24	11.51	11.51	9.07	9.91	9.13	9.37
CD at 5%	2.21	2.10	0.85		1.47	0.89	0.38	

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) registered a vitamin C content of 16.00 and 16.11 mg during kharif 2004 and 2005 respectively and was significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>2</sub>, T<sub>3</sub> and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). However, T<sub>4</sub> exhibited significant superiority over and at par results with T<sub>6</sub> during kharif 2004 and 2005, respectively. Pooled analysis also revealed significant effect of T<sub>4</sub>, recording a vitamin C content of 16.03 mg and was found significantly superior to T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 11 and Fig. IX).

Integration of organic sources exhibited an increase in vitamin C content over sole application of organics as well as inorganic fertilizers. Treatment T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) recorded a vitamin C content of 16.66 and 16.27 mg during kharif 2004 and 2005 respectively and was found significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with rest of the organic combinations. Pooled analysis also revealed the significance of T<sub>15</sub>, recording a vitamin C content of 16.37 mg which was significantly superior to T<sub>8</sub>, T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub>, T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with rest of the organic combinations (Table 11 and Fig. IX).

Integration of organic with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in vitamin C content over sole application of organics, inorganic fertilizers and combined application of organics. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>)

recorded a vitamin C content of 16.86 and 16.43 mg during kharif 2004 and 2005 respectively and was found significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but was at par with the vitamin C content recorded with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>15</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis also revealed the significance of T<sub>21</sub>, recording a vitamin C content of 16.83 mg. and was significantly superior to T<sub>1</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>7</sub>, T<sub>15</sub>, T<sub>22</sub> and T<sub>23</sub> (Table 11 and Fig. IX).

#### **4.20 Dry matter content (%)**

Dry matter content was significantly affected by different treatments (Table 11). Among various treatments, integration of organic with inorganic sources and RFD proved superior than sole application of organics as well as integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a dry matter content of 13.19 per cent during kharif 2004 and was significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>4</sub> (PM 6 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with rest of the treatment. During kharif 2005, T<sub>24</sub>

recorded a dry matter content of 12.75 per cent and was found significantly superior to all other treatments with exception of T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis revealed that T<sub>24</sub> recorded a dry matter of content of 12.95 per cent and was significantly superior to all other treatments (Table 11).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a dry matter content of 11.26 and 10.27 per cent during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>6</sub> but exhibited at par results with T<sub>2</sub>, T<sub>3</sub> and T<sub>5</sub>. However, during kharif 2005, it exhibited significantly lower values than T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis also revealed the significance of T<sub>4</sub> recording a dry matter content of 10.74 per cent which was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but recorded significantly lower values than T<sub>1</sub> (Table 11).

Integration of organic sources enhanced the dry matter content over sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a dry matter content of 11.47 and 10.87 per cent during kharif 2004 and 2005 and was significantly superior to T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic integration treatments and T<sub>1</sub>. However, T<sub>7</sub> exhibited significant superiority over T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>) during kharif 2005. Pooled analysis revealed that T<sub>7</sub> recorded a dry matter content of 11.17 per cent which was statistically

at par with T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) but recorded significantly higher values than rest of the organic combinations, T<sub>18</sub> and T<sub>25</sub> (Table 11).

Integration of organic sources with recommended fertilizer dose in a ratio of 50:50 enhanced the dry matter content over sole application of organics, inorganic fertilizers and integration of organic sources. Treatment combination of T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a dry matter content of 12.41 per cent during kharif 2004 and was found significantly superior to T<sub>18</sub> and control but exhibited at par results with T<sub>7</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>23</sub> and T<sub>1</sub>. However during kharif 2005 and pooled over seasons, T<sub>21</sub> recorded a dry matter content of 12.05 and 12.24 per cent which was significantly superior to T<sub>7</sub>, T<sub>19</sub>, T<sub>23</sub>, T<sub>18</sub> and T<sub>25</sub> but was at par with T<sub>1</sub>, T<sub>20</sub> and T<sub>22</sub> (Table 11).

### **Influence of organic manures and inorganic fertilizers on nutrient uptake in okra plants**

#### **4.21 Nitrogen uptake (kg ha<sup>-1</sup>)**

Perusal of Table 12 revealed significant variation for nitrogen uptake by okra plants. Among various treatments, integration of organic and inorganic sources proved superior to sole application of organics, inorganic fertilizers as well as integration of organics.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a nitrogen uptake of 132.17, 132.68 and 132.23 kg ha<sup>-1</sup> during kharif 2004, 2005 and pooled over seasons respectively and was found significantly superior to all other treatments but exhibited at par

**Table 12: Influence of organic manures and inorganic fertilizers on mean nitrogen and phosphorus uptake (kg ha<sup>-1</sup>) in okra plants**

Treatment	Nitrogen uptake			Mean of main treatments	Phosphorus uptake			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	<b>116.20</b>	<b>98.53</b>	<b>107.36</b>	<b>107.36</b>	<b>21.10</b>	<b>18.38</b>	<b>19.74</b>	<b>19.74</b>
T <sub>2</sub>	67.70	60.90	63.86		14.99	13.45	14.26	
T <sub>3</sub>	75.01	70.71	70.86		16.45	14.03	15.20	
T <sub>4</sub>	94.51	89.40	91.37		19.81	17.28	18.64	
T <sub>5</sub>	85.12	73.26	78.81		16.57	14.50	15.58	
T <sub>6</sub>	49.37	49.33	50.49		10.60	10.52	10.52	
<b>Mean</b>	<b>74.34</b>	<b>68.72</b>	<b>71.07</b>	<b>71.37</b>	<b>15.68</b>	<b>13.95</b>	<b>14.84</b>	<b>14.82</b>
T <sub>7</sub>	112.53	96.89	104.71		20.79	18.29	19.54	
T <sub>8</sub>	73.95	70.45	71.34		16.19	15.31	15.67	
T <sub>9</sub>	89.52	86.29	88.47		19.07	17.23	18.20	
T <sub>10</sub>	84.59	80.82	83.46		17.27	15.52	16.41	
T <sub>11</sub>	72.72	69.40	73.07		15.45	13.89	14.71	
T <sub>12</sub>	98.11	90.83	95.33		20.19	17.49	18.92	
T <sub>13</sub>	91.14	84.87	88.01		17.75	16.12	16.94	
T <sub>14</sub>	78.51	78.24	79.80		16.70	15.54	16.26	
T <sub>15</sub>	103.96	95.50	101.35		20.45	17.71	19.17	
T <sub>16</sub>	97.55	89.72	94.22		20.24	16.96	18.51	
T <sub>17</sub>	90.52	90.49	89.94		19.48	16.88	18.12	
<b>Mean</b>	<b>90.28</b>	<b>84.86</b>	<b>88.15</b>	<b>87.76</b>	<b>18.50</b>	<b>16.44</b>	<b>17.49</b>	<b>17.47</b>
T <sub>18</sub>	<b>68.39</b>	<b>69.98</b>	<b>67.76</b>	<b>68.71</b>	<b>10.75</b>	<b>10.89</b>	<b>10.69</b>	<b>10.77</b>
T <sub>19</sub>	100.25	101.09	100.67		20.46	19.60	20.03	
T <sub>20</sub>	108.64	109.40	109.22		23.49	21.93	22.67	
T <sub>21</sub>	124.26	118.73	121.88		29.48	26.45	27.92	
T <sub>22</sub>	116.27	111.90	113.33		26.00	23.06	24.52	
T <sub>23</sub>	103.53	97.74	99.01		22.98	21.49	22.14	
T <sub>24</sub>	132.17	132.68	132.33		32.21	31.51	31.91	
<b>Mean</b>	<b>114.18</b>	<b>111.92</b>	<b>112.72</b>	<b>113.10</b>	<b>25.77</b>	<b>24.00</b>	<b>24.86</b>	<b>24.87</b>
T <sub>25</sub>	<b>35.67</b>	<b>21.70</b>	<b>28.69</b>	<b>28.68</b>	<b>6.62</b>	<b>4.84</b>	<b>5.73</b>	<b>5.73</b>
CD at 5%	13.93	11.45	3.08		1.86	2.44	0.84	

results with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during kharif 2004 and 2005 (Table 12 and Fig. X).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a nitrogen uptake of 94.51 and 89.40 kg ha<sup>-1</sup> during kharif 2004 and 2005 respectively which was significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). However, during kharif 2004, T<sub>4</sub> recorded significantly lower values than T<sub>1</sub>. Pooled analysis revealed the significant superiority of T<sub>4</sub> over sole application, T<sub>18</sub> and T<sub>25</sub>, recording a nitrogen uptake of 91.37 kg ha<sup>-1</sup> (Table 12 and Fig. X).

Integration of organics, exhibited an increase in nitrogen uptake over sole application of organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a nitrogen uptake of 112.53 kg ha<sup>-1</sup> during kharif 2004, which was statistically at par with T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>1</sub> but significantly superior to rest of the organic combinations, T<sub>18</sub> and T<sub>25</sub>. During kharif 2005, T<sub>7</sub> registered a nitrogen uptake of 96.89 kg ha<sup>-1</sup> and was significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic combinations. Pooled analysis revealed that T<sub>7</sub> recorded a nitrogen uptake of 104.71 kg ha<sup>-1</sup>

and was significantly superior to all organic combinations, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>1</sub> (Table 12 and Fig. X).

Integration of organics with recommended fertilizer dose in equal proportion (50:50) increased the nitrogen uptake over sole application of organics, inorganic fertilizers and integration of organics. Treatment combination of PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) recorded a nitrogen uptake of 124.26 kg ha<sup>-1</sup> during kharif 2004 and was significantly superior to T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub> and T<sub>1</sub>. During kharif 2005, T<sub>21</sub> exhibited significant superiority over T<sub>7</sub>, T<sub>19</sub>, T<sub>23</sub>, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub>, recording a nitrogen uptake of 118.73 kg ha<sup>-1</sup> but exhibited at par results with T<sub>20</sub> and T<sub>22</sub>. Pooled analysis revealed the significant superiority of T<sub>21</sub> over T<sub>1</sub>, T<sub>7</sub>, T<sub>18</sub>, T<sub>25</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub> and T<sub>23</sub>, recording a nitrogen uptake of 121.88 kg ha<sup>-1</sup> (Table 12 and Fig. X).

#### **4.22 Phosphorus uptake (kg ha<sup>-1</sup>)**

Perusal of Table 12 depicted significant variation for phosphorus uptake by okra plants. Among various treatments, integration of organic with inorganic sources proved superior to sole application of organics, inorganic fertilizers and integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a phosphorus uptake of 32.21, 31.51 and 31.91 kg ha<sup>-1</sup> during

kharif 2004, 2005 and pooled over seasons respectively and was found significantly superior to all other treatments (Table 12 and Fig. XI).

Among sole application of organics, treatment T<sub>4</sub> (PM 6t ha<sup>-1</sup>) recorded a phosphorus uptake of 19.81, 17.28 and 18.64 kg ha<sup>-1</sup> during kharif 2004, 2005 and pooled over seasons, respectively and was found significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but exhibited at par results with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during kharif 2004 and 2005 and lower values than T<sub>1</sub> in pooled analysis (Table 12 and Fig. XI).

Integration among organic sources enhanced the phosphorus uptake over sole application of organic sources. Integration of FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup> (T<sub>7</sub>) registered a phosphorus uptake of 20.79 and 18.29 kg ha<sup>-1</sup> during kharif 2004 and 2005, respectively and exhibited significant superiority over T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was at par with T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>1</sub>. However, T<sub>7</sub> exhibited significant superiority over T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>) and T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>) during kharif 2004 and at par results with T<sub>13</sub> and T<sub>14</sub> during kharif 2005. Pooled analysis revealed that T<sub>7</sub> registered a phosphorus uptake of 19.54 kg ha<sup>-1</sup> which was significantly superior to T<sub>8</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub>, T<sub>13</sub>, T<sub>14</sub>, T<sub>16</sub>, T<sub>17</sub>, T<sub>18</sub>

and T<sub>25</sub> but exhibited at par results with T<sub>12</sub>, T<sub>15</sub> and T<sub>1</sub> (Table 12 and Fig. XI).

Integration of organic sources with recommended fertilizer dose in equal proportions (50:50) enhanced the phosphorus uptake in okra plants over sole application of organics, inorganic fertilizers and integration of organics. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a phosphorus uptake of 29.48, 26.45 and 27.92 kg ha<sup>-1</sup> during kharif 2004, 2005 and pooled over seasons respectively and was found significantly superior to all organic and inorganic integrations, T<sub>1</sub>, T<sub>7</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 12 and Fig. XI).

#### **4.23 Potassium uptake (kg ha<sup>-1</sup>)**

Perusal of Table 13 revealed significant variation due to various treatments in respect of potassium uptake. Among various treatments, integration of organics and inorganics proved superior over sole application of organics, inorganic fertilizers as well as integration of organics.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a potassium uptake of 147.48, 133.08 and 139.35 kg ha<sup>-1</sup> during kharif 2004, 2005 and pooled over seasons respectively and was found significantly superior to all other treatments (Table 13 and Fig. XII).

Among sole application of organics, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a potassium uptake of 90.33, 73.71 and 79.74 kg ha<sup>-1</sup> during

kharif 2004, 2005 and pooled over seasons, respectively and was found significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>5</sub> (VC 6t ha<sup>-1</sup>). However, T<sub>4</sub> exhibited at par results with T<sub>3</sub> during kharif 2005 and significantly lower values than T<sub>1</sub> in pooled over analysis (Table 13 and Fig. XII).

**Table 13: Influence of organic manures and inorganic fertilizers on mean potassium and sulphur uptake (kg ha<sup>-1</sup>) in okra plants**

Treatment	Potassium uptake			Mean of main treatments	Sulphur uptake			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	<b>107.36</b>	<b>95.48</b>	<b>101.42</b>	<b>101.42</b>	<b>16.06</b>	<b>14.36</b>	<b>15.21</b>	<b>15.21</b>
T <sub>2</sub>	65.46	60.83	62.56		12.48	11.76	12.10	
T <sub>3</sub>	75.36	70.58	71.93		13.00	12.58	12.74	
T <sub>4</sub>	90.33	73.71	79.74		14.36	13.51	13.79	
T <sub>5</sub>	78.58	71.57	75.86		13.91	12.96	13.25	
T <sub>6</sub>	42.97	43.33	73.74		10.00	9.65	9.86	
<b>Mean</b>	<b>70.54</b>	<b>64.00</b>	<b>66.76</b>	<b>67.10</b>	<b>12.75</b>	<b>12.09</b>	<b>12.34</b>	<b>12.39</b>
T <sub>7</sub>	105.07	92.70	98.88		15.80	14.19	14.99	
T <sub>8</sub>	76.10	69.97	72.58		13.17	12.66	12.89	
T <sub>9</sub>	91.32	82.82	86.45		14.40	13.35	13.75	
T <sub>10</sub>	78.45	72.24	75.65		13.94	12.96	13.29	
T <sub>11</sub>	66.57	60.04	64.35		12.60	12.05	12.37	
T <sub>12</sub>	93.04	84.81	89.68		14.98	13.45	14.25	
T <sub>13</sub>	87.55	79.87	83.71		14.26	12.60	13.43	
T <sub>14</sub>	81.57	74.10	77.66		13.48	12.54	12.92	
T <sub>15</sub>	94.30	85.87	90.54		15.25	13.60	14.30	
T <sub>16</sub>	92.37	82.91	88.86		15.18	13.20	14.34	
T <sub>17</sub>	90.74	82.78	87.39		14.70	13.08	14.01	
<b>Mean</b>	<b>87.00</b>	<b>78.91</b>	<b>83.25</b>	<b>83.05</b>	<b>14.34</b>	<b>13.06</b>	<b>13.68</b>	<b>13.69</b>
T <sub>18</sub>	<b>48.04</b>	<b>43.49</b>	<b>45.94</b>	<b>45.82</b>	<b>11.55</b>	<b>9.88</b>	<b>10.81</b>	<b>10.74</b>
T <sub>19</sub>	104.09	93.59	98.84		18.18	18.26	18.22	
T <sub>20</sub>	115.08	104.17	110.56		19.42	18.29	18.82	
T <sub>21</sub>	131.71	118.74	125.51		21.18	20.41	20.97	
T <sub>22</sub>	120.00	109.27	114.33		19.66	18.54	19.26	
T <sub>23</sub>	99.13	95.15	96.38		19.08	17.90	18.62	
T <sub>24</sub>	147.48	133.08	139.35		21.74	21.21	21.51	
<b>Mean</b>	<b>119.58</b>	<b>109.00</b>	<b>114.16</b>	<b>114.24</b>	<b>19.87</b>	<b>19.10</b>	<b>19.56</b>	<b>19.51</b>
T <sub>25</sub>	<b>25.31</b>	<b>23.49</b>	<b>24.40</b>	<b>24.40</b>	<b>7.10</b>	<b>5.50</b>	<b>6.30</b>	<b>6.30</b>
CD at 5%	13.97	9.45	4.22		1.49	1.53	0.44	

Integration of organic sources increased the potassium uptake over sole application of organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) registered a potassium uptake of 105.07 and 92.70 kg ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis depicted significant superiority of T<sub>7</sub>, recording potassium uptake of 98.88 kg ha<sup>-1</sup> over all organic integration treatments, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>1</sub> (Table 13 and Fig. XII).

Integration of different organic sources with recommended fertilizer dose in equal proportion (50:50) recorded an increase in potassium uptake by okra plants over sole application of organics, inorganic fertilizers and combined application of organic sources. Treatment integration of PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) recorded a potassium uptake of 131.71, 118.74 and 125.51 kg ha<sup>-1</sup> during kharif 2004, 2005 and pooled over seasons respectively and was found significantly superior to T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg

ha<sup>-1</sup>), T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub>. However, T<sub>21</sub> exhibited at par results with T<sub>22</sub> during kharif 2004 (Table 13 and Fig. XII).

#### 4.24 Sulphur uptake (kg ha<sup>-1</sup>)

Perusal of Table 13 revealed significant variation for sulphur uptake by okra plants due to various treatments. Integration of organic with inorganic sources proved more efficient in enhancing sulphur uptake than sole application of organics, inorganic fertilizers and integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a sulphur uptake of 21.74, 21.21 and 21.51 kg ha<sup>-1</sup> during kharif 2004, 2005 and pooled over seasons, respectively and was found significantly superior to all other treatments (Table 13 and Fig. XIII).

Among sole application of organics, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) registered a sulphur uptake of 14.36 and 13.51 kg ha<sup>-1</sup> during kharif 2004 and 2005, respectively and exhibited significant superiority over T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). However, T<sub>4</sub> exhibited at par results with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during kharif 2005 and recorded significantly lower values than T<sub>1</sub> during kharif 2004. Pooled

analysis revealed that T<sub>4</sub> recorded a sulphur uptake of 13.79 kg ha<sup>-1</sup> which was significantly superior to T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited significantly lower values than T<sub>1</sub> (Table 13 and Fig. XIII).

Integration among organic sources depicted an increase in sulphur uptake over sole application or organic sources. Treatment combination of FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup> (T<sub>7</sub>) registered a sulphur uptake of 15.80 and 14.19 kg ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>1</sub>. Pooled analysis revealed that T<sub>7</sub> recorded significantly superior sulphur uptake of 14.99 kg ha<sup>-1</sup> over that of all organic integration treatments, T<sub>18</sub> and T<sub>25</sub> (Table 13 and Fig. XIII).

#### **4.25 Calcium uptake (kg ha<sup>-1</sup>)**

Perusal of Table 14 revealed significant variations for calcium uptake due to various treatments. Integration of organics with inorganics proved superior than sole application or organics, inorganic fertilizers and integration of organic sources.

Among 25 treatments under study treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a calcium uptake of 136.64 and 134.10 kg ha<sup>-1</sup> during kharif

2004 and 2005, respectively and was found statistically at par with T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and significantly superior to rest of the treatments. However, T<sub>24</sub> exhibited at par results with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during kharif 2005. Pooled analysis revealed the significant superiority of T<sub>24</sub> over rest of the treatments, recording a calcium uptake of 135.37 kg ha<sup>-1</sup> (Table 14 and Fig. XIV).

Among sole application of organics, treatment T<sub>4</sub> (PM 3t ha<sup>-1</sup>) recorded a calcium uptake of 99.28 and 90.10 kg ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but exhibited at par results with T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis revealed significant superiority of T<sub>4</sub> over T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> recording a calcium uptake of 94.08 kg ha<sup>-1</sup> (Table 14 and Fig. XIV).

Integration of organic sources however, exhibited an increase in calcium uptake over sole application of organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a calcium uptake of 106.89 and 95.03 kg ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with rest of the organic integrations and

T<sub>1</sub>. However, T<sub>7</sub> exhibited significant superiority over T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>) and T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>) during kharif 2004. Pooled analysis revealed the significant superiority of T<sub>7</sub> over rest of the organic integrations, recording a calcium uptake of 100.96 kg ha<sup>-1</sup> but exhibited at par results with T<sub>1</sub> (Table 14 and Fig. XIV).

Integration of organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in calcium uptake over

**Table 14: Influence of organic manures and inorganic fertilizers on mean calcium and magnesium uptake (kg ha<sup>-1</sup>) in okra plants**

Treatment	Calcium uptake			Mean of main treatments	Magnesium uptake			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	<b>107.92</b>	<b>98.04</b>	<b>102.98</b>	<b>102.98</b>	<b>55.49</b>	<b>48.57</b>	<b>52.03</b>	<b>52.03</b>
T <sub>2</sub>	85.90	78.83	82.16		44.04	41.29	42.64	
T <sub>3</sub>	89.96	84.49	86.67		45.12	44.03	44.38	
T <sub>4</sub>	99.28	90.10	94.08		50.73	47.27	48.58	
T <sub>5</sub>	95.05	86.77	90.29		49.19	45.26	46.81	
T <sub>6</sub>	58.21	64.72	61.67		29.85	33.95	31.92	
<b>Mean</b>	<b>85.68</b>	<b>80.98</b>	<b>82.97</b>	<b>83.21</b>	<b>43.78</b>	<b>42.36</b>	<b>42.86</b>	<b>43.00</b>
T <sub>7</sub>	106.89	95.03	100.96		54.62	49.53	52.07	
T <sub>8</sub>	89.79	85.26	87.17		45.85	44.53	45.02	
T <sub>9</sub>	99.08	89.52	93.88		50.46	46.84	48.26	
T <sub>10</sub>	95.20	86.96	90.66		48.95	45.24	46.71	
T <sub>11</sub>	87.40	80.97	84.74		44.72	42.41	43.77	
T <sub>12</sub>	103.36	90.57	97.32		52.80	47.27	50.21	
T <sub>13</sub>	98.66	85.47	92.06		50.33	44.32	47.33	
T <sub>14</sub>	92.85	84.25	88.49		47.11	44.06	45.37	
T <sub>15</sub>	104.71	91.48	97.82		53.60	47.61	50.38	
T <sub>16</sub>	104.27	88.11	97.03		53.48	46.30	50.31	
T <sub>17</sub>	101.14	87.48	94.72		51.52	46.83	49.06	
<b>Mean</b>	<b>98.48</b>	<b>87.73</b>	<b>93.16</b>	<b>93.12</b>	<b>50.31</b>	<b>45.90</b>	<b>48.04</b>	<b>48.08</b>
T <sub>18</sub>	<b>68.54</b>	<b>66.32</b>	<b>67.49</b>	<b>67.45</b>	<b>34.82</b>	<b>34.80</b>	<b>35.03</b>	<b>34.88</b>
T <sub>19</sub>	123.91	122.51	123.21		64.94	61.63	63.29	
T <sub>20</sub>	130.17	127.84	129.01		67.96	63.76	65.86	
T <sub>21</sub>	133.19	129.87	132.15		68.89	64.67	67.20	
T <sub>22</sub>	131.77	129.60	131.09		68.22	64.55	66.78	
T <sub>23</sub>	123.19	117.11	120.21		64.28	58.92	61.82	
T <sub>24</sub>	136.64	134.10	135.37		71.54	69.62	70.58	
<b>Mean</b>	<b>129.81</b>	<b>126.83</b>	<b>128.50</b>	<b>128.38</b>	<b>67.63</b>	<b>63.85</b>	<b>65.92</b>	<b>65.80</b>
T <sub>25</sub>	<b>38.02</b>	<b>36.64</b>	<b>37.33</b>	<b>37.33</b>	<b>20.38</b>	<b>18.15</b>	<b>19.27</b>	<b>19.26</b>
CD at 5%	13.30	11.22	3.18		5.81	6.03	1.63	

organic integration as well as sole application of organics and inorganic fertilizers. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a calcium uptake of 133.19 kg during kharif 2004 which was significantly superior to T<sub>1</sub>, T<sub>7</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub> and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). During kharif 2005, T<sub>21</sub> registered a calcium uptake of 129.87 kg ha<sup>-1</sup> and was found significantly superior to T<sub>7</sub>, T<sub>11</sub>, T<sub>23</sub>, T<sub>18</sub> and T<sub>25</sub> but was comparable with T<sub>19</sub>, T<sub>20</sub> and T<sub>22</sub>. Pooled analysis depicted significant superiority of T<sub>21</sub> over T<sub>1</sub>, T<sub>7</sub>, T<sub>19</sub>, T<sub>23</sub>, T<sub>18</sub> and T<sub>25</sub>, recording a calcium uptake of 132.15 kg ha<sup>-1</sup> but was statistically at par with T<sub>20</sub> and T<sub>22</sub> (Table 14 and Fig. XIV).

#### **4.26 Magnesium uptake (kg ha<sup>-1</sup>)**

Perusal of Table 14 revealed significant variation for magnesium uptake by okra plants. Among various treatments, integration of organic and inorganic sources proved better than sole application of organics, inorganic fertilizers as well as integration of organics.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a magnesium uptake of 71.54 and 69.62 kg ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was found statistically at par with T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but was significantly superior to rest of the treatments. Pooled analysis revealed

the significance of T<sub>24</sub> over rest of the treatments, recording a magnesium uptake of 70.58 kg ha<sup>-1</sup> (Table 14 and Fig. XV).

Among sole application of organics, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a magnesium uptake of 50.73 and 47.27 kg ha<sup>-1</sup> during kharif 2004 and 2005, respectively and was found significantly superior to T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was comparable with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). Pooled analysis revealed the significance of T<sub>4</sub> over T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> recording a magnesium uptake of 48.58 kg ha<sup>-1</sup> but was significantly lower than T<sub>1</sub> (Table 14 and Fig. XV).

Integration of organic sources exhibited an increase in magnesium uptake over sole application of organics. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a magnesium uptake of 54.62 kg ha<sup>-1</sup> during kharif 2004 and was found significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was statistically at par with rest of the organic combinations and T<sub>1</sub>. However, during kharif 2005, T<sub>7</sub> recorded a magnesium uptake of 49.53 kg ha<sup>-1</sup> which was significantly superior to T<sub>11</sub>, T<sub>18</sub> and T<sub>25</sub> but comparable with rest of the organic combinations and T<sub>1</sub>. Pooled analysis revealed the significance of T<sub>7</sub> over rest of the organic integrations, recording a magnesium uptake of 52.07 kg ha<sup>-1</sup> and was found at par with T<sub>1</sub> (Table 14 and Fig. XV).

Integration of organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in magnesium uptake over sole application of organics and inorganic fertilizers as well as integration of organics. Integration of PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) registered a magnesium uptake of 68.89 and 64.67 kg ha<sup>-1</sup> during kharif 2004 and 2005 respectively and was found significantly superior to T<sub>1</sub>, T<sub>7</sub>, T<sub>18</sub> and T<sub>25</sub> but was statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub>, T<sub>22</sub> and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis revealed the significant superiority of T<sub>21</sub> over T<sub>1</sub>, T<sub>7</sub>, T<sub>18</sub>, T<sub>19</sub>, T<sub>23</sub> and T<sub>25</sub> recording a magnesium uptake of 67.20 kg ha<sup>-1</sup> but was at par with T<sub>20</sub> and T<sub>22</sub> (Table 14 and Fig. XV).

### **Influence of organic manures and inorganic fertilizers on physical characteristics of soil**

#### **4.27 Mechanical components**

Perusal of Table 15 revealed that applied treatments whether sole application of organics, inorganics, integration of organics or integration of organics with inorganic fertilizers exhibited, no change in mechanical components of the studied soil. However in treatments viz. T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>) and T<sub>7</sub> (FYM 6t + SM 4t + PM 1t +

VC 1t + BF 7 kg ha<sup>-1</sup>) a marginal increase in clay content was observed. The extent of increase was 0.11 and 0.08 per cent over control.

**Table 15: Influence of organic manures and inorganic fertilizers on mechanical components of soil**

Treatment	Mean values (%)				Textural class
	Fine sand	Coarse sand	Silt	Clay	
T <sub>1</sub>	3.74	18.15	41.79	33.71	Clay loam
T <sub>2</sub>	3.75	18.15	41.78	33.71	Clay loam
T <sub>3</sub>	3.75	18.15	41.78	33.71	Clay loam
T <sub>4</sub>	3.69	18.16	41.79	33.72	Clay loam
T <sub>5</sub>	3.75	18.15	41.78	33.71	Clay loam
T <sub>6</sub>	3.75	18.15	41.80	33.70	Clay loam
T <sub>7</sub>	3.70	18.15	41.78	33.73	Clay loam
T <sub>8</sub>	3.69	18.16	41.79	33.71	Clay loam
T <sub>9</sub>	3.69	18.15	41.79	33.72	Clay loam
T <sub>10</sub>	3.69	18.15	41.79	33.72	Clay loam
T <sub>11</sub>	3.75	18.15	41.78	33.71	Clay loam
T <sub>12</sub>	3.70	18.15	41.78	33.73	Clay loam
T <sub>13</sub>	3.69	18.16	41.79	33.71	Clay loam
T <sub>14</sub>	3.75	18.15	41.78	33.71	Clay loam
T <sub>15</sub>	3.70	18.15	41.78	33.73	Clay loam
T <sub>16</sub>	3.69	18.16	41.79	33.72	Clay loam
T <sub>17</sub>	3.75	18.15	41.79	33.71	Clay loam
T <sub>18</sub>	3.75	18.15	41.80	33.70	Clay loam
T <sub>19</sub>	3.69	18.16	41.79	33.71	Clay loam
T <sub>20</sub>	3.69	18.15	41.79	33.72	Clay loam
T <sub>21</sub>	3.70	18.15	41.78	33.73	Clay loam
T <sub>22</sub>	3.69	18.16	41.79	33.72	Clay loam
T <sub>23</sub>	3.75	18.15	41.78	33.71	Clay loam
T <sub>24</sub>	3.70	18.14	41.76	33.74	Clay loam
T <sub>25</sub>	3.75	18.15	41.80	33.70	Clay loam
Initial	3.75	18.15	41.80	33.70	Clay loam

#### 4.28 Bulk density ( $\text{g cm}^3$ )

Perusal of Table 16 revealed significant variations due to various treatments in respect of bulk density. Integration of organic and inorganic sources proved superior in reducing bulk density as compared to sole application of organics, inorganic fertilizers and integration of organics.

Among 25 treatments under study, treatment  $T_{24}$  (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg  $\text{ha}^{-1}$  + 60: 30: 30: N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$  kg  $\text{ha}^{-1}$ ) recorded a bulk density of 1.24  $\text{g cm}^3$  after the harvest of rabi 2005-2006 residual crop pea and was found significantly lower than the values recorded with  $T_1$  (120:60:60 N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$  kg  $\text{ha}^{-1}$ ),  $T_2$  (FYM 30 t  $\text{ha}^{-1}$ ),  $T_3$  (SM 20 t  $\text{ha}^{-1}$ ),  $T_4$  (PM 6 t  $\text{ha}^{-1}$ ),  $T_5$  (VC 6t  $\text{ha}^{-1}$ ),  $T_6$  (BF 7 kg  $\text{ha}^{-1}$ ),  $T_8$  (FYM 15t + SM 10t  $\text{ha}^{-1}$ ),  $T_{10}$  (FYM 15t + VC 3t  $\text{ha}^{-1}$ ),  $T_{11}$  (FYM 15t + BF 7 kg  $\text{ha}^{-1}$ ),  $T_{18}$  i.e. 50% RFD (60:30:30 N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$  kg  $\text{ha}^{-1}$ ),  $T_{25}$  (control) and initial but exhibited at par results with rest of the treatments. The extent of decrease in bulk density due to  $T_{24}$  was 14.48, 11.42 and 9.48 per cent over that of initial (1.45  $\text{g cm}^3$ ), control (1.40  $\text{g cm}^3$ ) and  $T_1$  (1.37  $\text{g cm}^3$ ), respectively (Table 16).

Among sole application of organics, treatment  $T_4$  (PM 6 t  $\text{ha}^{-1}$ ) recorded a bulk density of 1.29  $\text{g cm}^3$  after the harvest of rabi 2005-2006 residual crop pea and was found significantly lower than the values recorded with  $T_1$ ,  $T_6$ ,  $T_{18}$ ,  $T_{25}$  and initial but exhibited at par

results with  $T_2$ ,  $T_3$  and  $T_5$ . The extent of decrease in bulk density due to  $T_4$

**Table 16: Influence of organic manures and inorganic fertilizers on mean bulk density (g cm<sup>3</sup>), particle density (g cm<sup>3</sup>) and porosity (%)**

Treatment	Bulk density				Mean of main treatments	Particle density				Mean of main treatments	Porosity				Mean of main treatments
	Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06		Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06		Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06	
T <sub>1</sub>	<b>1.42</b>	<b>1.40</b>	<b>1.39</b>	<b>1.37</b>	<b>1.39</b>	<b>2.42</b>	<b>2.40</b>	<b>2.37</b>	<b>2.35</b>	<b>2.38</b>	<b>41.22</b>	<b>41.38</b>	<b>41.55</b>	<b>41.63</b>	<b>41.44</b>
T <sub>2</sub>	1.38	1.37	1.34	1.32		2.40	2.38	2.34	2.31		42.18	42.41	42.74	43.00	
T <sub>3</sub>	1.36	1.35	1.32	1.30		2.38	2.37	2.33	2.30		42.79	42.76	43.05	43.33	
T <sub>4</sub>	1.34	1.33	1.31	1.29		2.38	2.37	2.33	2.30		43.35	43.63	43.65	43.73	
T <sub>5</sub>	1.35	1.34	1.32	1.30		2.38	2.37	2.33	2.30		43.23	43.23	43.34	43.40	
T <sub>6</sub>	1.39	1.37	1.35	1.33		2.38	2.37	2.33	2.30		41.39	41.96	42.04	42.18	
<b>Mean</b>	<b>1.36</b>	<b>1.35</b>	<b>1.32</b>	<b>1.30</b>	<b>1.33</b>	<b>2.38</b>	<b>2.37</b>	<b>2.33</b>	<b>2.30</b>	<b>2.34</b>	<b>42.62</b>	<b>42.79</b>	<b>42.96</b>	<b>43.12</b>	<b>42.87</b>
T <sub>7</sub>	1.32	1.31	1.28	1.26		2.39	2.37	2.33	2.30		44.53	44.58	44.93	45.14	
T <sub>8</sub>	1.35	1.34	1.31	1.29		2.38	2.37	2.33	2.30		43.18	43.96	43.70	44.03	
T <sub>9</sub>	1.34	1.33	1.32	1.27		2.37	2.36	2.32	2.29		43.49	43.71	43.98	44.30	
T <sub>10</sub>	1.35	1.34	1.31	1.29		2.38	2.36	2.32	2.29		43.20	43.23	43.32	43.58	
T <sub>11</sub>	1.36	1.35	1.32	1.29		2.38	2.36	2.32	2.29		42.88	42.85	43.10	43.98	
T <sub>12</sub>	1.33	1.31	1.29	1.26		2.37	2.35	2.31	2.28		43.99	44.05	44.22	44.52	
T <sub>13</sub>	1.34	1.32	1.29	1.27		2.37	2.35	2.31	2.28		43.58	43.92	44.20	44.48	
T <sub>14</sub>	1.32	1.32	1.29	1.27		2.37	2.35	2.31	2.28		44.03	44.25	44.27	44.30	
T <sub>15</sub>	1.32	1.31	1.28	1.26		2.38	2.36	2.32	2.29		44.15	44.19	44.58	44.90	
T <sub>16</sub>	1.32	1.31	1.29	1.27		2.37	2.35	2.32	2.29		44.04	44.28	44.31	44.46	
T <sub>17</sub>	1.33	1.32	1.29	1.27		2.37	2.36	2.32	2.29		43.91	44.10	44.16	44.35	
<b>Mean</b>	<b>1.33</b>	<b>1.32</b>	<b>1.29</b>	<b>1.27</b>	<b>1.30</b>	<b>2.37</b>	<b>2.35</b>	<b>2.31</b>	<b>2.28</b>	<b>2.32</b>	<b>43.72</b>	<b>43.92</b>	<b>44.07</b>	<b>44.36</b>	<b>44.01</b>
T <sub>18</sub>	<b>1.43</b>	<b>1.42</b>	<b>1.38</b>	<b>1.37</b>	<b>1.40</b>	<b>2.42</b>	<b>2.40</b>	<b>2.34</b>	<b>2.33</b>	<b>2.37</b>	<b>40.91</b>	<b>40.84</b>	<b>41.03</b>	<b>41.21</b>	<b>40.99</b>
T <sub>19</sub>	1.31	1.30	1.27	1.25		2.36	2.35	2.31	2.28		44.55	44.87	44.89	45.06	
T <sub>20</sub>	1.31	1.29	1.27	1.25		2.36	2.34	2.30	2.28		44.56	45.05	44.99	45.12	
T <sub>21</sub>	1.31	1.29	1.26	1.24		2.38	2.36	2.32	2.29		44.99	45.31	45.44	45.63	
T <sub>22</sub>	1.33	1.31	1.29	1.26		2.37	2.36	2.32	2.29		44.01	44.32	44.41	44.66	
T <sub>23</sub>	1.33	1.32	1.29	1.27		2.35	2.33	2.31	2.29		43.44	43.52	44.16	44.55	
T <sub>24</sub>	1.29	1.28	1.26	1.24		2.37	2.36	2.32	2.29		45.42	45.56	45.61	45.81	
<b>Mean</b>	<b>1.31</b>	<b>1.29</b>	<b>1.27</b>	<b>1.25</b>	<b>1.28</b>	<b>2.36</b>	<b>2.35</b>	<b>2.31</b>	<b>2.28</b>	<b>2.32</b>	<b>44.49</b>	<b>44.77</b>	<b>44.91</b>	<b>45.13</b>	<b>44.82</b>
T <sub>25</sub>	<b>1.45</b>	<b>1.44</b>	<b>1.42</b>	<b>1.40</b>	<b>1.42</b>	<b>2.44</b>	<b>2.43</b>	<b>2.40</b>	<b>2.37</b>	<b>2.41</b>	<b>40.58</b>	<b>40.75</b>	<b>40.84</b>	<b>40.93</b>	<b>40.77</b>
Initial	<b>1.45</b>					<b>2.45</b>					<b>40.82</b>				
CD at 5%	0.02	0.03	0.02	0.03		0.01	0.01	0.01	0.01		1.30	1.43	1.30	1.24	

was 11.03, 7.85 and 5.83 per cent over initial, control and T<sub>1</sub> i.e. 100% RFD respectively (Table 16).

Integration of organic sources exhibited a decrease in bulk density as compared to sole application of organics as well as organic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a bulk density of 1.26 g cm<sup>3</sup> after the harvest of rabi 2005-2006 residual crop pea and was significantly lower than the values recorded with T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial but was statistically at par with rest of the organic integrations. The extent of decrease in bulk density due to T<sub>7</sub> was 13.10, 10.00 and 8.02 per cent, over initial, control and T<sub>1</sub> respectively (Table 16).

Integration of different organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited a decrease in bulk density over sole application of organics, inorganic fertilizers and integration of organics. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a bulk density of 1.24 g cm<sup>3</sup> and was found significantly lower than the values recorded with T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of decrease in bulk density due to T<sub>21</sub> was 14.48, 11.42 and 9.48 per cent over initial, control and T<sub>1</sub>, respectively (Table 16).

#### 4.29 Particle density ( $\text{g cm}^3$ )

Perusal of Table 16 revealed significant variations due to various treatments for particle density. Integration of organic with inorganic sources as well as integration organic sources proved superior in reducing the bulk density as compared to sole application of organics and inorganic fertilizers.

Among 25 treatments under study, treatment  $T_{24}$  (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg  $\text{ha}^{-1}$  + 60: 30: 30: N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$  kg  $\text{ha}^{-1}$ ) recorded a particle density of  $2.29 \text{ g cm}^3$  after the harvest of rabi 2005-2006 residual crop pea which was significantly lower than  $T_1$  i.e. 100% RFD (120:60:60 N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$  kg  $\text{ha}^{-1}$ ),  $T_2$  (FYM 30 t  $\text{ha}^{-1}$ ),  $T_{18}$  i.e. 50% RFD (60:30:30 N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$  kg  $\text{ha}^{-1}$ ) and  $T_{25}$  (control) but was statistically at par with rest of the treatments. The extent of decrease due to  $T_{24}$  was 6.53, 3.37 and 2.55 per cent over initial ( $2.45 \text{ g cm}^3$ ) control ( $2.37 \text{ g cm}^3$ ) and  $T_1$  ( $2.38 \text{ g cm}^3$ ) respectively (Table 16).

Among sole application of organic sources, treatment  $T_3$  (SM 20 t  $\text{ha}^{-1}$ ),  $T_4$  (PM 6 t  $\text{ha}^{-1}$ ),  $T_5$  (VC 6t  $\text{ha}^{-1}$ ) and  $T_6$  (BF 7 kg  $\text{ha}^{-1}$ ) recorded a particle density of  $2.30 \text{ g cm}^3$  after the harvest of rabi 2005-2006 residual crop pea which was significantly lower than the values recorded with  $T_1$ ,  $T_{18}$ ,  $T_{25}$  and initial but exhibited at par results with  $T_2$  (FYM 30 t  $\text{ha}^{-1}$ ). The extent of decrease in particle density was 6.12, 2.95 and 2.12 per cent over initial, control and  $T_1$ , respectively (Table 16).

Integration of organic sources exhibited a decrease in particle density over sole application of organics and inorganic fertilizers. Treatment T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>) and T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>) recorded a particle density of 2.28 g cm<sup>3</sup> after the harvest of rabi 2005-2005 residual crop pea and was significantly lower than the values recorded with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial but exhibited at par values with rest of the organic integrations. The extent of decrease in particle density was 6.93, 3.79 and 2.97 per cent over initial, control and T<sub>1</sub>, respectively (Table 16).

Integration of individual organic sources with recommended fertilizer dose in equal proportion (50:50) reduced the particle density over sole application of organics as well as inorganic fertilizers.

Treatments T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a particle density of 2.28 g cm<sup>3</sup> which was significantly lower than T<sub>1</sub>, T<sub>7</sub>, T<sub>18</sub>, T<sub>25</sub> and initial but was at par with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of decrease due to T<sub>19</sub> and T<sub>20</sub> was 6.93, 3.79 and 2.97 per cent over initial, control and T<sub>1</sub>, respectively (Table 16).

#### **4.30 Porosity**

Perusal of Table 31 revealed significant variation for porosity due to various treatments. Integration of organic with inorganic sources

proved superior in increasing porosity as compared to sole application of organics, inorganic fertilizers and integration among organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a porosity of 45.81 per cent after the harvest of rabi 2005-2006 residual crop pea and was found statistically at par with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but was significantly superior to rest of the treatments. The extent of increase in porosity due to T<sub>24</sub> was 10.89, 10.65 and 9.12 per cent over initial (40.82%), control (40.93%) and T<sub>1</sub> (41.63%), respectively (Table 16).

Among sole application of organics, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a porosity of 43.73 per cent after the harvest of rabi 2005-2006 residual crop (pea) which was significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> (control) and initial but exhibited at par results with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). The extent of increase in porosity due to T<sub>4</sub> was 6.65, 6.40 and 4.80 per cent over initial, control and T<sub>1</sub>, respectively (Table 16).

Integration of organic sources exhibited an increase in porosity over sole application of organics as well as inorganic fertilizers.

Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a porosity of 45.14 per cent after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial but was statistically at par with rest of the organic integration treatments. The extent of increase in porosity due to T<sub>7</sub> was 9.57, 9.32 and 7.77 per cent over initial, control and T<sub>1</sub>, respectively (Table 16).

Integration of different organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in porosity over sole application of organics and inorganic fertilizers as well as integration of organics. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a porosity of 45.63 per cent after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial but was statistically at par with T<sub>7</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub> and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of increase in porosity due to T<sub>21</sub> was 10.54, 10.30 and 8.76 per cent over initial, control and T<sub>1</sub>, respectively (Table 16).

### **Influence of organic manures and inorganic fertilizers on chemical characteristics of soil**

#### **4.31 Soil pH**

Perusal of Table 17 revealed significant variation for soil pH due to various treatments after the harvest of rabi 2005-2006 residual crop pea. Integration of organic sources with inorganics as well as

integration of organic sources proved superior in decreasing the soil pH over sole application of organics and inorganic fertilizers.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a pH of 6.51 after the harvest of rabi 2005-2006 residual crop

**Table 17: Influence of organic manures and inorganic fertilizers on mean soil pH, organic carbon (%) and electrical conductivity (Ecdsm<sup>-1</sup>)**

Treatment	Soil pH				Mean of main treatments	Organic carbon				Mean of main treatments	Electrical conductivity				Mean of main treatments
	Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06		Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06		Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06	
T <sub>1</sub>	<b>7.08</b>	<b>6.97</b>	<b>6.85</b>	<b>6.74</b>	<b>6.91</b>	<b>1.03</b>	<b>1.08</b>	<b>1.15</b>	<b>1.17</b>	<b>1.10</b>	<b>0.100</b>	<b>0.103</b>	<b>0.108</b>	<b>0.112</b>	<b>0.105</b>
T <sub>2</sub>	7.05	7.00	6.81	6.69		1.27	1.34	1.43	1.48		0.100	0.103	0.109	0.112	
T <sub>3</sub>	7.02	6.97	6.79	6.63		1.30	1.35	1.44	1.49		0.111	0.114	0.119	0.122	
T <sub>4</sub>	6.94	6.88	6.73	6.54		1.35	1.40	1.50	1.56		0.120	0.122	0.129	0.132	
T <sub>5</sub>	7.05	6.90	6.76	6.61		1.30	1.36	1.43	1.48		0.115	0.119	0.124	0.128	
T <sub>6</sub>	7.08	7.03	6.96	6.84		1.00	1.06	1.14	1.18		0.104	0.107	0.113	0.115	
<b>Mean</b>	<b>7.02</b>	<b>6.95</b>	<b>6.81</b>	<b>6.66</b>	<b>6.86</b>	<b>1.24</b>	<b>1.30</b>	<b>1.38</b>	<b>1.43</b>	<b>1.33</b>	<b>0.110</b>	<b>0.113</b>	<b>0.118</b>	<b>0.121</b>	<b>0.115</b>
T <sub>7</sub>	6.96	6.72	6.62	6.50		1.40	1.48	1.57	1.63		0.125	0.126	0.135	0.139	
T <sub>8</sub>	6.99	6.89	6.70	6.59		1.31	1.39	1.48	1.54		0.120	0.124	0.131	0.131	
T <sub>9</sub>	6.96	6.81	6.69	6.59		1.36	1.46	1.53	1.60		0.119	0.123	0.130	0.133	
T <sub>10</sub>	7.01	6.87	6.72	6.62		1.31	1.38	1.47	1.53		0.107	0.112	0.118	0.121	
T <sub>11</sub>	6.82	6.72	6.64	6.58		1.27	1.33	1.42	1.48		0.111	0.114	0.119	0.122	
T <sub>12</sub>	6.84	6.74	6.65	6.49		1.39	1.47	1.56	1.62		0.122	0.126	0.133	0.136	
T <sub>13</sub>	6.92	6.82	6.68	6.53		1.32	1.39	1.49	1.55		0.115	0.118	0.124	0.127	
T <sub>14</sub>	6.84	6.68	6.57	6.48		1.29	1.35	1.44	1.50		0.115	0.115	0.120	0.123	
T <sub>15</sub>	6.84	6.70	6.60	6.51		1.39	1.46	1.56	1.62		0.123	0.128	0.134	0.138	
T <sub>16</sub>	6.84	6.68	6.58	6.49		1.32	1.37	1.46	1.53		0.122	0.124	0.131	0.134	
T <sub>17</sub>	6.96	6.81	6.69	6.59		1.32	1.38	1.46	1.52		0.119	0.120	0.126	0.129	
<b>Mean</b>	<b>6.90</b>	<b>6.76</b>	<b>6.64</b>	<b>6.54</b>	<b>6.71</b>	<b>1.33</b>	<b>1.40</b>	<b>1.49</b>	<b>1.55</b>	<b>1.44</b>	<b>0.118</b>	<b>0.120</b>	<b>0.127</b>	<b>0.130</b>	<b>0.123</b>
T <sub>18</sub>	<b>7.09</b>	<b>6.98</b>	<b>6.77</b>	<b>6.68</b>	<b>6.88</b>	<b>0.99</b>	<b>1.04</b>	<b>1.08</b>	<b>1.10</b>	<b>1.05</b>	<b>0.095</b>	<b>0.099</b>	<b>0.103</b>	<b>0.106</b>	<b>0.100</b>
T <sub>19</sub>	6.91	6.95	6.72	6.59		1.33	1.40	1.50	1.56		0.119	0.124	0.130	0.134	
T <sub>20</sub>	6.86	6.76	6.65	6.51		1.38	1.44	1.54	1.60		0.120	0.125	0.131	0.135	
T <sub>21</sub>	6.80	6.70	6.61	6.51		1.42	1.47	1.57	1.63		0.125	0.129	0.136	0.140	
T <sub>22</sub>	6.91	6.87	6.72	6.57		1.36	1.42	1.52	1.58		0.122	0.127	0.133	0.137	
T <sub>23</sub>	6.89	6.85	6.70	6.56		1.26	1.32	1.40	1.46		0.116	0.120	0.125	0.127	
T <sub>24</sub>	6.86	6.66	6.55	6.51		1.41	1.48	1.57	1.65		0.126	0.130	0.137	0.145	
<b>Mean</b>	<b>6.86</b>	<b>6.79</b>	<b>6.65</b>	<b>6.54</b>	<b>6.71</b>	<b>1.36</b>	<b>1.42</b>	<b>1.51</b>	<b>1.58</b>	<b>1.46</b>	<b>0.121</b>	<b>0.125</b>	<b>0.132</b>	<b>0.136</b>	<b>0.128</b>
T <sub>25</sub>	<b>7.27</b>	<b>7.29</b>	<b>7.31</b>	<b>7.36</b>	<b>7.30</b>	<b>0.96</b>	<b>0.97</b>	<b>0.86</b>	<b>0.90</b>	<b>0.92</b>	<b>0.089</b>	<b>0.090</b>	<b>0.089</b>	<b>0.087</b>	<b>0.088</b>
Initial	<b>7.25</b>					<b>1.08</b>					<b>0.090</b>				
CD at 5%	0.13	0.20	0.17	0.18		0.08	0.07	0.07	0.08		0.009	0.011	0.010	0.012	

pea which was significantly lower than T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> (control) and initial but exhibited at par results with rest of the treatments. The extent of decrease in soil P<sub>H</sub> due to T<sub>24</sub> was 10.20, 11.54 and 3.41 per cent over initial (7.25), control (7.36) and T<sub>1</sub> (6.74), respectively (Table 17).

Among sole application of organics, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a pH of 6.54 after the harvest of rabi 2005-2006 residual crop pea which was significantly lower than T<sub>1</sub>, T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub>, T<sub>25</sub> and initial but exhibited at par results with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). The extent of decrease in soil pH due to T<sub>4</sub> was 9.79, 11.14 and 2.96 per cent over initial, control and T<sub>1</sub>, respectively (Table 17).

Integration of organics, exhibited a decrease in soil pH over sole application of organic and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a soil pH of 6.50 after the harvest of rabi 2005-2006 residual crop pea and was found significantly lower than T<sub>1</sub>, T<sub>25</sub> and initial but exhibited at par results with rest of the organic integration treatments. The extent of decrease in soil pH due to T<sub>7</sub> was 10.34, 11.68 and 3.56 per cent over initial, control and T<sub>1</sub>, respectively (Table 17).

Integration of individual organic with recommended fertilizer dose in equal proportions (50:50) exhibited a decrease in soil pH over sole application of organics and inorganic fertilizers. Treatment T<sub>21</sub> (PM 3t +

60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a soil P<sub>H</sub> of 6.51 after the harvest of rabi 2005-2006 residual crop pea which was significantly lower than T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial but was statistically at par with T<sub>7</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of decrease due to T<sub>21</sub> was 10.20, 11.54 and 3.41 per cent over initial, control and T<sub>1</sub>, respectively (Table 17).

#### 4.32 Organic carbon content (%)

Perusal of Table 17 revealed significant variation for organic carbon content. Among various treatments, integration of organic with inorganic sources and integration of organics proved superior in enhancing organic carbon content over sole application of organics and inorganic fertilizers.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an organic carbon content of 1.65 per cent after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to all treatments and initial status but exhibited at par results with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of increase in organic carbon content due to T<sub>24</sub> was 34.54, 45.45 and 29.09 per cent over initial (1.08%), control (0.90%) and T<sub>1</sub> (1.17%), respectively (Table 17).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded an organic carbon content of 1.56 per cent after the harvest of rabi 2005-2006 residual crop pea which was significantly higher than T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> (control) and initial but exhibited at par results with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). The extent of increase in organic carbon content due to T<sub>4</sub> was 30.76, 42.30 and 25.00 per cent over initial, control and T<sub>1</sub>, respectively (Table 17).

Integration of organic sources enhanced the organic carbon content over sole application of organics and inorganic fertilizers, recording a maximum value of 1.63 per cent with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) and was found significantly superior to T<sub>1</sub>, T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>18</sub>, T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was at par with T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>12</sub>, T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>) and T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>). The extent of increase in organic carbon content due to T<sub>7</sub> was 33.74, 44.78 and 28.22 per cent over initial, control and T<sub>1</sub> respectively (Table 17).

Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) increased the organic carbon content as compared to organic integration as well as sole application of organics and inorganic fertilizers. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>:

K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an organic carbon content of 1.63 per cent after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>23</sub>, T<sub>25</sub> and initial but exhibited at par results with T<sub>7</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> and T<sub>22</sub>. The extent of increase in organic carbon content due to T<sub>21</sub> was 33.74, 44.78 and 28.22 per cent over initial, control and T<sub>1</sub>, respectively (Table 17).

#### **4.33 Electrical conductivity dsm<sup>-1</sup>**

Perusal of Table 17 revealed significant variations for electrical conductivity. Among various treatments, integration among organic and inorganic sources proved superior in enhancing electrical conductivity over sole application of organics and inorganic fertilizers as well as integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an electrical conductivity of 0.145 d sm<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was statistically at par with T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but was significantly superior to rest of the treatments and initial status. The extent of increase in electrical conductivity due to T<sub>24</sub> was 37.93, 40.00 and 22.75 per cent over

initial ( $0.090 \text{ d sm}^{-1}$ ), control ( $0.087 \text{ d sm}^{-1}$ ) and  $T_1$  ( $0.112 \text{ d sm}^{-1}$ ), respectively (Table 17).

Among sole application of organic sources, treatment  $T_4$  (PM  $6 \text{ t ha}^{-1}$ ) recorded an electrical conductivity of  $0.132 \text{ d sm}^{-1}$  after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to  $T_1$  i.e. 100% RFD ( $120:60:60 \text{ N: P}_2\text{O}_5: \text{K}_2\text{O kg ha}^{-1}$ ),  $T_2$  (FYM  $30 \text{ t ha}^{-1}$ ),  $T_3$  (SM  $20 \text{ t ha}^{-1}$ ),  $T_6$ ,  $T_{18}$  i.e. 50% RFD ( $60:30:30 \text{ N: P}_2\text{O}_5: \text{K}_2\text{O kg ha}^{-1}$ ),  $T_{25}$  (control) and initial but exhibited at par results with  $T_5$  (VC  $6 \text{ t ha}^{-1}$ ). The extent of increase in electrical conductivity due to  $T_4$  was 31.81, 34.09 and 15.15 per cent over initial, control and  $T_1$ , respectively (Table 17).

Organic integrations exhibited an increase in electrical conductivity over sole application of organics and inorganic fertilizers. Treatment  $T_7$  (FYM  $6 \text{ t} + \text{SM } 4 \text{ t} + \text{PM } 1 \text{ t} + \text{VC } 1 \text{ t} + \text{BF } 7 \text{ kg ha}^{-1}$ ) recorded an electrical conductivity of  $0.139 \text{ d sm}^{-1}$  after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to  $T_1$ ,  $T_{10}$  (FYM  $15 \text{ t} + \text{VC } 3 \text{ t ha}^{-1}$ ),  $T_{11}$  (FYM  $15 \text{ t} + \text{BF } 7 \text{ kg ha}^{-1}$ ),  $T_{14}$  (SM  $10 \text{ t} + \text{BF } 7 \text{ kg ha}^{-1}$ ),  $T_{18}$ ,  $T_{25}$  and initial but exhibited at par results with rest of the organic combinations. The extent of increase in electrical conductivity due to  $T_7$  was 35.25, 37.41 and 19.42 per cent over initial, control and  $T_1$ , respectively (Table 17).

Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) recorded higher values for electrical conductivity as compared to sole application of organics and inorganic fertilizers as well as integration of organic sources. Treatment

T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an electrical conductivity of 0.140 d sm<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> and initial but was statistically at par with T<sub>7</sub>, T<sub>19</sub>, T<sub>20</sub> and T<sub>22</sub>. The extent of increase in electrical conductivity due to T<sub>21</sub> was 35.71, 37.85 and 20.00 per cent over initial, control and T<sub>1</sub>, respectively (Table 17).

### **Influence of organic manures and inorganic fertilizers on availability of plant nutrients**

#### **4.34 Available nitrogen (kg ha<sup>-1</sup>)**

Perusal of Table 18 exhibited significant variation for available nitrogen in soil due to various treatments. Integration of organic and inorganic sources proved superior in enhancing the availability of nitrogen in soil over sole application of organics, inorganic fertilizers and organic integrations.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a nitrogen build up of 266.13 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to all treatments but was statistically at par with T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of increase in available nitrogen due to T<sub>24</sub> was 22.23, 72.08 and

32.68 per cent over initial (206.95 kg ha<sup>-1</sup>), control (74.28 kg ha<sup>-1</sup>) and T<sub>1</sub> (179.15 kg ha<sup>-1</sup>), respectively (Table 18 and Fig. XVI).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded an available nitrogen content of 216.31 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). The extent of increase in available nitrogen content due to T<sub>4</sub> was 4.32, 65.66 and 17.17 per cent over initial, control and T<sub>1</sub>, respectively (Table 18 and Fig. XVI).

Integration of organic sources exhibited an increase in available nitrogen content over sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a nitrogen content of 231.79 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was statistically at par with the available nitrogen content recorded with T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) but exhibited significant superiority over rest of the organic combination, T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial. The extent of increase in available nitrogen content due to T<sub>7</sub> was 10.71, 67.95 and 22.71 per cent over initial, control and T<sub>1</sub>, respectively (Table 18 and Fig. XVI).

Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) recorded higher values for available nitrogen build up in soil over sole application of organics, inorganic fertilizers and integration of organic sources. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an available nitrogen content of 260.88 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>7</sub>, T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial but was statistically at par with T<sub>19</sub>,

**Table 18: Influence of organic manures and inorganic fertilizers on mean available nitrogen and phosphorus (kg ha<sup>-1</sup>)**

Treatment	Available nitrogen				Mean of main treatments	Available phosphorus				Mean of main treatments
	Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06		Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06	
T <sub>1</sub>	<b>223.72</b>	<b>178.78</b>	<b>223.31</b>	<b>179.15</b>	<b>201.24</b>	<b>40.18</b>	<b>29.97</b>	<b>42.20</b>	<b>30.94</b>	<b>35.82</b>
T <sub>2</sub>	234.37	186.82	262.22	207.25		45.48	33.51	43.45	33.71	
T <sub>3</sub>	238.60	191.76	262.34	210.40		45.65	34.00	46.96	34.74	
T <sub>4</sub>	242.93	195.98	268.91	216.31		47.92	37.27	51.05	39.37	
T <sub>5</sub>	229.53	183.08	270.64	215.46		44.53	31.19	49.43	31.64	
T <sub>6</sub>	186.93	149.86	195.02	156.05		25.49	18.13	30.23	21.17	
<b>Mean</b>	<b>226.47</b>	<b>181.50</b>	<b>251.82</b>	<b>201.09</b>	<b>215.22</b>	<b>41.81</b>	<b>30.82</b>	<b>44.82</b>	<b>32.12</b>	<b>37.39</b>
T <sub>7</sub>	255.40	210.26	290.29	231.79		53.44	40.62	55.32	41.90	
T <sub>8</sub>	234.32	186.96	263.62	210.95		45.21	33.41	46.73	34.35	
T <sub>9</sub>	246.32	197.98	270.74	216.43		47.59	37.34	51.58	40.21	
T <sub>10</sub>	239.96	191.92	266.91	212.92		45.18	35.27	46.88	36.52	
T <sub>11</sub>	222.13	190.88	260.04	208.56		44.90	32.96	46.02	33.31	
T <sub>12</sub>	245.35	195.52	271.92	217.30		48.15	37.09	51.63	39.06	
T <sub>13</sub>	238.69	182.48	268.73	215.42		45.39	35.43	47.97	37.19	
T <sub>14</sub>	226.72	196.08	269.09	213.92		44.56	34.47	47.97	37.19	
T <sub>15</sub>	241.85	196.98	282.94	225.83		50.52	39.62	52.63	41.31	
T <sub>16</sub>	240.79	200.69	273.11	219.06		47.12	36.52	50.22	38.71	
T <sub>17</sub>	238.28	202.08	271.32	216.90		46.67	36.50	49.93	39.01	
<b>Mean</b>	<b>239.07</b>	<b>195.62</b>	<b>271.70</b>	<b>217.18</b>	<b>230.89</b>	<b>47.15</b>	<b>36.29</b>	<b>49.71</b>	<b>38.06</b>	<b>42.80</b>
T <sub>18</sub>	<b>208.69</b>	<b>167.08</b>	<b>218.72</b>	<b>175.22</b>	<b>192.42</b>	<b>35.55</b>	<b>26.87</b>	<b>36.99</b>	<b>27.89</b>	<b>31.82</b>
T <sub>19</sub>	300.69	238.39	315.07	251.72		50.51	39.06	55.19	42.70	
T <sub>20</sub>	308.89	252.48	326.04	259.53		52.14	39.96	54.90	42.66	
T <sub>21</sub>	310.38	154.98	326.64	260.88		57.34	44.71	61.42	50.40	
T <sub>22</sub>	301.40	238.96	317.51	252.92		52.98	40.29	54.43	41.63	
T <sub>23</sub>	236.53	191.02	255.18	207.63		46.58	35.61	48.32	37.34	
T <sub>24</sub>	319.77	265.48	333.80	266.13		59.54	46.86	63.40	52.36	
<b>Mean</b>	<b>296.27</b>	<b>240.21</b>	<b>312.37</b>	<b>249.80</b>	<b>274.66</b>	<b>53.18</b>	<b>41.08</b>	<b>56.27</b>	<b>44.51</b>	<b>48.76</b>
T <sub>25</sub>	<b>145.74</b>	<b>133.55</b>	<b>94.80</b>	<b>74.28</b>	<b>112.09</b>	<b>10.03</b>	<b>8.54</b>	<b>6.99</b>	<b>6.40</b>	<b>7.99</b>
Initial	<b>206.95</b>					<b>28.00</b>				
CD at 5%	23.51	20.77	18.43	14.68		6.91	5.54	6.85	5.54	

T<sub>20</sub> and T<sub>22</sub>. The extent of increase in available nitrogen content due to T<sub>21</sub> was 20.67, 71.52 and 31.32 per cent over initial, control and T<sub>1</sub>, respectively (Table 18 and Fig. XVI).

The Table 18 further revealed that treatment T<sub>1</sub>, T<sub>6</sub> and T<sub>18</sub> registered a decline in available nitrogen content after the harvest of rabi 2005-2006 residual crop pea by 13.43, 24.59 and 15.33 per cent over initial, respectively.

#### **4.35 Available phosphorus (kg ha<sup>-1</sup>)**

Perusal of Table 18 revealed significant variations for available phosphorus content in the soil. Among various treatments, integration of organic with inorganic sources proved superior in available phosphorus build up in soil over sole application of organics, inorganic fertilizers and organic integration.

Among 25 treatments under study, maximum phosphorus build up of 52.36 kg ha<sup>-1</sup> was recorded with T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) after the harvest of rabi 2005-2006 residual crop pea and was statistically at par with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but exhibited significant superiority over rest of the treatments and initial. The extent of increase in available phosphorus content due to T<sub>24</sub> was 46.52, 87.77 and 40.90 per cent over initial (28.00 kg ha<sup>-1</sup>), control (6.40 kg ha<sup>-1</sup>) and T<sub>1</sub> (30.94 kg ha<sup>-1</sup>), respectively (Table 18 and Fig. XVII).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded an available phosphorus content of 39.37 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea and was significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> (control) and initial but was statistically at par with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>). T<sub>4</sub> increased the available phosphorus content by 28.87, 83.74 and 21.41 per cent over initial, control and T<sub>1</sub>, respectively (Table 18 and Fig. XVII).

Organic integrations enhanced the build up of available phosphorus in soil over sole application of organics and inorganic fertilizers. Maximum phosphorus build up of 41.90 kg ha<sup>-1</sup> was recorded with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) after the harvest of rabi 2005-2006 residual crop pea and was found significantly superior to T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial but exhibited at par values with rest of the organic integration treatments. T<sub>7</sub> increased the availability of phosphorus content by 33.17, 84.72 and 26.15 per cent over initial, control and T<sub>1</sub>, respectively (Table 18 and Fig. XVII).

Integration of organic sources with recommended fertilizer dose in equal proportion (50:50) depicted an increase in available phosphorus content over sole application or organics, inorganic fertilizer and integration of organic sources, recording maximum phosphorus build up of 50.40 kg ha<sup>-1</sup> with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) after the

harvest of rabi 2005-2006 residual crop pea which was found significantly superior to T<sub>1</sub>, T<sub>7</sub>, T<sub>18</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> and initial. The extent of increase in phosphorus build up due to T<sub>21</sub> was 44.44, 87.30 and 38.61 per cent over initial, control and T<sub>1</sub>, respectively (Table 18 and Fig. XVII).

The Table 18 further revealed that treatment T<sub>6</sub> and T<sub>18</sub> exhibited a decline in available phosphorus content to the tune of 24.39 and 0.39 per cent, respectively over initial status.

#### **4.36 Available potassium (kg ha<sup>-1</sup>)**

Perusal of Table 19 revealed significant variation for available potassium build up in soil. Among various treatments, conjugation of organic and inorganic sources proved superior over sole application of organics, inorganic fertilizers and organic integrations.

Among 25 treatments under study, highest build up of available potassium 197.10 kg ha<sup>-1</sup> was recorded with T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to all treatments but was statistically at par with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) and T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of increase in available potassium due to T<sub>24</sub> was 12.49, 69.86 and

17.13 per cent over initial (172.48 kg ha<sup>-1</sup>), control (59.40 kg ha<sup>-1</sup>) and T<sub>1</sub> (63.32 kg ha<sup>-1</sup>), respectively (Table 19 and Fig. XVIII).

Among sole application of organics, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded an available potassium content of 180.66 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically comparable with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). The extent of increase in available potassium due to T<sub>4</sub> was 4.52, 67.12 and 9.59 per cent over initial, control and T<sub>1</sub>, respectively (Table 19 and Fig. XVIII).

Integration of organic sources exhibited an increase in available potassium content over sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a maximum available potassium content of 188.32 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea and was found significantly superior to T<sub>1</sub>, T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>18</sub>, T<sub>25</sub> and initial but exhibited at par results with rest of the organic integrations. The extent of increase in available potassium content due to T<sub>7</sub> was 8.41, 68.45 and 13.27 per cent over initial, control and T<sub>1</sub>, respectively (Table 19 and Fig. XVIII).

Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in

available potassium content over sole application of organics, inorganic fertilizers and organic integrations. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an available potassium content of 195.86 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> and initial but was statistically at par with T<sub>7</sub>. The extent of

**Table 19: Influence of organic manures and inorganic fertilizers on mean available potassium and sulphur (kg ha<sup>-1</sup>)**

Treatment	Available potassium				Mean of main treatments	Available sulphur				Mean of main treatments
	Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06		Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06	
T <sub>1</sub>	<b>177.66</b>	<b>139.19</b>	<b>181.24</b>	<b>163.32</b>	<b>165.35</b>	<b>23.91</b>	<b>14.99</b>	<b>24.82</b>	<b>15.80</b>	<b>19.88</b>
T <sub>2</sub>	186.00	148.34	198.31	175.88		27.56	18.09	30.63	20.19	
T <sub>3</sub>	189.79	150.81	196.84	177.96		28.05	18.11	31.23	20.43	
T <sub>4</sub>	195.37	155.03	200.76	180.66		30.29	20.49	33.00	22.04	
T <sub>5</sub>	192.43	151.87	196.42	177.44		29.14	20.13	31.64	21.10	
T <sub>6</sub>	179.08	142.84	169.16	151.10		21.76	16.07	22.52	16.66	
<b>Mean</b>	<b>188.53</b>	<b>149.77</b>	<b>192.29</b>	<b>172.60</b>	<b>175.79</b>	<b>27.36</b>	<b>18.57</b>	<b>29.82</b>	<b>20.08</b>	<b>23.95</b>
T <sub>7</sub>	199.52	161.53	211.98	188.32		33.88	21.69	36.98	23.76	
T <sub>8</sub>	185.49	148.88	193.83	173.91		29.27	18.75	31.06	20.34	
T <sub>9</sub>	189.57	153.08	200.45	178.98		31.05	20.53	33.99	21.57	
T <sub>10</sub>	186.63	148.80	193.34	173.33		30.08	20.27	32.70	20.95	
T <sub>11</sub>	188.67	149.11	197.86	177.18		29.05	19.24	30.76	20.28	
T <sub>12</sub>	195.46	156.64	204.93	183.90		32.05	20.47	34.52	22.59	
T <sub>13</sub>	191.23	150.92	197.18	178.95		30.78	20.15	33.16	22.08	
T <sub>14</sub>	190.35	151.48	196.43	177.36		30.19	20.04	32.46	21.43	
T <sub>15</sub>	197.72	156.83	203.34	184.36		33.38	21.27	36.60	23.49	
T <sub>16</sub>	194.03	155.09	203.91	183.49		31.41	20.28	34.43	21.99	
T <sub>17</sub>	190.40	152.84	201.89	180.11		30.85	20.37	33.55	21.71	
<b>Mean</b>	<b>191.73</b>	<b>153.20</b>	<b>200.46</b>	<b>179.99</b>	<b>181.34</b>	<b>31.09</b>	<b>20.27</b>	<b>33.65</b>	<b>21.83</b>	<b>26.71</b>
T <sub>18</sub>	<b>163.92</b>	<b>134.94</b>	<b>168.53</b>	<b>152.16</b>	<b>154.88</b>	<b>22.09</b>	<b>15.37</b>	<b>23.10</b>	<b>15.58</b>	<b>19.03</b>
T <sub>19</sub>	207.64	166.56	211.82	179.62		32.80	21.12	35.80	22.82	
T <sub>20</sub>	214.68	172.48	216.99	178.55		34.22	21.82	40.67	25.75	
T <sub>21</sub>	234.23	186.43	236.93	195.86		35.13	22.23	41.77	26.42	
T <sub>22</sub>	226.99	180.08	229.14	182.46		34.20	21.72	40.45	25.59	
T <sub>23</sub>	196.10	154.27	203.50	179.16		31.45	19.35	34.56	21.38	
T <sub>24</sub>	236.32	188.69	238.59	197.10		37.55	24.02	45.17	29.20	
<b>Mean</b>	<b>219.32</b>	<b>174.75</b>	<b>222.82</b>	<b>185.45</b>	<b>200.58</b>	<b>34.22</b>	<b>21.71</b>	<b>39.73</b>	<b>25.19</b>	<b>30.21</b>
T <sub>25</sub>	<b>135.02</b>	<b>107.19</b>	<b>81.81</b>	<b>59.40</b>	<b>95.85</b>	<b>12.29</b>	<b>9.01</b>	<b>3.44</b>	<b>2.55</b>	<b>6.82</b>
Initial	<b>172.48</b>					<b>20.16</b>				
CD at 5%	14.56	10.29	14.23	11.31		1.20	1.13	1.44	0.84	

increase in available potassium content due to T<sub>21</sub> was 11.93, 69.67 and 16.61 per cent over initial, control and T<sub>1</sub>, respectively (Table 37 and Fig. XVIII).

The Table 19 further revealed that treatment T<sub>1</sub>, T<sub>6</sub> and T<sub>18</sub> exhibited a decline in available potassium content to the tune of 5.31, 12.39 and 11.78 per cent, respectively over initial status.

#### **4.37 Available sulphur (kg ha<sup>-1</sup>)**

Perusal of Table 19 revealed significant variation for available sulphur build up. Among various treatments, integration of organic with inorganic sources proved superior over sole applications of organics, inorganic fertilizers and integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered 29.20 kg ha<sup>-1</sup> of available sulphur after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to all treatments and initial status. The extent of increase in available sulphur due to T<sub>24</sub> was 30.95, 91.26 and 45.89 per cent over initial (20.16 kg ha<sup>-1</sup>), control (2.55 kg ha<sup>-1</sup>) and T<sub>1</sub> (15.80 kg ha<sup>-1</sup>), respectively (Table 19 and Fig. XIX).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded an available sulphur content of 22.04 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM

20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> (control) and initial. The extent of increase in available sulphur content due to T<sub>4</sub> was 8.52, 88.43 and 28.31 per cent over initial, control and T<sub>1</sub>, respectively (Table 19 and Fig. XIX).

Organic integrations exhibited an increase in available sulphur build up over sole application of organics and inorganic fertilizers, recording maximum build up of 23.76 kg ha<sup>-1</sup> with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to all organic integrations, T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial. However, T<sub>7</sub> exhibited at par results with T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>). The extent of increase in available sulphur content due to T<sub>7</sub> was 15.15, 89.26 and 33.50 per cent over initial, control and T<sub>1</sub>, respectively (Table 19 and Fig. XIX).

Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) registered higher available sulphur content over sole application of organics, inorganic fertilizers and organic integrations.

Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an available sulphur content of 26.42 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub>, T<sub>7</sub>, T<sub>18</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> and initial but exhibited at par results with T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>:

K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of increase due to T<sub>21</sub> in available sulphur content was 23.69, 90.34 and 40.19 per cent over initial status, control and T<sub>1</sub>, respectively (Table 19 and Fig. XIX).

The Table 19 further revealed that treatment T<sub>1</sub>, T<sub>6</sub> and T<sub>18</sub> exhibited a decline in available sulphur content by 21.62, 17.36 and 22.71 per cent, respectively over initial status.

#### **4.38 Available calcium (kg ha<sup>-1</sup>)**

Perusal of Table 20 revealed significant variation due to various treatments for available calcium content in the soil. Integration of organic and inorganic sources proved superior over sole application of organics, inorganic fertilizers and integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded 3526.08 kg ha<sup>-1</sup> of available calcium after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to all treatments and initial. However, exhibited at par results with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of increase in available calcium content due to T<sub>24</sub> was 2.10, 5.44 and 0.59 per cent over initial (3451.84 kg ha<sup>-1</sup>), control (3334.06 kg ha<sup>-1</sup>) and T<sub>1</sub> (3505.01 kg ha<sup>-1</sup>), respectively (Table 20 and Fig. XX).

Among sole application, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a maximum available calcium content of 3513.90 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> (control) and initial but was statistically comparable with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). The extent of increase in available calcium build up due to T<sub>4</sub> was 1.76, 5.11 and 0.25 per cent over initial, control and T<sub>1</sub>, respectively (Table 20 and Fig. XX).

Organic integrations enhanced the available calcium content in soil over sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded an available calcium content of 3518.47 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub>, T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>11</sub> (FYM 15t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub>, T<sub>25</sub> and initial but was statistically at par with rest of the organic integrations. The extent of increase in available sulphur content due to T<sub>7</sub> was 1.89, 5.24 and 0.38 per cent over initial, control and T<sub>1</sub>, respectively (Table 20 and Fig. XX).

Integration of organic sources with recommended fertilizer dose in equal proportions (50:50) registered an increase in available calcium content over sole application of organics, inorganic fertilizers and organic integrations. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an available calcium content of 3522.88 kg ha<sup>-1</sup> after the harvest

of rabi 2005-2006 residual crop pea and was found significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and initial but exhibited at par results with T<sub>7</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of increase in available calcium content due to T<sub>21</sub> was 2.00, 5.35 and 0.50 per cent over initial, control and T<sub>1</sub>, respectively (Table 20 and Fig. XX).

**Table 20: Influence of organic manures and inorganic fertilizers on mean available calcium and magnesium (kg ha<sup>-1</sup>)**

Treatment	Available calcium				Mean of main treatments	Available magnesium				Mean of main treatments
	Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06		Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06	
T <sub>1</sub>	<b>3471.90</b>	<b>3437.42</b>	<b>3542.10</b>	<b>3505.01</b>	<b>3489.10</b>	<b>1028.06</b>	<b>1015.34</b>	<b>1050.65</b>	<b>1033.23</b>	<b>1031.82</b>
T <sub>2</sub>	3474.15	3438.93	3543.25	3507.23		1030.65	1017.41	1050.97	1035.30	
T <sub>3</sub>	3475.60	3440.70	3547.50	3506.80		1031.60	1017.86	1052.60	1037.57	
T <sub>4</sub>	3479.20	3443.95	3549.55	3513.90		1035.70	1022.31	1056.59	1040.78	
T <sub>5</sub>	3473.65	3439.52	3545.10	3508.88		1030.37	1017.34	1051.73	1036.55	
T <sub>6</sub>	3466.65	3430.90	3469.75	3447.83		1022.20	1010.76	1040.97	1025.24	
<b>Mean</b>	<b>3473.85</b>	<b>3438.80</b>	<b>3531.03</b>	<b>3496.92</b>	<b>3485.15</b>	<b>1030.10</b>	<b>1017.13</b>	<b>1050.57</b>	<b>1035.08</b>	<b>1033.22</b>
T <sub>7</sub>	3487.40	3451.66	3552.90	3518.47		1042.63	1029.57	1063.17	1062.62	
T <sub>8</sub>	3478.35	3443.06	3546.65	3510.31		1030.48	1017.03	1051.15	1036.08	
T <sub>9</sub>	3481.45	3445.57	3550.20	3516.41		1033.54	1020.20	1053.75	1038.92	
T <sub>10</sub>	3479.90	3444.45	3549.25	3513.39		1029.06	1016.38	1049.53	1035.32	
T <sub>11</sub>	3479.60	3441.74	3546.00	3509.10		1031.01	1017.32	1052.05	1036.16	
T <sub>12</sub>	3482.35	3447.00	3551.15	3515.81		1035.15	1021.58	1056.26	1041.12	
T <sub>13</sub>	3481.30	3445.38	3550.40	3512.90		1031.29	1018.00	1052.55	1037.30	
T <sub>14</sub>	3480.40	3444.87	3549.95	3514.50		1031.40	1017.61	1051.68	1036.67	
T <sub>15</sub>	3482.85	3448.74	3553.00	3517.28		1039.30	1027.52	1065.44	1050.82	
T <sub>16</sub>	3482.70	3447.14	3552.55	3517.90		1041.20	1019.72	1058.59	1042.75	
T <sub>17</sub>	3481.45	3445.07	3549.70	3515.91		1031.48	1018.68	1055.89	1041.03	
<b>Mean</b>	<b>3481.34</b>	<b>3445.88</b>	<b>3550.15</b>	<b>3514.72</b>	<b>3498.02</b>	<b>1034.23</b>	<b>1020.32</b>	<b>1055.46</b>	<b>1041.70</b>	<b>1037.92</b>
T <sub>18</sub>	<b>3466.90</b>	<b>3431.60</b>	<b>3529.95</b>	<b>3482.00</b>	<b>3477.61</b>	<b>1023.65</b>	<b>1010.21</b>	<b>1043.38</b>	<b>1028.52</b>	<b>1026.44</b>
T <sub>19</sub>	3485.50	3449.94	3555.00	3520.10		1042.83	1028.66	1069.01	1053.35	
T <sub>20</sub>	3484.95	3452.32	3558.60	3521.08		1043.56	1030.83	1071.78	1057.01	
T <sub>21</sub>	3487.65	3454.02	3558.60	3522.88		1049.42	1034.79	1078.73	1063.79	
T <sub>22</sub>	3482.90	3449.95	3552.75	3516.89		1042.18	1030.83	1071.53	1056.40	
T <sub>23</sub>	3482.35	3449.24	3551.00	3515.98		1040.37	1027.12	1068.51	1050.65	
T <sub>24</sub>	3493.95	3454.32	3559.55	3526.08		1066.06	1043.23	1095.65	1078.87	
<b>Mean</b>	<b>3486.21</b>	<b>3451.63</b>	<b>3555.91</b>	<b>3520.50</b>	<b>3503.56</b>	<b>1047.40</b>	<b>1032.57</b>	<b>1075.86</b>	<b>1060.01</b>	<b>1053.96</b>
T <sub>25</sub>	<b>3438.90</b>	<b>3400.70</b>	<b>3364.40</b>	<b>3334.06</b>	<b>3384.51</b>	<b>990.49</b>	<b>979.88</b>	<b>960.79</b>	<b>949.03</b>	<b>970.04</b>
Initial	<b>3451.84</b>					<b>1008.00</b>				
CD at 5%	6.40	5.40	9.76	8.15		8.20	6.49	9.80	12.81	

The Table 20 further revealed a marginal decline in available calcium content over initial status in treatment T<sub>6</sub>.

#### **4.39 Available magnesium (kg ha<sup>-1</sup>)**

Perusal of Table 20 revealed significant variation due to various treatments for available magnesium content in the soil. Integration of organic and inorganic sources proved superior over sole application of organics, inorganic fertilizers and integration of organic sources.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded the maximum available magnesium content of 1078.87 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to all treatments and initial. The extent of increase in available magnesium content due to T<sub>24</sub> was 6.56, 12.03 and 4.23 per cent over initial (1008.00 kg ha<sup>-1</sup>), control (949.03 kg ha<sup>-1</sup>) and T<sub>1</sub> (1033.23 kg ha<sup>-1</sup>), respectively (Table 20 and Fig. XXI).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6t ha<sup>-1</sup>) recorded an available magnesium content of 1040.78 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> (control) and initial but was statistically at par with T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). The extent of increase in available magnesium content due to

T<sub>4</sub> was 3.14, 8.81 and 0.72 per cent over initial, control and T<sub>1</sub>, respectively (Table 20 and Fig. XXI).

Integration among organics enhanced the available magnesium content over sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded an available magnesium content of 1062.62 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to all organic integration treatments T<sub>18</sub>, T<sub>25</sub> and initial but was statistically at par with T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>). The extent of increase in magnesium availability due to T<sub>7</sub> was 5.14, 10.68 and 2.76 per cent over initial, control and T<sub>1</sub>, respectively (Table 20 and Fig. XXI).

Substitution of nutrients in equal proportions (50:50) through individual organic sources and recommended fertilizer dose exhibited an increase in magnesium availability over sole application of organics, inorganic fertilizers and integration of organics. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded an available magnesium content of 1063.79 kg ha<sup>-1</sup> after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> and initial but was statistically comparable with T<sub>7</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The extent of increase in available magnesium content due to T<sub>21</sub> was 5.24,

10.78 and 2.87 per cent, respectively over initial, control and T<sub>1</sub>, respectively (Table 20 and Fig. XXI).

### **Influence of organic manures and inorganic fertilizers on Rhizosphere microbial population**

#### **4.40 Fungal population (No. g<sup>-1</sup> of soil x 10<sup>5</sup>)**

Perusal of Table 21 revealed significant variation due to various treatments for fungal population. Integration of organic sources proved superior in fungal build up over sole application of organics, inorganic fertilizers and integration of organic with inorganic sources.

Among 25 treatments under study, maximum fungal count of 60.11 g<sup>-1</sup> soil x 10<sup>5</sup> was recorded with T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to all treatments and initial status. The extent of increase in fungal population due to T<sub>24</sub> was 93.34, 95.59 and 80.70 per cent over initial count (4.00 x 10<sup>5</sup>), control (2.65 x 10<sup>5</sup>) and T<sub>1</sub> (11.60 x 10<sup>5</sup>), respectively (Table 21 and Fig. XXII).

Among sole application of organic sources, treatment T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) recorded a fungal count of 31.10 x 10<sup>5</sup> g<sup>-1</sup> of soil after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub>

(control) and initial but was statistically at par with T<sub>4</sub> (PM 6 t ha<sup>-1</sup>). The extent of increase in fungal population due to T<sub>6</sub> was 87.13, 91.47 and 62.70 percent over initial count, control and T<sub>1</sub>, respectively (Table 21 and Fig. XXII).

Integration of organic sources registered a maximum build up of fungal population as compared to sole application of organics, inorganic fertilizers and integration of organic with recommended fertilizer dose. Treatment T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) recorded a fungal population of 51.06 x 10<sup>5</sup> g<sup>-1</sup> soil after the harvest of rabi 2005-2006 residual crop pea which was significantly superior to T<sub>1</sub>, T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>18</sub>, T<sub>25</sub> and initial count but exhibited at par values with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>). The extent of increase in fungal build up was 92.16, 94.81 and 77.28 per cent over initial count, control and T<sub>1</sub>, respectively (Table 21 and Fig. XXII).

Integration of individual organic sources with recommended fertilizer in equal proportion exhibited an increase in fungal population over sole application of organic sources and recommended fertilizer dose. Treatment T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a fungal build up of 43.89 x 10<sup>5</sup> g<sup>-1</sup> soil after the harvest of rabi 2005-2006 residual crop pea and was found significantly superior to T<sub>1</sub>, T<sub>19</sub>

(FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub>, T<sub>25</sub> and initial status but was statistically at par with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>7</sub>. However, T<sub>23</sub> registered significantly lower values than T<sub>16</sub> and T<sub>24</sub>. The extent of increase

**Table 21: Influence of organic manures and inorganic fertilizers on mean fungal and bacterial population (No. g<sup>-1</sup> of soil x 10<sup>5</sup>)**

Treatment	Fungal population				Mean of main treatments	Bacterial population				Mean of main treatments
	Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06		Kharif 2004	Rabi 2004-05	Kharif 2005	Rabi 2005-06	
T <sub>1</sub>	<b>6.51</b>	<b>7.90</b>	<b>11.38</b>	<b>11.60</b>	<b>9.34</b>	<b>19.30</b>	<b>19.90</b>	<b>24.60</b>	<b>26.40</b>	<b>22.55</b>
T <sub>2</sub>	8.30	10.50	16.65	20.10		21.05	26.25	31.85	34.80	
T <sub>3</sub>	9.60	9.90	15.79	21.84		25.45	28.30	33.40	37.25	
T <sub>4</sub>	10.64	13.53	20.51	26.56		27.45	28.65	33.50	40.45	
T <sub>5</sub>	9.41	10.42	16.76	24.15		26.00	28.65	39.65	45.10	
T <sub>6</sub>	12.35	13.50	24.75	31.10		30.55	29.25	45.85	59.80	
<b>Mean</b>	<b>10.06</b>	<b>11.57</b>	<b>18.89</b>	<b>24.75</b>	<b>16.31</b>	<b>26.10</b>	<b>28.17</b>	<b>36.85</b>	<b>43.48</b>	<b>33.67</b>
T <sub>7</sub>	15.45	19.50	33.12	47.10		46.10	48.10	56.60	67.70	
T <sub>8</sub>	12.39	16.60	25.66	29.84		25.20	30.15	38.15	41.65	
T <sub>9</sub>	12.49	23.13	30.38	40.06		29.70	35.00	39.25	45.85	
T <sub>10</sub>	11.26	20.52	29.13	38.15		26.75	33.00	37.90	44.00	
T <sub>11</sub>	20.00	23.40	29.79	39.84		30.45	33.80	42.90	46.75	
T <sub>12</sub>	14.44	24.50	31.66	41.84		30.20	40.15	46.65	54.65	
T <sub>13</sub>	12.19	20.90	28.70	39.58		29.60	41.70	45.45	49.10	
T <sub>14</sub>	21.73	25.53	32.92	44.80		36.60	42.55	49.30	60.30	
T <sub>15</sub>	15.00	24.42	34.17	45.89		36.15	44.05	59.95	65.45	
T <sub>16</sub>	22.64	30.53	46.51	51.06		43.45	47.65	65.00	70.45	
T <sub>17</sub>	21.99	26.13	38.38	47.56		45.20	51.00	64.25	70.58	
<b>Mean</b>	<b>16.32</b>	<b>23.19</b>	<b>32.76</b>	<b>42.33</b>	<b>28.65</b>	<b>34.54</b>	<b>40.65</b>	<b>49.58</b>	<b>56.04</b>	<b>45.20</b>
T <sub>18</sub>	<b>5.73</b>	<b>6.03</b>	<b>8.92</b>	<b>10.70</b>	<b>7.84</b>	<b>16.10</b>	<b>17.55</b>	<b>19.30</b>	<b>24.00</b>	<b>19.23</b>
T <sub>19</sub>	8.78	11.66	19.15	25.02		28.60	32.40	33.40	39.50	
T <sub>20</sub>	9.55	11.85	21.90	29.11		29.15	35.40	37.05	42.65	
T <sub>21</sub>	13.91	15.42	30.26	40.15		32.00	35.65	40.65	49.60	
T <sub>22</sub>	11.26	12.02	26.13	35.15		30.75	33.00	43.90	56.00	
T <sub>23</sub>	13.50	14.92	30.67	43.89		32.65	40.05	49.95	69.45	
T <sub>24</sub>	22.65	31.55	44.65	60.11		47.15	51.40	66.55	74.15	
<b>Mean</b>	<b>13.27</b>	<b>16.23</b>	<b>28.79</b>	<b>28.90</b>	<b>24.29</b>	<b>33.38</b>	<b>37.98</b>	<b>45.25</b>	<b>55.22</b>	<b>42.95</b>
T <sub>25</sub>	<b>3.72</b>	<b>3.19</b>	<b>2.75</b>	<b>2.65</b>	<b>3.15</b>	<b>13.70</b>	<b>14.90</b>	<b>12.20</b>	<b>10.30</b>	<b>12.77</b>
Initial	<b>4.00</b>					<b>15.00</b>				
CD at 5%	2.73	3.69	6.29	6.35		6.27	5.60	8.03	10.37	

in fungal build up due to T<sub>23</sub> was 90.88, 93.96 and 73.57 per cent over initial population, control and T<sub>1</sub>, respectively (Table 21 and Fig. XXII).

#### 4.41 Bacterial population (No. g<sup>-1</sup> of soil x 10<sup>5</sup>)

Perusal of Table 21 revealed significant variation due to various treatments for bacterial population. Integration of organic sources registered more bacterial build up as compared to sole application of organics, inorganic fertilizers and integration of organic and inorganic sources.

Among 25 treatments under study, maximum bacterial count (74.15 x 10<sup>5</sup> g<sup>-1</sup> soil) was recorded with T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) after the harvest of rabi 2005-2006 residual crop pea which was statistically at par with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but exhibited significant superiority over rest of the treatments and initial status. The extent of increase in bacterial population due to T<sub>24</sub> was 79.77, 86.10 and 64.39 per cent over initial (15 x 10<sup>5</sup>), control (10.30 x 10<sup>5</sup>) and T<sub>1</sub> (26.40 x 10<sup>5</sup>), respectively (Table 21 and Fig. XXIII).

Among sole application of organic sources, treatment T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) recorded a bacterial count of 59.80 x 10<sup>5</sup> g<sup>-1</sup> of soil after the harvest of rabi 2005-2006 residual crop pea and was found significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub>

(SM 20 t ha<sup>-1</sup>), T<sub>4</sub> (PM 6 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> and initial population. The extent of increase in bacterial build up due to T<sub>6</sub> was 74.91, 82.77 and 55.85 per cent over initial count, control and T<sub>1</sub>, respectively (Table 21 and Fig. XXIII).

Integration among organic sources exhibited an increase in bacterial population over sole application of organics and inorganic fertilizers as well as integration of organics with recommended fertilizer dose. Treatment T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) recorded a bacterial count of 70.58 x 10<sup>5</sup> cell g<sup>-1</sup> soil after the harvest of rabi 2005-2006 residual crop pea and was found significantly superior to T<sub>1</sub>, T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>18</sub>, T<sub>25</sub> and initial population but was statistically at par with T<sub>7</sub>, T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>), T<sub>15</sub> and T<sub>16</sub>. The extent of increase in bacterial population due to T<sub>17</sub> was 78.74, 85.40 and 62.59 per cent over initial count, control and T<sub>1</sub>, respectively (Table 21 and Fig. XXIII).

Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in bacterial population over sole application of organic sources and recommended fertilizer dose. Treatment T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a bacterial build up of 69.45 x 10<sup>5</sup> cells g<sup>-1</sup> of soil after the harvest of rabi 2005-2006 residual crop pea and was found significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>

<sup>1-</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>25</sub> and initial but exhibited at par results with T<sub>17</sub>, T<sub>16</sub> and T<sub>7</sub>. The extent of increase in bacterial population due to T<sub>23</sub> was 78.40, 85.16 and 61.98 per cent over initial status, control and T<sub>1</sub>, respectively (Table 21 and Fig. XXIII).

### **Residual effect of organic manures and inorganic fertilizers on pea**

#### **4.42 Plant height (cm)**

Perusal of Table 22 exhibited significant variations due to various treatments in respect of plant height. Integration of organic and inorganic sources exhibited better residual effect as compared to sole application as well as integration of organics.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a maximum plant height of 43.20 and 45.38 cm during rabi 2004-2005 and 2005-2006, respectively and were found statistically at par with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>4</sub> (PM 6 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>) and T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) but were significantly superior to rest of the treatments. Pooled analysis revealed that T<sub>24</sub> recorded a plant height of 44.43 cm which was statistically at par with T<sub>7</sub>, T<sub>20</sub> (SM 10t + 60:

30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but significantly superior to rest of the treatments (Table 22).

Among sole applications of organics, treatment T<sub>4</sub> (PM 6t ha<sup>-1</sup>) recorded a plant height of 39.72, 41.62 and 40.57 cm during rabi 2004-2005, 2005-2006 and pooled over seasons respectively and was found significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but exhibited at par results with T<sub>2</sub>, T<sub>3</sub> and T<sub>5</sub>.

Integration among organics exhibited an increase in plant height over sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a plant height of 42.36 and 44.40 cm during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par values with rest of the organic integration treatments. Pooled over analysis revealed that T<sub>7</sub> recorded a plant height of 43.38 cm which was statistically at par with T<sub>15</sub> but was significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>25</sub> and rest of the organic integration treatments (Table 22).

Integration of organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited an increase in plant height over sole application or organics, inorganic fertilizers and integration of organics. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a plant of 42.96, 45.11 and 44.27 cm during rabi 2004-2005,

2005-2006 and pooled over seasons, respectively and were found significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with

**Table 22: Residual effect of organic manures and inorganic fertilizers on mean plant height (cm) and pod number plant<sup>-1</sup> in pea**

Treatment	Plant height			Mean of main treatments	Pod number plant <sup>-1</sup>			Mean of main treatments
	Kharif 2004	Kharif 2005	Pooled		Kharif 2004	Kharif 2005	Pooled	
T <sub>1</sub>	<b>34.08</b>	<b>35.55</b>	<b>34.81</b>	<b>34.81</b>	<b>14.22</b>	<b>14.80</b>	<b>14.51</b>	<b>14.51</b>
T <sub>2</sub>	39.32	40.87	39.89		15.28	15.98	15.73	
T <sub>3</sub>	39.82	40.81	40.11		15.65	16.25	16.22	
T <sub>4</sub>	39.72	41.62	40.57		16.27	17.11	16.89	
T <sub>5</sub>	39.16	41.16	39.93		15.28	15.82	15.59	
T <sub>6</sub>	23.62	25.07	24.55		13.18	13.88	13.43	
<b>Mean</b>	<b>36.32</b>	<b>37.90</b>	<b>37.01</b>	<b>37.01</b>	<b>15.13</b>	<b>15.80</b>	<b>15.57</b>	<b>15.50</b>
T <sub>7</sub>	42.36	44.40	43.38		21.04	22.46	21.75	
T <sub>8</sub>	39.96	41.69	40.83		18.11	19.03	18.74	
T <sub>9</sub>	40.56	42.44	41.61		19.13	20.24	19.78	
T <sub>10</sub>	40.00	42.04	40.99		18.14	19.45	18.73	
T <sub>11</sub>	39.42	40.91	40.37		17.75	18.10	17.66	
T <sub>12</sub>	40.96	42.69	41.82		20.21	21.18	20.53	
T <sub>13</sub>	39.96	41.68	40.82		20.18	20.96	20.57	
T <sub>14</sub>	40.26	41.68	41.08		19.70	20.47	20.01	
T <sub>15</sub>	41.60	43.53	42.53		21.21	22.08	21.41	
T <sub>16</sub>	41.22	42.72	42.06		20.37	21.31	20.64	
T <sub>17</sub>	40.76	42.54	41.54		20.13	21.14	20.54	
<b>Mean</b>	<b>40.64</b>	<b>42.39</b>	<b>41.54</b>	<b>41.52</b>	<b>19.63</b>	<b>20.58</b>	<b>20.03</b>	<b>20.08</b>
T <sub>18</sub>	<b>31.06</b>	<b>32.13</b>	<b>31.49</b>	<b>31.59</b>	<b>13.60</b>	<b>13.97</b>	<b>13.85</b>	<b>13.80</b>
T <sub>19</sub>	42.16	44.09	43.12		21.22	22.28	21.75	
T <sub>20</sub>	42.50	44.38	43.30		21.78	22.72	22.21	
T <sub>21</sub>	42.96	45.11	44.27		22.03	22.99	22.35	
T <sub>22</sub>	42.30	44.44	43.39		20.74	21.75	21.31	
T <sub>23</sub>	41.20	42.78	42.02		20.41	21.08	20.97	
T <sub>24</sub>	43.20	45.38	44.43		22.53	23.59	23.22	
<b>Mean</b>	<b>42.38</b>	<b>44.36</b>	<b>43.42</b>	<b>43.38</b>	<b>21.45</b>	<b>22.40</b>	<b>21.96</b>	<b>21.93</b>
T <sub>25</sub>	<b>18.14</b>	<b>17.98</b>	<b>18.06</b>	<b>18.06</b>	<b>9.40</b>	<b>9.50</b>	<b>9.72</b>	<b>9.54</b>
CD at 5%	4.94	5.32	1.29		3.27	3.30	0.95	

T<sub>7</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> and T<sub>22</sub>. However, T<sub>21</sub> exhibited at par results with T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during rabi 2004-2005 and 2005-2006 (Table 22).

#### **4.43 Pod number plant<sup>-1</sup>**

Perusal of Table 22 revealed significant variations among various treatments for pod number plant<sup>-1</sup>. Integration of organics with inorganic sources and integration of different organics depicted superior residual influence as compared to sole application of organics and inorganic fertilizers.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded maximum pod number of 22.53 and 23.59 plant<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>4</sub> (PM 6 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>), T<sub>11</sub> (FYM 11t + BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but exhibited at par results with rest of the treatments. Pooled over analysis revealed the significance of T<sub>24</sub>, recording a pod number of 23.22 plant<sup>-1</sup> which was significantly superior to all other treatments but was statistically at par with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a pod number of 16.27 and 17.11 plant<sup>-1</sup> during rabi 2004-

2005 and 2005-2006, respectively and was found significantly superior to T<sub>25</sub> but exhibited at par results with T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>18</sub>. Pooled analysis revealed the significance of T<sub>4</sub> recording a pod number of 16.89 plant<sup>-1</sup> which was significantly superior to T<sub>1</sub>, T<sub>2</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>3</sub> (Table 22).

Integration among organic sources enhanced the pod number plant<sup>-1</sup> over sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a pod number of 21.04 and 22.46 plant<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and were found significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but were statistically at par with rest of the organic integration treatments. Pooled analysis revealed that treatment T<sub>7</sub> recorded a pod number of 21.75 plant<sup>-1</sup> which was statistically at par with T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) but exhibited significant superiority over rest of the organic integration treatments, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 22).

Integration of different organics with recommended fertilizer in equal proportions (50:50) increased the pod number plant<sup>-1</sup> over sole application of organics, inorganic fertilizers and integration of organics. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a pod number of 22.03, 22.99 and 22.35 during rabi 2004-2005, 2005-2006 and pooled over seasons, respectively and was found significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>7</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

However T<sub>21</sub> exhibited at par results with T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during rabi 2004-2005 and 2005-2006 (Table 22).

#### **4.44 Pod yield plant<sup>-1</sup> (g)**

Perusal of Table 23 revealed significant variations due to various treatments for pod yield plant<sup>-1</sup>. Integration of organic with inorganic sources exhibited a superior residual effect as compared to sole application of organics, inorganic fertilizers and integration of organics.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a maximum pod yield of 35.73 and 38.14 g during rabi 2004-2005 and 2005-2006, respectively and was found statistically at par with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but exhibited significant superiority over rest of the treatments. However, T<sub>24</sub> was statistically at par with T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during rabi 2004-2005. Pooled analysis revealed the significant superiority of T<sub>24</sub> over rest of the treatments recording a pod yield of 37.07 g plant<sup>-1</sup> (Table 23).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a pod yield of 25.54 and 26.72 g plant<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to

T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). Pooled analysis revealed the significance of T<sub>4</sub>, recording a pod yield of 26.23 g plant<sup>-1</sup> and was found significantly superior to T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 23).

Integration among organic sources enhanced the pod yield plant<sup>-1</sup> over sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a pod yield of 33.81 and 35.67 g plant<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to rest of the organic integration treatments, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but was found statistically at par with T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> and T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>). Pooled analysis revealed the significance of T<sub>7</sub>, recording a pod yield of 34.74 g plant<sup>-1</sup> and was found significantly superior to rest of the organic integration treatments, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 23).

Integration of organic sources with recommended fertilizer dose in equal proportions (50:50) recorded higher values for pod yield plant<sup>-1</sup> as compared to sole application of organics, inorganic fertilizers and integration of organic sources. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a pod yield of 34.78 and 36.47 g plant<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>7</sub>, T<sub>19</sub>, T<sub>20</sub> and

T<sub>22</sub>. However, T<sub>21</sub> exhibited significant superiority over T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during rabi 2004-2005 but was statistically at par with T<sub>23</sub> during rabi 2005-2006. Pooled analysis revealed that T<sub>21</sub> recorded a pod yield of 35.65 g plant<sup>-1</sup> which

**Table 23: Residual effect of organic manures and inorganic fertilizers on mean pod yield plant<sup>-1</sup> (g), pod yield ha<sup>-1</sup> (q) and nodule number plant<sup>-1</sup> in pea**

Treatment	Pod yield plant <sup>-1</sup>			Mean of main treatments	Pod yield ha <sup>-1</sup>			Mean of main treatments	Nodule number plant <sup>-1</sup>			Mean of main treatments
	Rabi 2004-05	Rabi 2005-06	Pooled		Rabi 2004-05	Rabi 2005-06	Pooled		Rabi 2004-05	Rabi 2005-06	Pooled	
T <sub>1</sub>	<b>20.00</b>	<b>20.83</b>	<b>20.42</b>	<b>20.41</b>	<b>66.69</b>	<b>69.44</b>	<b>68.06</b>	<b>68.06</b>	<b>26.66</b>	<b>27.76</b>	<b>27.21</b>	<b>27.21</b>
T <sub>2</sub>	22.60	23.49	23.38		75.35	78.29	77.92		29.70	30.88	30.23	
T <sub>3</sub>	23.08	23.99	23.61		77.07	79.96	78.70		31.27	32.42	31.84	
T <sub>4</sub>	25.54	26.72	26.23		85.10	89.08	87.43		32.94	34.05	33.35	
T <sub>5</sub>	22.52	23.59	23.03		74.97	78.64	76.67		31.58	32.65	31.66	
T <sub>6</sub>	15.75	16.44	15.76		52.52	54.79	52.56		31.10	32.18	31.70	
<b>Mean</b>	<b>21.89</b>	<b>22.84</b>	<b>22.40</b>	<b>22.37</b>	<b>73.00</b>	<b>76.15</b>	<b>74.65</b>	<b>74.60</b>	<b>31.31</b>	<b>32.43</b>	<b>31.75</b>	<b>31.83</b>
T <sub>7</sub>	23.81	35.67	34.74		112.69	118.92	115.80		43.14	44.70	43.92	
T <sub>8</sub>	25.84	27.01	26.16		86.24	90.04	87.22		33.51	34.69	34.15	
T <sub>9</sub>	29.64	31.05	30.11		98.77	103.51	100.38		34.88	35.92	35.31	
T <sub>10</sub>	28.62	30.05	28.97		95.32	100.18	96.51		35.12	36.47	35.40	
T <sub>11</sub>	24.83	26.06	25.37		82.91	86.87	84.71		33.27	34.47	33.88	
T <sub>12</sub>	31.44	32.89	32.42		104.91	109.63	108.19		38.71	40.09	39.35	
T <sub>13</sub>	28.67	31.05	29.86		95.79	103.50	99.65		36.28	37.44	36.86	
T <sub>14</sub>	27.87	29.21	28.57		92.99	97.38	95.35		36.15	37.27	36.57	
T <sub>15</sub>	31.85	33.21	32.42		108.36	110.70	109.21		43.39	44.77	43.63	
T <sub>16</sub>	30.04	31.82	30.83		100.12	106.08	102.75		36.54	37.80	37.32	
T <sub>17</sub>	29.14	31.10	30.35		97.11	103.67	101.15		36.58	37.25	37.24	
<b>Mean</b>	<b>29.25</b>	<b>30.82</b>	<b>29.98</b>	<b>30.01</b>	<b>97.74</b>	<b>102.77</b>	<b>100.08</b>	<b>100.19</b>	<b>37.05</b>	<b>38.26</b>	<b>37.60</b>	<b>37.63</b>
T <sub>18</sub>	<b>15.37</b>	<b>16.16</b>	<b>15.74</b>	<b>14.75</b>	<b>51.33</b>	<b>53.88</b>	<b>52.44</b>	<b>52.55</b>	<b>19.15</b>	<b>19.77</b>	<b>19.60</b>	<b>19.50</b>
T <sub>19</sub>	32.27	33.98	33.12		107.52	113.26	110.39		36.82	38.35	37.58	
T <sub>20</sub>	33.05	34.79	33.79		109.80	115.99	112.41		40.06	41.75	40.59	
T <sub>21</sub>	34.78	36.47	35.65		115.84	121.56	118.84		44.28	45.90	45.55	
T <sub>22</sub>	31.62	34.12	33.23		105.32	113.74	110.77		40.32	42.12	41.62	
T <sub>23</sub>	30.85	32.73	31.89		102.86	109.10	106.30		40.19	42.02	41.55	
T <sub>24</sub>	35.73	38.14	37.07		119.00	127.16	123.56		45.06	47.10	46.39	
<b>Mean</b>	<b>33.05</b>	<b>35.03</b>	<b>34.12</b>	<b>34.06</b>	<b>110.05</b>	<b>116.80</b>	<b>113.71</b>	<b>113.52</b>	<b>41.12</b>	<b>42.87</b>	<b>42.21</b>	<b>42.06</b>
T <sub>25</sub>	<b>11.18</b>	<b>11.06</b>	<b>11.14</b>	<b>11.12</b>	<b>37.10</b>	<b>36.88</b>	<b>36.99</b>	<b>39.99</b>	<b>16.40</b>	<b>16.05</b>	<b>16.22</b>	<b>16.22</b>
CD at 5%	3.84	3.93	1.00		12.71	13.12	3.38		4.02	4.77	1.03	

was significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub> and T<sub>25</sub> but exhibited at par results with T<sub>7</sub> (Table 23).

#### 4.45 Pod yield ha<sup>-1</sup> (q)

Perusal of Table 23 revealed significant variations due to various treatments for pod yield ha<sup>-1</sup>. Integration of organic and inorganic sources exhibited a superior residual influence as compared to sole applications and integration of organics.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered a maximum pod yield of 119.00 and 127.16 q ha<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found statistically at par with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but exhibited significant superiority over rest of the treatments. Pooled analysis revealed the significant superiority of T<sub>24</sub> over rest of the treatments, recording a pod yield of 123.56 q ha<sup>-1</sup> (Table 23 and Fig. XXIV).

Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded a pod yield of 85.10 and 89.08 q ha<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). Pooled analysis revealed the significance of T<sub>4</sub>, recording a pod yield of 87.43 q

ha<sup>-1</sup> which was significantly superior to T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 23 and Fig. XXIV).

Integration of organic sources exhibited a better residual influence and recorded higher pod yield ha<sup>-1</sup> than sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a pod yield of 112.69 and 118.92 q ha<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to rest of the organic integration treatments, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but was found statistically at par with T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>). Pooled analysis revealed the significance of T<sub>7</sub>, recording a pod yield of 115.80 q ha<sup>-1</sup> and was found significantly superior to rest of the organic integration treatments, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 23 and Fig. XXIV).

Integration of organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited superior residual influence in enhancing pod yield ha<sup>-1</sup> as compared to sole application of organics, inorganic fertilizers and integration of organic sources. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a pod yield of 115.84 and 121.56 q ha<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub> but exhibited at par results with T<sub>7</sub>, T<sub>19</sub>, T<sub>20</sub> and T<sub>22</sub>. However, T<sub>21</sub> exhibited significant superiority over T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during rabi 2004-2005 but was statistically at par with T<sub>23</sub> during rabi 2005-2006. Pooled analysis

revealed that T<sub>21</sub> recorded a pod yield of 118.84 q ha<sup>-1</sup> which was significantly superior to T<sub>1</sub>, T<sub>18</sub>, T<sub>19</sub>, T<sub>20</sub>, T<sub>22</sub>, T<sub>23</sub> and T<sub>25</sub> but was statistically at par with T<sub>7</sub> (Table 23 and Fig. XXIV).

#### 4.46 Nodule number plant<sup>-1</sup>

Perusal of Table 23 revealed significant variation due to various treatments for nodule number plant<sup>-1</sup>. Integration of organic and inorganic sources exhibited superior residual influence as compared to sole application of organics, inorganics and integration of organics.

Among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a nodule number of 45.06 and 47.10 plant<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to all other treatments but exhibited at par results with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Pooled analysis revealed that T<sub>24</sub> recorded a nodule number of 46.39 plant<sup>-1</sup> which was significantly superior to all other treatments but exhibited at par results with T<sub>21</sub> (Table 23).

Among sole application of organics, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) registered a nodule number of 32.94 and 34.05 plant<sup>-1</sup> during rabi 2004-2005 and 2005-2006 respectively and was found significantly superior to T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) but was statistically at par with T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>).

<sup>1</sup>). Pooled analysis revealed the significance of T<sub>4</sub>, recording a nodule number of 33.35 plant<sup>-1</sup> which was significantly superior to T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> (Table 23).

Integration of organic sources exhibited a better residual influence and recorded higher nodule number plant<sup>-1</sup> than sole application of organics and inorganic fertilizers. Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded a nodule number of 43.14, 44.70 and 43.92 plant<sup>-1</sup> during rabi 2004-2005, 2005-2006 and pooled over seasons respectively and was found statistically at par with T<sub>15</sub> but exhibited significant superiority over rest of the organic integration treatments, T<sub>1</sub>, T<sub>18</sub> and T<sub>25</sub>. However, T<sub>7</sub> exhibited at par results with T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>) during rabi 2005-2006 (Table 23).

Integration of organic sources with recommended fertilizer dose in equal proportions (50:50) exhibited significant residual effect in enhancing the nodule number plant<sup>-1</sup>. Integration of PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> (T<sub>21</sub>) recorded a nodule number of 44.28 and 45.90 plant<sup>-1</sup> during rabi 2004-2005 and 2005-2006, respectively and was found significantly superior to T<sub>1</sub>, T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>18</sub> and T<sub>25</sub> but was found statistically at par with T<sub>7</sub> and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). However, T<sub>21</sub> exhibited at par results with T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) during rabi 2005-2006. Pooled analysis revealed that T<sub>21</sub> recorded a

nodule number  $45.55 \text{ plant}^{-1}$ , which was significantly superior to  $T_1$ ,  $T_{18}$ ,  $T_{19}$ ,  $T_{20}$ ,  $T_{22}$ ,  $T_{23}$  and  $T_{25}$  (Table 23).

#### **4.47 Economic of production in okra**

##### **4.47.1 Cost structure in okra crop**

Since all other operations except the use of organic sources, chemical fertilizers and their spreading were common, under all treatments, the additional cost incurred on this account was added to the expenditure on all the treatments except control (Table 24).

The per hectare and treatment wise cost of cultivation is presented in Table 25-26 respectively.

The cultivation of okra turned labour intensive and created an employment of 230 labour day  $\text{ha}^{-1}$  from ploughing of land upto the harvesting of crop.

Maximum cost of cultivation (Rs.  $60,372.20 \text{ ha}^{-1}$ ) was estimated in  $T_5$  (VC  $6t \text{ ha}^{-1}$ ) and the lowest in  $T_6$  (BF  $7 \text{ kg ha}^{-1}$ ) and  $T_{25}$  (control) which respectively accounted for Rs.  $42,512.20 \text{ ha}^{-1}$  and Rs.  $41,812.20 \text{ ha}^{-1}$ .

##### **4.47.2 Income distribution and benefit cost ratio**

Perusal of Table 27 revealed the position of input and output in terms of economics of production. The treatment wise cost of cultivation and their returns revealed maximum returns of Rs. 1,25,140.80 were registered in  $T_7$  (FYM  $6t + \text{SM } 4t + \text{PM } 1t + \text{VC } 1t + \text{BF } 7 \text{ kg ha}^{-1}$ ) followed by

$T_{16}$  (PM 3t + BF 7 kg ha<sup>-1</sup>),  $T_{15}$  (PM 3t + VC 3t ha<sup>-1</sup>),  $T_{12}$  (SM 10t + PM 3t ha<sup>-1</sup>) ,  $T_4$  (PM 6 t ha<sup>-1</sup>) and  $T_{17}$  (VC 3t + BF 7 kg ha<sup>-1</sup>)

**Table 24: Resource optimization for various nutrient combinations and treatment-wise added cost in okra cultivation**

Treatment	Resource optimization in okra for various nutrient combinations			Treatment-wise added cost in okra cultivation				
				Cost involved on		No. of labours for spreading @ Rs.70 labour <sup>-1</sup>	Amount involved on labour (Rs)	Total added cost Rs. ha <sup>-1</sup>
	Qty used t ha <sup>-1</sup>	Factor input cost unit Rs. t <sup>-1</sup>	Total factor cost Rs. ha <sup>-1</sup>	Fertilizer (Rs)	Manures (Rs)			
T <sub>1</sub>	0.735	6226.61	4576.56	4576.56	-	8	560.00	5136.56
T <sub>2</sub>	30.00	500.00	15000.00	-	15000.00	10	700.00	15700.00
T <sub>3</sub>	20.00	800.00	16000.00	-	16000.00	10	700.00	16700.00
T <sub>4</sub>	6.00	1500.00	9000.00	-	9000.00	8	560.00	9560.00
T <sub>5</sub>	6.00	3000.00	1800.00	-	18000.00	8	560.00	18560.00
T <sub>6</sub>	0.007	40000.00	280.00	-	280.00	6	420.00	700.00
T <sub>7</sub>	6+4+1+1+.007	941.46	10980.00	-	10980.00	8	560.00	11540.00
T <sub>8</sub>	15.00+10.00	620.00	15500.00	-	15500.00	8	560.00	16060.00
T <sub>9</sub>	15.00+3.00	666.66	12000.00	-	12000.00	8	560.00	12560.00
T <sub>10</sub>	15.00+3.00	916.66	16500.00	-	16500.00	8	560.00	17060.00
T <sub>11</sub>	15.00+0.007	518.42	7780.00	-	7780.00	8	560.00	8340.00
T <sub>12</sub>	10.00+3.00	961.53	12500.00	-	12500.00	8	560.00	13060.00
T <sub>13</sub>	10.00+3.00	1307.69	17000.00	-	17000.00	8	560.00	17560.00
T <sub>14</sub>	10.00+0.007	827.42	8280.00	-	8280.00	8	560.00	8840.00
T <sub>15</sub>	3.00+3.00	2250.00	13500.00	-	13500.00	8	560.00	14060.00
T <sub>16</sub>	3.00+0.007	1589.62	4780.00	-	4780.00	8	560.00	5340.00
T <sub>17</sub>	3.00+0.007	3086.13	9280.00	-	9280.00	8	560.00	9840.00
T <sub>18</sub>	0.367	6226.53	2288.28	2288.28	-	6	420.00	2708.28
T <sub>19</sub>	15.00+0.367	636.96	9788.28	2288.28	7500.00	7	490.00	10278.28
T <sub>20</sub>	10.00+0.367	992.40	10288.28	2288.28	8000.00	7	490.00	10778.28
T <sub>21</sub>	3.00+0.367	2016.12	6788.28	2288.28	4500.00	7	490.00	7278.28
T <sub>22</sub>	3.00+0.367	3352.62	11288.28	2288.28	9000.00	7	490.00	11778.28
T <sub>23</sub>	0.007+0.367	6760.10	2568.28	2288.28	280.00	6	420.00	2988.28
T <sub>24</sub>	3+2+0.5+0.6+0.007+0.367	1347.25	8218.28	2288.28	5930.00	7	490.00	8708.28
T <sub>25</sub>	No Manure/ Fertilizer/BF	-	-	-	-	-	-	-

**Table 25: Cost of cultivation of okra**

<b>Cost involved on variable and fixed factors</b>		<b>Rs. ha<sup>-1</sup></b>
<b>A.</b>	<b>Preparatory tillage</b>	
	Two ploughing @ Rs. 2000 ha <sup>-1</sup>	4000.00
	Clod breaking/leveling, 20 labours @ Rs. 70.00 labour <sup>-1</sup>	1400.00
	Preparation of beds/channels, 40 labours @ Rs. 70.00 labour <sup>-1</sup>	2800.00
	<b>Total</b>	<b>8200.00</b>
<b>B.</b>	<b>Seed sowing</b>	
	Seed sowing, 15 labours @ Rs. 70.00 labour <sup>-1</sup>	1050.00
	<b>Total</b>	<b>1050.00</b>
<b>C.</b>	<b>Irrigation</b>	
	Five irrigations, 15 labours @ Rs. 70.00 labour <sup>-1</sup>	1050.00
	<b>Total</b>	<b>1050.00</b>
<b>D.</b>	<b>Cultural operations</b>	
	Three weeding/hoeings, 60 labours @ Rs. 70.00 labour <sup>-1</sup>	4200.00
	<b>Total</b>	<b>4200.00</b>
<b>E.</b>	<b>Aftercare operations, 10 labours, 10 labours @ Rs. 70.00 labour<sup>-1</sup></b>	<b>700.00</b>
	<b>Total</b>	<b>700.00</b>
<b>F.</b>	<b>Harvesting and picking</b>	
	Pod picking (12 pickings), 5 labours for each picking @ Rs. 70.00 labour <sup>-1</sup>	4200.00
	Harvesting of plants, after last picking, 10 labours @ Rs. 70.00 labour <sup>-1</sup>	700.00
	<b>Total</b>	<b>4900.00</b>
	<b>Total (A+B+C+D+E+F)</b>	<b>20100.00</b>
	Incidental charges @ 5% of the working capital	1005.00
	Total labour component involved in total cost of cultivation	21105.00
<b>G.</b>	<b>Cost of seed</b>	
	Cost of seed @ Rs. 300.00 q <sup>-1</sup> for 20 kg of seed ha <sup>-1</sup>	600.00
	<b>Total</b>	<b>600.00</b>
	Variable cost (Labour + Cost of seed: 21105.00 + 600.00)	21705.00
	Land rent @ Rs.900.00 kanal <sup>-1</sup>	18000.00
	Land tax	80.00
	Depreciation on implements	800.00
	<b>Total</b>	<b>18880.00</b>
	Interest @ 6.5% on fixed factors	1227.20
	<b>Total fixed cost (18880.00 + 1227.20)</b>	<b>20107.20</b>

**Treatment-wise comparative economics of cost of cultivation in okra**

**Table 26:**

<b>Treatment</b>	<b>Fixed cost Rs.ha<sup>-1</sup></b>	<b>Variable cost Rs.ha<sup>-1</sup></b>	<b>Added cost Rs. Ha<sup>-1</sup></b>	<b>Total variable cost Rs. ha<sup>-1</sup></b>	<b>Total cost of cultivation Rs.ha<sup>-1</sup></b>
T <sub>1</sub>	20107.20	21705.00	5136.56	26841.56	46948.76
T <sub>2</sub>	20107.20	21705.00	15700.00	37405.00	57512.20
T <sub>3</sub>	20107.20	21705.00	16700.00	38405.00	58512.20
T <sub>4</sub>	20107.20	21705.00	9560.00	31265.00	51372.20
T <sub>5</sub>	20107.20	21705.00	18560.00	40265.00	60372.20
T <sub>6</sub>	20107.20	21705.00	700.00	22405.00	42512.20
T <sub>7</sub>	20107.20	21705.00	11540.00	33245.00	53352.20
T <sub>8</sub>	20107.20	21705.00	16060.00	37765.00	57872.20
T <sub>9</sub>	20107.20	21705.00	12560.00	34265.00	54372.20
T <sub>10</sub>	20107.20	21705.00	17060.00	38765.00	58872.20
T <sub>11</sub>	20107.20	21705.00	8340.00	30045.00	50152.20
T <sub>12</sub>	20107.20	21705.00	13060.00	34765.00	54872.20
T <sub>13</sub>	20107.20	21705.00	17560.00	39265.00	59372.20
T <sub>14</sub>	20107.20	21705.00	8840.00	30545.00	50652.20
T <sub>15</sub>	20107.20	21705.00	14060.00	35765.00	55872.20
T <sub>16</sub>	20107.20	21705.00	5340.00	27045.00	47152.20
T <sub>17</sub>	20107.20	21705.00	9840.00	31545.00	51652.20
T <sub>18</sub>	20107.20	21705.00	2708.28	24413.28	44520.48
T <sub>19</sub>	20107.20	21705.00	10278.28	31983.28	52090.48
T <sub>20</sub>	20107.20	21705.00	10778.28	32483.28	52590.48
T <sub>21</sub>	20107.20	21705.00	7278.28	28983.28	49090.20
T <sub>22</sub>	20107.20	21705.00	11778.28	33483.28	53590.48
T <sub>23</sub>	20107.20	21705.00	2988.28	24693.28	44800.48
T <sub>24</sub>	20107.20	21705.00	8708.28	30413.28	50520.48
T <sub>25</sub>	20107.20	21705.00	-	21705.00	41812.20

Total variable cost = (Variable cost + added cost), Total cost of cultivation = (Total variable cost + fixed cost\_

with returns per rupee invested of 3.34, 3.63, 3.10, 3.14, 3.25 and 3.22, respectively.

Integration of organic and inorganic sources did not exhibit an increase in net returns as compared to sole application of chemical fertilizer T<sub>1</sub> (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) but T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded a maximum net returns of Rs. 85,834.52 with returns Re<sup>-1</sup> invested of 2.70. However, the lowest net returns of Rs. 7,467.52 were recorded with T<sub>25</sub> (control) followed by T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) with returns Re<sup>-1</sup> invested of 1.17, 1.91 and 2.55, respectively.

#### **4.47.3 Break even analysis and margin of safety**

Perusal of Table 27 revealed variation for BEP (break even point) due to various treatments, recording minimum BEP of 32.70 q ha<sup>-1</sup> in T<sub>7</sub> followed by 32.82 and 32.85 q ha<sup>-1</sup> in T<sub>15</sub> and T<sub>12</sub>, respectively. However, maximum BEP of 71.86 q ha<sup>-1</sup> was recorded with T<sub>25</sub> (control). Maximum margin of safety 224.89 q ha<sup>-1</sup> was recorded with T<sub>24</sub> followed by 222.29, 215.36, 213.53, 211.88, 211.81, 210.78, 209.20, 205.77 and 205.28 q ha<sup>-1</sup> in T<sub>7</sub>, T<sub>15</sub>, T<sub>12</sub>, T<sub>16</sub>, T<sub>21</sub>, T<sub>1</sub>, T<sub>22</sub>, T<sub>4</sub> and T<sub>17</sub>, respectively. However, the minimum margin of safety 26.70 q ha<sup>-1</sup> was recorded in T<sub>25</sub> (control) (Table 27 and Fig. XXV).

**Table 27: Economics of production, break even analysis and relative share of various factors of production under different treatments in okra cultivation**

Treatment	Total cost of cultivation Rs.ha <sup>-1</sup>	Pooled yield q ha <sup>-1</sup>	Gross returns Rs. ha <sup>-1</sup>	Added returns Rs.ha <sup>-1</sup>	Net returns Rs.ha <sup>-1</sup>	Returns Re <sup>-1</sup> invested (B:C ratio)	BEP q ha <sup>-1</sup>	Margin of safety q ha <sup>-1</sup>	Factor share		
									Land	Labour	Capital
T <sub>1</sub>	46948.76	259.08	129540.00	80260.00	82591.24	2.75	48.30	210.78	0.778	0.127	0.095
T <sub>2</sub>	57512.20	209.00	146300.00	97020.00	88787.80	2.54	33.72	175.28	0.731	0.114	0.155
T <sub>3</sub>	58512.20	221.14	154798.00	105518.00	96285.80	2.64	33.40	187.74	0.739	0.108	0.153
T <sub>4</sub>	51372.20	238.78	167145.00	117865.00	115772.80	3.25	33.01	205.77	0.802	0.099	0.099
T <sub>5</sub>	60372.20	231.19	161833.00	112553.00	101460.80	2.68	33.17	198.02	0.740	0.102	0.158
T <sub>6</sub>	42512.20	155.13	108591.00	59311.00	66078.80	2.55	35.89	119.29	0.775	0.152	0.073
T <sub>7</sub>	53352.20	254.99	178493.00	129213.00	125140.80	3.34	32.70	222.29	0.803	0.093	0.104
T <sub>8</sub>	57872.20	221.08	154756.00	105476.00	96883.80	2.67	33.41	187.67	0.744	0.107	0.149
T <sub>9</sub>	54372.20	236.67	165669.00	116389.00	111296.50	3.04	33.05	203.62	0.782	0.100	0.118
T <sub>10</sub>	58872.20	230.37	161259.00	111979.00	102386.50	2.73	33.19	197.18	0.747	0.103	0.150
T <sub>11</sub>	50152.20	214.13	149891.00	100611.00	99738.80	2.98	33.58	180.55	0.786	0.111	0.103
T <sub>12</sub>	54872.20	246.38	172466.00	123186.00	117593.80	3.14	32.85	213.53	0.787	0.096	0.117
T <sub>13</sub>	59372.20	233.00	163100.00	113820.00	103727.80	2.74	33.13	199.87	0.747	0.102	0.151
T <sub>14</sub>	50652.20	223.95	156765.00	107485.00	106112.80	3.09	33.34	190.61	0.792	0.106	0.102
T <sub>15</sub>	55872.20	248.18	173726.00	124445.00	117853.80	3.10	32.82	215.36	0.783	0.095	0.122
T <sub>16</sub>	47152.20	244.77	171339.00	122059.00	124186.80	3.63	32.89	211.88	0.831	0.097	0.072
T <sub>17</sub>	51652.20	238.30	166810.00	117530.00	115157.80	3.22	33.02	205.28	0.800	0.099	0.101
T <sub>18</sub>	44520.48	170.50	85250.00	35970.00	40729.52	1.91	53.95	116.55	0.690	0.192	0.118
T <sub>19</sub>	52090.48	243.34	121670.00	72390.00	69579.52	2.33	48.94	194.40	0.721	0.136	0.143
T <sub>20</sub>	52590.48	254.33	127165.00	77885.00	74574.52	2.41	48.49	205.84	0.729	0.130	0.141
T <sub>21</sub>	49090.48	260.08	130040.00	80760.00	80949.52	2.64	48.27	211.81	0.762	0.127	0.111
T <sub>22</sub>	53590.48	257.56	128780.00	79500.00	75189.52	2.40	48.36	209.20	0.725	0.128	0.147
T <sub>23</sub>	44800.48	237.79	118895.00	69615.00	74094.52	2.65	49.19	188.60	0.766	0.138	0.086
T <sub>24</sub>	50520.48	272.71	136355.00	87075.00	85834.52	2.70	47.82	224.89	0.763	0.121	0.116
T <sub>25</sub>	41812.20	98.56	49280.00	-	7467.52	1.17	71.86	26.70	0.518	0.326	0.156

BEP = Break even point, B:C ratio = Gross returns / cost of cultivation.

#### 4.47.4 Relative share

Relative shares were calculated in respect of three important factors of production viz. land, labour and capital. The figures registered in Table 27 reveal that minimum relative capital share of Rs. 0.072 was found in T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) followed by 0.073, 0.086 and 0.095 in T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), respectively. The maximum relative capital share of Rs. 0.158 ha<sup>-1</sup> was observed with T<sub>5</sub> (VC 6t ha<sup>-1</sup>) followed by 0.155, 0.153, 0.151, 0.150, 0.149 recorded in T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>), T<sub>3</sub> (SM 20 t ha<sup>-1</sup>), T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>) and T<sub>8</sub> (FYM 15t + SM 10t ha<sup>-1</sup>), respectively.

The labour recorded its minimum share of Rs. 0.093 ha<sup>-1</sup> in treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) followed by 0.095, 0.096, 0.097, 0.099 in T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) respectively. Maximum labour share of Rs. 0.326 ha<sup>-1</sup> was found in T<sub>25</sub> (control). The maximum relative share of land (Rs. 0.831 ha<sup>-1</sup>) was recorded in T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) followed by Rs. 0.803, 0.802, 0.792 in T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>), T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) and T<sub>14</sub> (SM 10t + BF 7 kg ha<sup>-1</sup>) respectively while the minimum relative share of land (Rs. 0.518 ha<sup>-1</sup>) was estimated in T<sub>25</sub> (control).

#### **4.48 Economics of production of residual crop pea**

##### **4.48.1 Cost structure in pea crop**

The details of cost of cultivation  $\text{ha}^{-1}$  and the treatment wise cost of cultivation are presented in Table 28-29 respectively.

The cultivation of residual crop pea provided an employment to the tune of 171 labour days  $\text{ha}^{-1}$  from ploughing of land upto the harvesting of crop.

Since in residual crop, no addition of organics or chemical fertilizers was adopted, thus no additional cost was added to the total expenditure of all treatments. Table 29 revealed that a common cost of cultivation of Rs. 38,825.70 was incurred in all treatments.

##### **4.48.2 Income distribution and benefit cost ratio**

Perusal of Table 30 documents in put output scenario of crop. The treatment wise cost of cultivation and their returns revealed the significance of organics either as sole or integration among themselves or integration with chemical fertilizer over sole application of recommended fertilizer dose and control. Maximum net returns of Rs. 22,944.30 was observed in  $T_{24}$  (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7  $\text{kg ha}^{-1}$  + 60: 30: 30: N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ) followed by  $T_{21}$  (PM 3t + 60:30:30 N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ),  $T_7$  (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7  $\text{kg ha}^{-1}$ ),  $T_{20}$  (SM 10t + 60: 30: 30: N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$   $\text{kg ha}^{-1}$ ),  $T_{22}$  (VC 3t + 60:30:30 N:  $\text{P}_2\text{O}_5$ :

K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>:

K<sub>2</sub>O kg ha<sup>-1</sup>), 15

(PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>)

**Table 28: Cost of cultivation of residual crop pea**

<b>Cost involved on variable and fixed factor</b>		
<b>A.</b>	<b>Two ploughings @ Rs. 1500 ha<sup>-1</sup></b>	<b>3000.00</b>
	Clod breading, leveling and preparation of beds/channel, 40 labours @ Rs. 70 labour <sup>-1</sup>	2800.00
	<b>Total</b>	<b>5800.00</b>
<b>B.</b>	<b>Seed sowing, 10 labours @ Rs. 70 labour<sup>-1</sup></b>	<b>700.00</b>
	<b>Total</b>	<b>700.00</b>
<b>C.</b>	<b>Irrigation</b>	
	Three irrigations, 6 labours @ Rs.70 labour <sup>-1</sup>	420.00
	<b>Total</b>	<b>420.00</b>
<b>D.</b>	<b>Cultural operations</b>	
	Two weedings/hoeings, 40 labours @ Rs.70 labour <sup>-1</sup>	2800.00
	<b>Total</b>	<b>2800.00</b>
<b>E.</b>	<b>Aftercare operations, 5 labours @ Rs. 70.00 labour<sup>-1</sup></b>	<b>350.00</b>
	<b>Total</b>	<b>350.00</b>
<b>F.</b>	<b>Harvesting and picking</b>	
	Three pickings, 60 labours @ Rs. 70 labour <sup>-1</sup>	4200.00
	Harvesting of plants after last picking 10 labours @ Rs.70 labour <sup>-1</sup>	700.00
	<b>Total</b>	<b>4900.00</b>
	<b>Total (A+B+C+D+E+F)</b>	<b>14970.00</b>
	Incidental charges @ 5% of the working capital	748.50
	<b>Total labour component involved in total cost of cultivation</b>	<b>15718.50</b>
<b>G.</b>	<b>Cost of seed</b>	
	Cost of seed @ Rs. 5000.00 q <sup>-1</sup> for 60 kg of seed ha <sup>-1</sup>	3000.00
	<b>Total</b>	<b>3000.00</b>
	Variable cost (Labour + Cost of seed: 15718.50.00 + 3000.00)	18718.50
	Land rent	18000.00
	Land tax	80.00
Depreciation on implements	800.00	
	<b>Total</b>	<b>18880.00</b>
	Interest @ 6.5% on fixed factors	1227.20
	<b>Total fixed cost (18880.00 + 1227.20)</b>	<b>20107.20</b>

**Table 29: Residual effect of various treatments on economics of cost of cultivation of pea**

<b>Treatment</b>	<b>Fixed cost Rs.ha<sup>-1</sup></b>	<b>Variable cost Rs. ha<sup>-1</sup></b>	<b>Added cost Rs.ha<sup>-1</sup></b>	<b>Total variable Rs.ha<sup>-1</sup></b>	<b>Total cost of cultivation Rs.ha<sup>-1</sup></b>
T <sub>1</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>2</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>3</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>4</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>5</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>6</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>7</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>8</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>9</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>10</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>11</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>12</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>13</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>14</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>15</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>16</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>17</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>18</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>19</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>20</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>21</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>22</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>23</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>24</sub>	20107.20	18718.50	-	18718.50	38825.70
T <sub>25</sub>	20107.20	18718.50	-	18718.50	38825.70

with returns per rupee invested of 1.59, 1.53, 1.49, 1.44, 1.42, 1.42, 1.40 and 1.39 respectively. However, the lowest net returns of Rs. 134.30 was observed in T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>) with returns Re<sup>-1</sup> invested of 1.0. Treatment T<sub>1</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> recorded negative net returns and were found beyond economic optima (Table 30 and Fig. XXVI).

#### **4.48.3 Break even analysis and margin of safety**

Perusal of Table 30 revealed variation for BEP (break even point) due to various treatments, a minimum BEP of 57.69 q ha<sup>-1</sup> was observed in T<sub>24</sub> followed by 58.70, 59.42 and 60.29 recorded in T<sub>21</sub>, T<sub>7</sub> and T<sub>20</sub>, respectively. However, maximum BEP of 77.40 q ha<sup>-1</sup> was recorded in T<sub>2</sub> followed by 76.69, 72.06 and 70.45 q ha<sup>-1</sup> in T<sub>3</sub>, T<sub>11</sub> and T<sub>8</sub>, respectively. Maximum margin of safety 65.87 q ha<sup>-1</sup> was recorded in T<sub>24</sub> followed by 60.14, 56.38 and 52.12 q ha<sup>-1</sup> in T<sub>21</sub>, T<sub>7</sub> and T<sub>20</sub>, respectively. However, the minimum margin of safety 0.52 q ha<sup>-1</sup> was recorded in T<sub>2</sub> (FYM 30 t ha<sup>-1</sup>).

#### **4.48.4 Relative shares**

Perusal of Table 30 revealed that minimum relative capital share of Rs. 0.143 ha<sup>-1</sup> was recorded in T<sub>24</sub> followed by 0.159 and 0.152 in T<sub>21</sub> and T<sub>7</sub>, respectively. Maximum relative capital share of Rs. 0.478 was exhibited by T<sub>25</sub> followed by 0.337, 0.336, 0.260 and 0.230 ha<sup>-1</sup> recorded with T<sub>18</sub>, T<sub>6</sub>, T<sub>1</sub> and T<sub>5</sub>, respectively.

Labour recorded its minimum share of Rs. 0.193 ha<sup>-1</sup> in T<sub>24</sub> followed by 0.201 and 0.206 ha<sup>-1</sup> in T<sub>21</sub> and T<sub>7</sub>, respectively. While the

**Table 30: Economics of production, break even analysis and relative share of various factors of production under different treatments in residual crop pea cultivation**

Treatment	Total cost of cultivation Rs.ha <sup>-1</sup>	Pooled yield q ha <sup>-1</sup>	Gross returns Rs.ha <sup>-1</sup>	Added returns due to residual effect Rs.ha <sup>-1</sup>	Net returns Rs.ha <sup>-1</sup>	Returns Re. <sup>-1</sup> invested	BEP q ha <sup>-1</sup>	Margin of safety q ha <sup>-1</sup>	Factor share		
									Land	Labour	Capital
T <sub>1</sub>	38825.70	68.06	34030	15535	-4795.70	0.87	(**)	(**)	0.389	0.351	0.260
T <sub>2</sub>	38825.70	77.92	38960	20465	134.30	1.00	77.40	0.52	0.466	0.307	0.227
T <sub>3</sub>	38825.70	78.70	39350	20855	524.30	1.01	76.69	2.01	0.471	0.304	0.225
T <sub>4</sub>	38825.70	87.43	43715	24220	4889.30	1.12	70.32	17.11	0.525	0.273	0.202
T <sub>5</sub>	38825.70	76.68	38340	19845	-485.70	0.98	(**)	(**)	0.458	0.312	0.230
T <sub>6</sub>	38825.70	52.56	26280	7785	-12545.70	0.67	(**)	(**)	0.209	0.455	0.336
T <sub>7</sub>	38825.70	115.80	57900	39405	19704.30	1.49	59.42	56.38	0.642	0.206	0.152
T <sub>8</sub>	38825.70	87.22	43610	25115	4784.30	1.12	70.45	16.77	0.523	0.274	0.203
T <sub>9</sub>	38825.70	100.38	50190	31695	11364.30	1.29	64.63	36.25	0.586	0.238	0.176
T <sub>10</sub>	38825.70	96.51	48255	29760	9429.30	1.24	65.69	30.82	0.569	0.248	0.183
T <sub>11</sub>	38825.70	84.71	42355	23860	3529.30	1.09	72.06	12.65	0.509	0.282	0.209
T <sub>12</sub>	38825.70	108.19	54095	35600	15269.30	1.39	61.49	46.70	0.615	0.222	0.163
T <sub>13</sub>	38825.70	99.65	49825	31330	10999.30	1.28	64.41	35.24	0.583	0.240	0.177
T <sub>14</sub>	38825.70	95.35	47675	29180	8849.30	1.22	66.20	29.15	0.564	0.251	0.185
T <sub>15</sub>	38825.70	109.21	54605	36110	15779.30	1.40	61.18	48.03	0.619	0.219	0.162
T <sub>16</sub>	38825.70	102.75	51375	32880	12549.30	1.32	63.26	39.49	0.596	0.232	0.172
T <sub>17</sub>	38825.70	101.15	50575	32080	11749.30	1.30	63.84	37.31	0.589	0.236	0.175
T <sub>18</sub>	38825.70	52.44	26220	7725	-12605.50	0.67	(**)	(**)	0.207	0.456	0.337
T <sub>19</sub>	38825.70	110.39	55195	36700	16369.30	1.42	60.84	49.55	0.624	0.216	0.160
T <sub>20</sub>	38825.70	112.41	56205	37710	17379.30	1.44	60.29	52.12	0.631	0.212	0.157
T <sub>21</sub>	38825.70	118.84	59420	40925	20594.30	1.53	58.70	60.14	0.650	0.201	0.149
T <sub>22</sub>	38825.70	110.77	55385	36890	16559.30	1.42	60.74	50.03	0.625	0.216	0.159
T <sub>23</sub>	38825.70	106.30	53150	34655	14324.30	1.36	62.07	44.23	0.609	0.225	0.166
T <sub>24</sub>	38825.70	123.56	61780	43285	22944.30	1.59	57.69	65.87	0.644	0.193	0.143
T <sub>25</sub>	38825.70	36.99	18495	-	-20330.70	0.47	(**)	(**)	-0.125	0.647	0.478

(\*\*): Beyond economic optima.

maximum relative labour share of Rs. 0.647 was found in T<sub>25</sub> followed by 0.456, 0.455 and 0.351 ha<sup>-1</sup> in T<sub>18</sub>, T<sub>6</sub> and T<sub>1</sub>, respectively.

The minimum relative share of land (Rs.-0.125) was estimated in T<sub>25</sub> (control) and the maximum share of land of (Rs. 0.0650, 0.644, 0.625 and 0.624) was recorded in T<sub>21</sub>, T<sub>24</sub>, T<sub>22</sub> and T<sub>19</sub>, respectively.

#### **4.48.5 Income distribution and benefit cost ratio under okra pea rotation**

Perusal of the Table 31 revealed that maximum net returns of Rs. 1,44,215.10, 1,36,736.10, 1,33,633.10 and 1,32,863.10 ha<sup>-1</sup> were recorded in T<sub>7</sub>, T<sub>16</sub>, T<sub>15</sub> and T<sub>12</sub> with returns per rupee invested of 2.56, 2.59, 2.41 and 2.41, respectively. However, treatment T<sub>25</sub> (control) exhibited a net returns of Rs. -12,862.90 which was beyond economic optima (Table 31 and Fig. XXVII).

**Table 31: Returns to the scale parameters under okra – pea rotation**

Treatment	Cost of cultivation Rs. ha <sup>-1</sup>			Total returns Rs. ha <sup>-1</sup>			Pooled yield q ha <sup>-1</sup>		Net return Rs. ha <sup>-1</sup>	Returns Re <sup>-1</sup> invested
	Okra	Pea	Total	Okra	Pea	Total	Okra	Pea		
T <sub>1</sub>	46948.76	38825.70	85774.46	129540	34030.00	163570	259.08	68.06	77795.54	1.90
T <sub>2</sub>	57512.20	38825.70	96337.90	146300	3896.00	185260	209.00	77.92	88922.10	1.92
T <sub>3</sub>	58512.30	38825.70	97337.90	154798	39350.00	194148	221.14	78.70	96810.10	1.99
T <sub>4</sub>	51372.20	38825.70	90197.90	167145	43715.00	210860	238.78	87.43	120662.10	2.33
T <sub>5</sub>	60372.20	38825.70	99197.90	161833	38341.00	200173	231.19	76.68	100975.10	2.01
T <sub>6</sub>	42512.20	38825.70	81337.90	108591	26280.00	134871	155.13	52.56	53533.10	1.65
T <sub>7</sub>	53352.20	38825.70	92177.90	178493	57900.00	236393	254.99	115.80	144515.10	2.56
T <sub>8</sub>	57872.20	38825.70	96697.90	154756	43610.00	198366	221.08	87.22	101668.10	2.05
T <sub>9</sub>	54372.20	38825.70	93197.90	165669	50190.00	215859	236.67	100.38	122661.10	2.31
T <sub>10</sub>	58872.20	38825.70	97697.90	161259	48255.00	209514	230.37	96.51	111816.10	2.14
T <sub>11</sub>	50152.20	38825.70	88977.90	149891	42355.00	192246	214.13	84.71	103268.10	2.16
T <sub>12</sub>	54872.20	38825.70	93697.90	172466	54095.00	226561	246.38	108.19	132863.10	2.41
T <sub>13</sub>	59372.20	38825.70	98197.90	163100	49825.00	212925	233.00	99.65	114717.10	2.16
T <sub>14</sub>	50652.20	38825.70	89477.90	156765	47675.00	204440	223.95	95.35	114962.10	2.28
T <sub>15</sub>	55872.20	38825.70	94697.90	173726	54605.00	228331	248.18	109.21	133633.10	2.41
T <sub>16</sub>	4715.20	38825.70	85977.90	171339	51375.00	222714	244.77	102.75	136736.10	2.59
T <sub>17</sub>	51652.20	38825.70	90477.90	166810	50575.00	217385	238.30	101.15	126907.10	2.40
T <sub>18</sub>	44520.48	38825.70	83346.18	85250	26220.00	111470	170.50	52.44	28123.82	1.33
T <sub>19</sub>	52090.48	38825.70	90916.18	121670	55195.00	176865	243.34	110.39	85948.82	1.94
T <sub>20</sub>	52590.48	38825.70	91416.18	127165	56205.00	183370	254.33	112.41	91953.82	2.00
T <sub>21</sub>	49090.48	38825.70	87916.18	130040	59420.00	189460	260.08	118.84	101543.82	2.15
T <sub>22</sub>	53590.48	38825.70	92416.18	128780	55385.00	184165	257.56	110.77	91748.82	1.99
T <sub>23</sub>	44800.48	38825.70	83626.18	118895	53150.00	172045	237.79	106.30	88418.82	2.05
T <sub>24</sub>	50520.48	38825.70	89346.18	163355	61780.00	198135	272.71	123.56	108788.82	2.21
T <sub>25</sub>	41812.20	38825.70	80637.40	49280	18495.00	67775	98.56	36.99	-12862.90	0.84

## Chapter 5

### DISCUSSION

Okra [*Abelmoschus esculentus* (L.) Moench] is one of the popular vegetable grown in India. It produces fruits from very early stage and continues for long time and thus needs proper and adequate supply of plant nutrients for higher yields and better quality which can be supplied through organic and inorganic sources. Inadequate nutrient supply is one of the major constraints in harvesting higher yield. Substitution of high analysis fertilizers and/or insufficient use of organics have rendered most of the Indian soils deficient in macro and micro nutrients, besides deteriorating soil health (physical, chemical and biological) leading to decline in yield and quality of vegetables and vegetable products, causing environmental pollution and finally the impairment of human health. The solution of these problems lies in the use of organics, where our objective is to cooperate with nature rather than confrontation. Organic sources constitute a dependable source of nutrients, besides being helpful in improvement of soil health, both in terms of physical, chemical and biological aspects. Organics are known to release plant nutrients slowly, as such they have a residual effect and this property can be used to raise succeeding crop without addition of any nutrient source. However, organic sources, as sole applications cannot attain the desired yield potential but organic vegetables are sold at premium prices as compared to inorganic ones.

Integration of organics with inorganic sources have been found to register higher values for growth, yield and quality of vegetables including okra. Kashmir valley has potential to produce okra, capable of meeting international quality standards as it remains free from all pests, with minimum/ no use of pesticides. In the present investigation on influence of organic manures and inorganic fertilizers on growth, yield and quality of okra (*Abelmoschus esculentus* L.), efforts were made to investigate the potential of organics, as sole applications, as integration of organic sources and integration of organics with inorganic sources on a wide range of parameters related to crop growth and fruit yield, soil health, residual influence on succeeding crop growth as well as economics of production. The results of the present investigation are discussed in this chapter under various sub-headings.

### **5.1 Growth attributes**

The data presented in Table 2 and 3 revealed that maximum values for plant height (186.82 cm), number of braches plant<sup>-1</sup> (3.08), internodal distance (6.99 cm) and number of nodes plant<sup>-1</sup> (26.82) on main stem were observed in treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Among sole application of organics, treatment T<sub>4</sub> (PM 6t ha<sup>-1</sup>) recorded higher values (165.98, 2.22, 6.82 and 24.49 cm) for plant height, number of branches plant<sup>-1</sup>, internodal distance and number of nodes plant<sup>-1</sup> (main stem), respectively, followed by T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>). Among organic integrations, treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) registered higher values of 176.61 cm, 2.63 and 25.67 for

plant height, number of branches and number of nodes plant<sup>-1</sup> (main stem), respectively. However, T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) recorded higher values (6.93 cm) for internodal distance followed by T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>).

Integration of individual organic sources with recommended fertilizer dose in equal proportions registered higher values for growth attributes. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded the higher values of 181.01 cm, 2.88, 7.01 cm and 25.90 for plant height, number of branches plant<sup>-1</sup>, internodal distance and number of nodes plant<sup>-1</sup> (main stem), respectively, followed by T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Recommended fertilizer dose T<sub>1</sub> (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) in general recorded higher values for growth attributes except that of T<sub>24</sub>. Minimum values for growth attributes were observed in treatment T<sub>25</sub> (control), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) and T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Integration of organic and inorganic sources as well as integration among organic sources, exhibited an increase in growth related attributes of okra, probably due to balanced C/N ratio, better organic matter build up, efficient microbial activity, better root proliferation, abundant supply and availability of nutrients from soil, more translocation of nutrients to aerial parts for protoplasmic proteins and synthesis of other compounds (Singh *et al.*, 1970). Superiority of poultry manure over farm yard manure, sheep manure, vermi compost and

biofertilizers in improvement of growth related characters of okra can be attributed to its nutritional richness, quick mineralization, more availability of nitrogen and other plant nutrients. Besides this, poultry manure contains uric acid having 60 per cent nitrogen, which gets rapidly converted to ammonical form and becomes readily available to plants. In addition to these qualities, it is an excellent source of organic matter and contains some growth promoting substances, thus leading to better growth, whether used as sole application or in combination with organic or inorganic sources (Smith, 1950; Brown, 1958; Singh *et al.*, 1970; Garg *et al.*, 1980 and Abusaleha and Sahanmugavelu, 1988).

The higher values of growth related attributes in okra due to use of inorganic fertilizers could be attributed to quick and ready availability of plant nutrients. Similar results have also been reported by other workers (Singh *et al.*, 1970; Singh *et al.*, 1973; Abusaleha and Shanmugavelu, 1988; Jose *et al.*, 1988; Montasser, 1991; John 1997; Thanunathan *et al.*, 1997; Naidu *et al.*, 2000; Magray, 2002; Prakash *et al.*, 2002; Datt *et al.*, 2003; Nuruzzaman *etal.*, 2003 and Dash *et al.*, 2005) in number of vegetable crops.

## **5.2 Yield and yield related attributes**

The data presented in Table 4, 5, and 6 revealed that significantly maximum values for number of fruits plant<sup>-1</sup> (28.93) fruit length (14.74 cm), fruit diameter (1.41 cm) average fruit weight (14.14 g), average fruit yield plot<sup>-1</sup> (24.53 kg) and fruit yield ha<sup>-1</sup> (272.71 kg) were observed

in treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Among sole application of organic sources, T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded higher values (26.50 cm, 13.94 cm, 1.33 cm, 13.40 g, 21.48 kg and 238.78 q) for number of fruits plant<sup>-1</sup>, fruit length, fruit diameter, average fruit weight, fruit yield plot<sup>-1</sup> and fruit yield ha<sup>-1</sup>, respectively, followed by T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>).

Among organic integrations, treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded maximum values of (27.84, 14.20 cm, 1.35 cm, 13.71 g, 22.95 kg and 254.99q) for number of fruits plant<sup>-1</sup>, fruit length, fruit diameter, average fruit weight, fruit yield plot<sup>-1</sup> and fruit yield ha<sup>-1</sup>, respectively, followed by T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>9</sub> (FYM 15t + PM 3t ha<sup>-1</sup>) and T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>). Integration of individual organic sources with recommended fertilizer dose in equal proportions registered higher values for yield related attributes. Treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered higher values of 27.98, 14.56 cm, 1.39 cm, 13.95 g, 23.40 kg and 260.08 q for number of fruits plant<sup>-1</sup>, fruit length, fruit diameter, average fruit weight, fruit yield plot<sup>-1</sup> and fruit yield ha<sup>-1</sup>, respectively, followed by T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>20</sub> (SM 10t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Recommended fertilizer dose (T<sub>1</sub>) in general registered higher values for yield and yield related attributes of okra except that of T<sub>21</sub> and T<sub>24</sub>. Minimum values were observed with T<sub>25</sub> (control), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) and T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Integration of different organic source and inorganic sources as well as integration among organic sources exhibited an increase in yield and yield related attributes of okra. This could be due to balanced C/N ratio, more decomposition, more mineralization, more availability of native and applied macro and micro nutrients, besides this, the synergistic interaction between organic manures, vermi compost and biofertilizers might have resulted in more concentration of nutrients. All this might have accelerated the synthesis of carbohydrates and its better translocation from sink to source might have led to an improvement in yield and yield related attributes.

Poultry manure proved its superiority in enhancing yield and yield related attributes of okra over rest of the organic sources (farm yard manure, sheep manure, vermi compost and biofertilizers). Whether used as a sole application or in conjugation with organic sources or with inorganic sources. This superiority could be attributed to nutritional richness, production of growth promoting substances, balanced C/N ratio, synergistic interaction with organic manures, vermi compost and biofertilizers, efficient microbial activity leading to sustainable nutrient availability and improvement in soil physical conditions. All these might have led to better root proliferation, better translocation of plant nutrients and accelerated carbohydrate synthesis, finally leading to better yields. The higher values for yield and yield related attributes due to inorganic fertilizers could be attributed to quick release of nutrients in sufficient amount.

Similar trend has also been reported by other workers (Singh *et al.*, 1973; Abusaleha and Shanmugavlu, 1988; Jose *et al.*, 1988; Sharma and Bhalla 1995; John, 1997; Mahendran and Kumar, 1997; Issac and Pushpakumari, 1998; Ushakumari *et al.*, 1999; Aliyu, 2000; Naidu *et al.*, 2000; Singh *et al.*, 2000; Bahadur *et al.*, 2004 and Naryan *et al.*, 2004) in okra and several other vegetables.

### 5.3 Seed yield and related attributes

The data presented in Table 7, 8, and 9 revealed that among various treatments, the treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded significantly maximum number of seed pods plant<sup>-1</sup> (11.76), number of seeds pod<sup>-1</sup> (43.75), seed yield plant<sup>-1</sup> (39.94 g), seed yield ha<sup>-1</sup> (26.62 q) and 100 seed weight (6.93 g).

Among sole application of organic sources, application of PM 6 t ha<sup>-1</sup> (T<sub>4</sub>) registered higher number of seed pods plant<sup>-1</sup> (10.20), number of seeds pod<sup>-1</sup> (40.38), seed yield plant<sup>-1</sup> (31.09 g), seed yield ha<sup>-1</sup> (20.71 q) and 100 seed weight (6.11 g), followed by T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>).

Among organic integrations, the combined application of FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup> (T<sub>7</sub>) recorded higher values for number of seed pods plant<sup>-1</sup> (10.98), number of seeds pod<sup>-1</sup> (41.50), seed yield plant<sup>-1</sup> (34.09 g), seed yield ha<sup>-1</sup> (22.72 q) and 100 seed weight (6.36 g), followed by T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>).

On the other hand, integration of individual organic source and recommended fertilizer dose in equal proportion registered higher, number of seed pods plant<sup>-1</sup> (11.52), number of seeds pod<sup>-1</sup> (42.81), seed yield plant<sup>-1</sup> (36.39 g), seed yield ha<sup>-1</sup> (24.26 g) and 100 seed weight (6.76 g) with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) followed by T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Treatment T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) recorded maximum values for seed yield and related attributes except that of T<sub>21</sub> and T<sub>24</sub>. However, minimum values were observed in T<sub>25</sub> (control), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) and T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Improvement in seed yield and related attributes of okra due to integrated use of organic and inorganic sources as well as integration among organic sources could be attributed to balanced C/N ratio, more organic matter build up, enhanced microbial activity, improvement in soil properties, better root proliferation, sustainable availability and accelerated transport and higher concentration of plant nutrients, all these might have accelerated metabolic activities, leading to better photo syntheses and efficient translocation of photosynthates from sink to sources, resulting in improvement of seed yield and its related attributes.

Superiority of poultry manure over farm yard manure, sheep manure, vermi compost and biofertilizers in improving seed yield and related attributes could be due to its nutritional richness, quick decomposition and mineralization, leading to sustainable availability and

uptake of nutrients, stimulatory role, synergistic effect with other organics, more microbial population and improvement in soil physical properties and all these might have ultimately promoted an increase in seed yield.

Increase in seed yield in okra due to inorganic fertilizers can be attributed to quick availability of plant nutrients. Improvement in seed yield due to organic and inorganic nutrient sources have also been reported by other workers (Pandey *et al.*, 1980, Isaac and Pushpakumari, 1998, and Thakur and Singh, 2001) in different vegetable crops.

#### **5.4 Quality attributes**

The data in Table 9, 10, and 11 revealed maximum values for protein content of dry seeds (22.65%), protein content of fresh fruits (3.01%), low fibre content of fresh fruits (1.28%), vitamin C content (17.59 mg) and dry matter content of fresh fruits (12.95%) were observed in T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Among sole application of organic sources, poultry manure 6t ha<sup>-1</sup> (T<sub>4</sub>) recorded higher values of 19.93 per cent, 2.47 per cent, 16.03 mg, 10.74 per cent for protein content of dry seeds, protein content of fresh fruits, vitamin C content and dry matter content, respectively, followed by T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>). A low fibre content of 1.38 per cent was observed in T<sub>5</sub>, followed by T<sub>4</sub> and T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>).

Among organic integrations, treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) registered higher values of 2.45 and 11.17 per

cent for protein content and dry matter content of fresh fruits, followed by T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>). However, T<sub>15</sub> recorded higher values of 20.11 per cent and 16.37 mg of protein content of dry seeds and vitamin C content of fresh fruits, respectively, followed by T<sub>7</sub> and T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>). Treatment T<sub>15</sub> registered a low fibre content of 1.36 per cent followed by T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>7</sub>.

Integration of individual organic sources with recommended fertilizer dose in equal proportion (50:50), registered maximum values of 21.98 per cent, 2.77 per cent, 16.83 mg and 12.24 per cent for protein content of dry seeds, protein content of fresh fruits, vitamin C and dry matter content of okra fruits with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), respectively, followed by T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). However, T<sub>22</sub> recorded a low fibre content of 1.33 per cent followed by T<sub>20</sub> and T<sub>23</sub>. Recommended fertilizer dose registered higher values for protein content of dry seeds, protein content of fresh fruits and dry matter content except that of T<sub>21</sub>, T<sub>22</sub> and T<sub>24</sub>. However, it registered lower values for vitamin C content and higher values for fibre content as compared to sole applications, integration among organics as well as integration of organics with chemical fertilizers. Treatment T<sub>25</sub> (control) recorded lower values for all the quality attributes but recorded maximum fibre content.

Improvement in quality attributes of okra due to integration of organic and inorganic fertilizers as well as integration among organic sources could be attributed to better and balanced nutrition and

production of growth promoting substances by organics which might have led to better quality like enhanced protein and vitamin C content as well as a decrease in crude fibre content of fresh fruits. Improvement in quality of okra can also be attributed to improvement in soil physical, chemical and biological properties which might have led to better root proliferation, improved nutrient uptake and better accumulation of photosynthates. While in chemical fertilizers reduction in quality attributes in comparison to integrations could be attributed to the fact that these provide either single or sometimes two essential nutrients but not other nutrients. Higher fibre content in control can be attributed to low and imbalanced nutrient supply. The superiority of poultry manure and vermi compost can be attributed to their nutritional richness, as well as to their stimulatory behaviour.

Our findings are in accordance with the findings of other workers (Singh *et al.*, 1970; Singh *et al.*, 1973; Abuslaleha and Shanmugavelu, 1988; Jose *et al.*, 1988; Sainz *et al.*, 1998; Naidu *et al.*, 2000; Singh *et al.*, 2000; Raj and Kumari, 2001; Bhadoria *et al.*, 2002; Twaio *et al.*, 2002; Xu *et al.*, 2003 and Naryan *et al.*, 2004) who reported similar improvement in quality attributes in different vegetable crops.

### **5.5 Nutrient uptake**

The data presented in Table 12, 13 and 14 indicate that significantly maximum uptake of 132.23, 31.91, 139.35, 21.51, 135.37 and 70.58 kg ha<sup>-1</sup> by okra plants of nitrogen, phosphorus, potassium, sulphur, calcium and magnesium respectively was observed with T<sub>24</sub>

(FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Among sole application of organic sources, poultry manure 6t ha<sup>-1</sup> (T<sub>4</sub>) recorded higher uptake of 91.37, 18.64, 79.74, 13.79, 94.08 and 48.58 kg ha<sup>-1</sup> by okra plants for nitrogen, phosphorus, potassium, sulphur, calcium and magnesium, respectively, followed by T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>).

Among organic integration, treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) registered a nutrient uptake of 104.71, 19.54, 98.88, 14.99, 100.96 and 52.07 kg ha<sup>-1</sup> by okra plants for nitrogen, phosphorus, potassium, sulphur, calcium and magnesium, respectively, followed by T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>) and T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>). Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) registered higher uptake of 121.88, 27.92, 125.51, 20.97, 132.15 and 67.20 kg ha<sup>-1</sup> by okra plants for nitrogen, phosphorus, potassium, sulphur, calcium and magnesium, respectively with treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Recommended fertilizer dose T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered higher uptake values for nitrogen and potassium except that of T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>24</sub>. However, in case of phosphorus, sulphur, calcium and magnesium, T<sub>1</sub> proved superior than sole as well as integrated application of organics but recorded lower

values than those recorded with organic and inorganic integrations. Minimum uptake values were observed in T<sub>25</sub> (control), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) and T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Enhanced nutrient uptake by okra plants due to integration of organic with inorganic sources as well as conjugation among organic sources in equal proportions could be attributed to balanced C/N and C/P ratios, more organic matter build up, more cation exchange capacity, more nutrient retention and less leaching losses, enhanced microbial activity, leading to more nitrogen fixation and phosphorus solubilization. Production of organic and inorganic acids leading to solubilization of native nutrient compounds, more availability of plant nutrients, more adsorption, besides this, improvement in soil physical, chemical and biological activities might have improved the ability of okra plants to draw more nutrients from the soil. Besides this, synergistic effect among organic manures and the stimulatory effect of certain organic sources (PM, VC and BF) might have resulted in better root development, keeping the plants photosynthetically active for a longer period. The increase in nitrogen, phosphorus have synergistic effect on potassium uptake, increase in nitrogen would have accelerated the uptake of calcium and magnesium. Increase in the uptake of sulphur, calcium and magnesium is attributed to the fact that organics are excellent sources of these nutrients (Tandon, 1993) and due to decomposition, mineralization and solubilization might have accelerated their availability and uptake by okra plants.

Poultry manure exhibited higher nutrient uptake as compared to other organic sources and can be attributed to that fact the it ferments and mineralizes quickly, because the liquid and solid excreta are excreted together resulting in no loss of nutrients, besides this, it contains narrow C/P ratio as compared to other organic manures. Another factor contributing to more nutrient uptake with poultry manure might be due to presence of high phosphorus content and increased availability of native soil phosphorus. Increased uptake of N and P from poultry manure might have increased the uptake of K, Ca and Mg.

Enhanced nutrient uptake due to treatment T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) may be attributed to the fact that plants take nutrients quickly in inorganic form and these become readily available to plants. Josh *et al.* (1988), Abuslaleha, (1992), Mehendran and Kumar, (1996), Prabakaran, (2003), Swain *et al.* (2003), Dademal *et al.* (2004) and Naryan *et al.* (2004) also made similar observations on nutrient uptake in different vegetables as has been observed in the present study.

## **5.6 Physical characteristics**

The physical characteristics (mechanical components, bulk density, particle density and porosity) of soil as influenced by various treatments after the harvest of rabi 2005-2006 residual crop pea is depicted in Table 15 and 16, respectively.

Data presented in Table 15 revealed no change in mechanical components of studied soil. However, in treatments T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>) and T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) a marginal increase in clay content to the extent of 0.11 and 0.08 per cent over initial was observed and this may probably be due to weathering of silt due to acidulation by adding organic manures.

Data presented in Table 16 revealed that treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered lower values for bulk density (1.24 g cm<sup>3</sup>), particle density (2.29 g cm<sup>3</sup>) and maximum porosity (45.81%). Among sole application of organics, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) recorded lower values of 1.29 and 2.30 g cm<sup>3</sup> for bulk and particle density, respectively, as well as higher porosity of 44.73 per cent, followed by T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>). Among organic integration, lower values for bulk density 1.26 gcm<sup>3</sup>, particle density 2.30 gcm<sup>3</sup> and higher porosity of 45.14 per cent were observed in T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) followed by T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) and T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>). Integration of individual sources of organics and recommended fertilizer dose in equal proportions (50:50) registered lower values for bulk density 1.24 gcm<sup>3</sup> with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) followed by T<sub>19</sub> (FYM 15t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) while as T<sub>20</sub> recorded lower particle density of 2.28 gcm<sup>3</sup> followed by T<sub>19</sub> and T<sub>21</sub>. However, maximum porosity 45.63 per cent was

observed in T<sub>21</sub>, followed by T<sub>20</sub> and T<sub>19</sub>. Higher values for bulk density, particle density and lower values for porosity were observed in T<sub>25</sub> (control), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>).

Decrease in bulk density can be attributed to the fact that organics have a favourable effect on soil aggregation, increased biomass production and soil organic matter build up, leading to increased porosity. Decrease in particle density could be due to lower weight of organic matter, more organic matter, less will be bulk density. These results are in conformity with the findings of other research workers (Melawar *et al.*, 1998; Maheswarappa *et al.*, 1999; Appuvu *et al.*, 2000; Renuka and Sankar, 2001 and Bhattacharyya *et al.*, 2004).

## 5.7 Soil chemical characteristics

The data regarding soil chemical characteristics viz. P<sub>H</sub>, organic carbon and electrical conductivity as influenced by various treatments after the harvest of rabi 2005-2006 residual crop pea is depicted in Table 17.

Lower P<sub>H</sub> (6.51), higher organic carbon content (1.65%) and maximum electrical conductivity (0.145 d sm<sup>-1</sup>) was observed in treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Among sole application of organics, lower P<sub>H</sub> (6.54), higher organic carbon content (1.56%) and higher electrical conductivity (0.132 d sm<sup>-1</sup>) was registered in treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>)

followed by T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>). Integration of organic sources recorded lower value of pH (6.50), higher organic carbon content (1.63%) and higher electrical conductivity (0.139 d sm<sup>-1</sup>) with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) followed by T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>). Integration of individual organic sources with recommended fertilizer dose in equal proportions (50:50) recorded lower pH (6.51), higher organic carbon content (1.63%) and higher electrical conductivity (0.140 d sm<sup>-1</sup>) with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) followed by T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). The highest P<sub>H</sub> (7.36), lowest organic carbon content (0.90) and lowest electrical conductivity (0.087 d sm<sup>-1</sup>) was observed in treatment T<sub>25</sub> (control).

The decrease in soil pH could be ascribed to acidifying effect of organic acids like lactic acid, formic acid produced during decomposition of organic manures. Decrease in pH results an increase in electrical conductivity. Increase in organic carbon content of soil due to integrations can be attributed to narrow C/N ratio, leading to more decomposition, more microbial population, enhanced biological conservation and higher build up of organic carbon. Superiority of poultry manure in improving soil chemical characteristics over rest of the organic sources can be attributed to the fact that poultry manure is rich in essential nutrients and decomposes quickly, thereby helps in building up of more organic carbon content. The decrease in pH results an increase in organic carbon. Similar trend has also been reported by other research workers (Shelke *et al.*, 1999; Maheswarappa *et al.*, 1999;

Tawio *et al.*, 2002; Estefamous *et al.*, 2003; Sharma *et al.*, 2003; Swain *et al.*, 2003 and Walia and Kler, 2005).

## 5.8 Nutrient availability

The data regarding the availability of nitrogen, phosphorus, potassium, sulphur, calcium and magnesium as influenced by various treatments after the harvest of rabi 2005-2006 residual crop pea are presented in Table 18, 19 and 20.

Maximum availability of nitrogen ( $266.13 \text{ kg ha}^{-1}$ ), phosphorus ( $52.36 \text{ kg ha}^{-1}$ ), potassium ( $197.10 \text{ kg ha}^{-1}$ ), sulphur ( $29.20 \text{ kg ha}^{-1}$ ), calcium ( $3526.08 \text{ kg ha}^{-1}$ ) and magnesium ( $1078.87 \text{ kg ha}^{-1}$ ) was observed in treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Sole application of organic sources registered higher build up of nitrogen ( $216.31 \text{ kg ha}^{-1}$ ), phosphorus ( $39.37 \text{ kg ha}^{-1}$ ), potassium ( $180.66 \text{ kg ha}^{-1}$ ), sulphur ( $22.04 \text{ kg ha}^{-1}$ ), calcium ( $3512.90 \text{ kg ha}^{-1}$ ) and magnesium ( $1040.78 \text{ kg ha}^{-1}$ ) with treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) followed by T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) in general. Among organic integration treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) recorded higher availability of nitrogen ( $231.79 \text{ kg ha}^{-1}$ ), phosphorus ( $41.90 \text{ kg ha}^{-1}$ ), potassium ( $188.32 \text{ kg ha}^{-1}$ ), sulphur ( $23.76 \text{ kg ha}^{-1}$ ), calcium ( $3518.47 \text{ kg ha}^{-1}$ ) and magnesium ( $1062.62 \text{ kg ha}^{-1}$ ) followed by T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>) and T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>). Integration of individual organic sources with recommended fertilizer dose in equal proportion, registered higher build up of nitrogen ( $260.88$

kg ha<sup>-1</sup>), phosphorus (50.40 kg ha<sup>-1</sup>), potassium (195.86 kg ha<sup>-1</sup>), sulphur (26.42 kg ha<sup>-1</sup>), calcium (3522.88 kg ha<sup>-1</sup> and magnesium (1063.79 kg ha<sup>-1</sup>) with T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) followed by T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Depletion in nitrogen, phosphorus, potassium, sulphur, calcium and magnesium was observed in treatments viz. T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>), T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>25</sub> (control) over initial status.

The increased nutrient availability with organic and inorganic as well as with organic integration could be attributed to residual effects of organic manures, balanced C/N ratio, more decomposition, enhanced biomass addition which contains humus (a source of plant nutrients), production of organic acid which makes insoluble forms of nutrients into available forms. Another reason for enhanced nutrient availability could be due to dissolution of certain complex components like calcium carbonates into soluble form, production of carbon dioxide and organic acids during decomposition of organic manures which would have increased the availability of phosphorus and potassium, besides this, narrow C/P ratio might have accelerated the availability of phosphorus, organic acid produced during decomposition also tides Fe, Al and Mn, thereby increases the phosphorus availability. Organic manures are an excellent source of sulphur, calcium and magnesium. The increase in these nutrients might also be attributed to the effect of organic acids produced during process of decomposition which enhances the solubility of Ca, Mg and their retention by organic colloids. Precipitation

of sulphur impurities by organic acids also helps in sulphur build up. Enhanced nutrient availability can also be attributed to nitrogen fixation and phosphorus solubilization by *Azospirillum* and *Phosphobacteria* which might have led to enhance nitrogen and phosphorus availability in rhizosphere. Besides, improved soil properties (physical, chemical and biological) might also be responsible for enhanced nutrient availability. The increased nutrient availability with poultry manure as compared to other sources could be attributed to balanced C/N ratio, narrow C/P ratio, more organic carbon content and quick mineralization to available forms. The reason behind depletion of nutrients with T<sub>1</sub>, T<sub>6</sub>, T<sub>18</sub> and T<sub>25</sub> (control) might be due to leaching of nutrients or becoming a part of fixed nutrient pool of the soil. Another reason for depletion over initial status is that there is no exogenous addition of S, Ca and Mg in these treatments.

The increase in nutrient availability in soil due to organics, their integration or integration of individual organic sources with inorganic fertilizers have also been reported by several workers (Prasad *et al.*, 1984; Mehendran and Kumar, 1996; Kaistha *et al.*, 1997; Sainz *et al.*, 1998; Reddy and Reddy, 1999; Wong *et al.*, 1999; Umar and Jada, 2000; Shelke *et al.*, 2001; Datt *et al.*, 2003; Perumal *et al.*, 2003; and Dademal *et al.*, 2004) in different vegetable crops.

## **5.9 Rhizosphere microbial population**

The data regarding the rhizosphere microbial population as influenced by various treatments after the harvest of rabi 2005-2006 residual crop pea is presented in Table 21.

Maximum fungal ( $60 \times 10^5 \text{ g}^{-1}$  of soil) and bacterial population ( $74.15 \times 10^5 \text{ g}^{-1}$  of soil) were observed in treatment  $T_{24}$  (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg  $\text{ha}^{-1}$  + 60: 30: 30: N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$  kg  $\text{ha}^{-1}$ ). Among sole application of organics,  $T_6$  (BF 7 kg  $\text{ha}^{-1}$ ) registered a fungal and bacterial population of  $31.10 \times 10^5$  and  $59.80 \times 10^5 \text{ g}^{-1}$  of soil, respectively, followed by  $T_4$  (PM 6 t  $\text{ha}^{-1}$ ) and  $T_5$  (VC 6t  $\text{ha}^{-1}$ ). Integration among organics registered a fungal population of  $51.06 \times 10^5 \text{ g}^{-1}$  of soil with  $T_{16}$  (PM 3t + BF 7 kg  $\text{ha}^{-1}$ ) followed by  $T_7$  (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg  $\text{ha}^{-1}$ ),  $T_{17}$  (VC 3t + BF 7 kg  $\text{ha}^{-1}$ ) and  $T_{15}$  (PM 3t + VC 3t  $\text{ha}^{-1}$ ). However,  $T_{17}$  recorded maximum bacterial population of  $70.58 \times 10^5 \text{ g}^{-1}$  of soil, followed by  $T_{16}$ ,  $T_7$  and  $T_{15}$ . Integration of individual organic sources with recommended fertilizer dose in equal proportions, registered maximum fungal and bacterial count of  $43.89 \times 10^5$  and  $69.45 \times 10^5 \text{ g}^{-1}$  of soil, respectively with  $T_{23}$  (BF 7 kg + 60: 30: 30: N:  $\text{P}_2\text{O}_5$ :  $\text{K}_2\text{O}$  kg  $\text{ha}^{-1}$ ). Minimum microbial count was observed in control, 50 and 100 per cent RFD.

Increase in rhizosphere microbial population may be due to balanced C/N ratio and more decomposition leading to more microbial build up. Balanced nutrition for microbial growth as well as stimulation of soil micro organisms by certain organic compounds associated with organics. Improvement in soil physical and chemical properties can also

be some of the reasons for improvement in rhizosphere microbial population.

Our results are in conformity with findings of other research workers (Azam and Banerjee, 1989; Ganeshe *et al.*, 1998; El-Din *et al.*, 2000; Marinari *et al.*, 2000; Naidu *et al.*, 2000; Tawio *et al.*, 2000; Perumal *et al.*, 2003; Swain *et al.*, 2003 and Gogi *et al.*, 2004).

### 5.10 Residual effect on pea crop

The data in Table 22 and 23 revealed significant variations for various attributes viz. plant height, pod number plant<sup>-1</sup>, pod yield plant<sup>-1</sup>, pod yield ha<sup>-1</sup> and nodule number plant<sup>-1</sup> in pea due to residual effect of various treatments.

Maximum values of plant height (44.43 cm), pod number plant<sup>-1</sup> (23.22), pod yield plant<sup>-1</sup> (37.07 g), pod yield ha<sup>-1</sup> (123.56 q) and nodule number plant<sup>-1</sup> (46.39) were observed in treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Among sole application of organics, T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) registered higher values of 40.57 cm, 16.89, 26.23 g, 87.43 q and 33.35 for plant height, pod number, pod yield plant<sup>-1</sup>, pod yield ha<sup>-1</sup> and nodule number plant<sup>-1</sup>, respectively, followed by T<sub>3</sub> (SM 20 t ha<sup>-1</sup>) and T<sub>5</sub> (VC 6t ha<sup>-1</sup>). Organic integration recorded higher values of plant height (43.38 cm), pod number plant<sup>-1</sup> (21.75), pod yield plant<sup>-1</sup> (34.74 g), pod yield ha<sup>-1</sup> (115.80 q) and nodule number plant<sup>-1</sup> (43.92) with treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) followed by T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>) T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>) and T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>). Integration of

organic with inorganic sources in equal proportion (50:50) registered higher values of 44.27 cm, 22.35, 35.65 g, 118.84 q and 45.55 for plant height, pod number plant<sup>-1</sup>, pod yield plant<sup>-1</sup>, pod yield ha<sup>-1</sup> and nodule number plant<sup>-1</sup> with treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) respectively, followed by T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>). Minimum values were observed with control, 50 per cent and 100 per cent RFD.

The beneficial effects of organic and inorganic integrations, organic integration, as well as the sole applications of organics in raising the succeeding crop pea can be attributed to their residual effects, as the organics exhibit a slow release of nutrients, desired build up of organic matter, less loss of nutrients under ordinary soil conditions, hence they exhibit a residual effect.

Our results are in conformity with the findings of Rao (1976) in okra and Duraiswami and Mani (2001) in soybean.

### **5.11 Economics**

The results in Table 27 revealed that capital investment exhibited variation with different treatments in okra cultivation. Maximum cost of cultivation Rs. 60,372.20 was observed with T<sub>5</sub> (VC 6t ha<sup>-1</sup>) followed by Rs. 59,372.20 with T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>) and Rs. 58,872.20 with T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>). A low cost of cultivation Rs. 41,812.20 was registered with T<sub>25</sub> (control). Higher or lower capital investment in cost of cultivation is not a criteria for high returns.

Treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) registered highest net returns of Rs. 1,25,140.80 with returns of 3.34 per rupee invested followed by Rs. 1,24,186.80 recorded with T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) with returns Re<sup>-1</sup> invested of 3.63, thus T<sub>16</sub> proved more profitable. Lowest net returns of Rs. 7,467.52 was observed with T<sub>25</sub> with returns Re<sup>-1</sup> invested of 1.17. Similar trend has also been reported by various workers in different vegetable crops.

The lowest BEP of 32.70 q ha<sup>-1</sup> was observed in treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) followed by 32.82, 32.85 and 32.89 q ha<sup>-1</sup> recorded with T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>) and T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>), respectively, while as maximum BEP of 71.86 q ha<sup>-1</sup> was recorded with T<sub>25</sub> (control). Indicating that level of production at which neither losses nor profits is low with T<sub>7</sub>, T<sub>15</sub>, T<sub>12</sub> and T<sub>16</sub> as compared to T<sub>25</sub> where the level of production is very high. Treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60:30:30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered maximum margin of safety 224.89 q ha<sup>-1</sup> followed by 222.29, 215.36, 213.53, 211.88, 211.81 and 210.78 q ha<sup>-1</sup> recorded with T<sub>7</sub>, T<sub>15</sub>, T<sub>12</sub>, T<sub>16</sub>, T<sub>21</sub> and T<sub>1</sub>, respectively which is an indicative of more profits. Lowest margin of safety 26.70 q ha<sup>-1</sup> was observed with T<sub>25</sub>.

Treatment T<sub>25</sub> (control) and T<sub>18</sub> i.e. 50% RFD (60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) registered lower values of 0.518 and 0.690 for relative share of land while as low relative share of labour 0.093 and 0.095 were registered in T<sub>7</sub> and T<sub>15</sub>. However, T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>6</sub> (BF 7 kg ha<sup>-1</sup>) recorded lower values of 0.072 and 0.073 for relative capital

share, respectively, indicating that there is a further scope to exploit land, labour and capital resources to generate more income and consequently the employment.

The results presented in Table 30 depicted that capital investment exhibited no variation among different treatments, as no input in terms of manures or fertilizers was applied in pea crop after harvest of main crop okra. A uniform cost of cultivation of Rs. 38,825.70 was observed in all treatments. Treatment T<sub>24</sub> registered maximum net returns of Rs. 22,944.30 ha<sup>-1</sup> with returns Re<sup>-1</sup> invested of 1.59, followed by T<sub>21</sub> (Rs. 20,594.30 ha<sup>-1</sup>, 1.53 Re<sup>-1</sup>), T<sub>7</sub> (19,704.30 ha<sup>-1</sup>, 1.49 Re<sup>-1</sup>), indicating that T<sub>24</sub> is more profitable followed by T<sub>21</sub> and T<sub>7</sub>. Treatment T<sub>24</sub> registered a lowest BEP of 57.69 q ha<sup>-1</sup> with a maximum margin of safety 65.87 q ha<sup>-1</sup>, indicating more profits. Treatments T<sub>1</sub> i.e. 100% RFD, T<sub>5</sub>, T<sub>6</sub>, T<sub>18</sub> i.e. 50% RFD and T<sub>25</sub> were found beyond economic optima. The lowest relative share of land (-0.125), labour (0.193) and capital (0.143) were observed in T<sub>25</sub> and T<sub>24</sub>, respectively, indicating that there is further scope to exploit land, labour and capital to generate more income and employment.

In treatments both in main crop okra and residual pea, where relative shares of land, labour and capital are high, the possibility of further exploitation to generate more income is restricted or limited. The cumulative economics of okra-pea rotation as indicated in Table 31 revealed that maximum cost of cultivation Rs. 99,197.90 ha<sup>-1</sup> was observed with T<sub>5</sub> followed by Rs. 98, 197.90, 97,697.90 and 97,337.90 ha<sup>-1</sup> in T<sub>13</sub> (SM 10t + VC 3t ha<sup>-1</sup>), T<sub>10</sub> (FYM 15t + VC 3t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20

t ha<sup>-1</sup>), respectively. Treatment T<sub>7</sub> recorded a maximum net return of Rs. 1,44,215.10 ha<sup>-1</sup> with returns Re<sup>-1</sup> invested of 2.56. However, highest returns Re<sup>-1</sup> invested of 2.59 was recorded in T<sub>16</sub>, indicating that this treatment is more profitable.

It can be perceived that more employment with sustained returns and optimization of resources are obtained only, if optimum use of factors of production are made. Thus, it can be assumed that optimization of resources and managerial skill are vital tools in profitable cultivation of okra and residual crop pea. Okra-pea rotation was found economically viable.

### **Conclusion**

- In the present investigation, among 25 treatments under study, treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) proved superior over rest of the treatments with respect to improvement in plant growth, fruit and seed yield of okra, fruit and seed quality of okra, nutrient uptake by okra plants, physical and chemical properties of soil, nutrient availability, rhizosphere microbial population and pod yield in residual crop pea.
- Among integration of different organic sources with recommended fertilizer dose in equal proportions (50:50), treatment T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) proved superior over rest of the treatments except T<sub>24</sub> with respect to

improvement in all characters under study in main crop okra, residual crop pea and soil health.

- Treatment T<sub>1</sub> i.e. 100% RFD (120:60:60 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) in general proved superior over rest of the treatments except T<sub>21</sub> and T<sub>24</sub> with respect to plant growth, fruit and seed yield of okra. Besides, recording higher values for protein content of dry okra seeds, protein and dry matter content of fresh okra fruits and nutrient uptake by okra plants as compared to sole as well as combined application of organic sources but registered lower nutrient uptake as compared to organic and inorganic integrations. However, T<sub>1</sub> did not improve the fruit quality with respect to fibre and vitamin C content, physical, chemical and biological properties of soil, nutrient availability and pod yield in residual crop pea as compared to sole application of organics, their integration as well as combined application of organics and inorganics.
- Among sole application of organic sources, treatment T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) proved superior over rest of the organic sources with respect to improvement in all characters under study in main crop okra, residual crop pea and soil health.
- Among organic integrations, treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) in general proved superior over rest of the organic integration treatments as well as sole application of

organics with regard to improvement of all characters under study in main crop okra, residual crop pea and soil health.

- In main crop okra, treatment  $T_{16}$  (PM 3t + BF 7 kg ha<sup>-1</sup>) proved more profitable with highest returns Re<sup>-1</sup> invested of 3.63. While in residual crop pea, treatment  $T_{24}$  registered maximum returns Re<sup>-1</sup> invested of 1.59.
- In okra-pea rotation, treatment  $T_{16}$  proved more profitable with highest returns Re<sup>-1</sup> invested of 2.59.

## Chapter 6

### SUMMARY AND CONCLUSION

The present investigation “Influence of organic manures and inorganic fertilizers on growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench]” was carried out at the experimental fields of Division of Olericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar. The main crop okra was raised during kharif 2004 and 2005, while as residual crop pea was immediately raised after the harvest of okra, during rabi 2004-2005 and rabi 2005-2006, with the objective of ascertaining the influence of organics and inorganics on growth, yield and quality of okra; to work out the optimum combination of organic and inorganic sources of nutrients for optimizing the yield of okra; to evaluate the impact of organic manures and inorganic fertilizers on soil health, nutrient availability, rhizosphere microbial build up; to ascertain the residual effect of nutrient sources under study on succeeding crop pea; to study the comparative economics of production and to ascertain the feasibility of okra-pea rotation under Kashmir conditions.

The experiment was laid in simple square lattice design with two replications. The experiment comprised of 25 treatments. Observations on growth, fruit yield and quality, seed yield and quality, nutrient uptake by okra plants, physical and chemical characteristics of studied soil, nutrient availability, rhizosphere microbial population and response of residual crop pea with respect to growth, yield and nodule number were

recorded. The results obtained were statistically analyzed and are summarized as under:

- In general, it was observed that integration of organic with inorganic sources of plant nutrients and recommended fertilizer dose exhibited a significant influence on all parameters under study over sole application of organics as well as integration of organic sources.
- Treatment T<sub>24</sub> (FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) proved superior over rest of the treatments with respect to improvement in plant growth, fruit and seed yield, fruit and seed quality, nutrient uptake in okra as well as pod yield in residual crop pea.
- Treatment T<sub>24</sub> proved most effective in improving physical and chemical properties of soil, nutrient availability and rhizosphere microbial population. Next to T<sub>24</sub>, T<sub>21</sub> (PM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>22</sub> (VC 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>20</sub> (SM 10t + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and T<sub>23</sub> (BF 7 kg + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) proved superior with respect to all characters under study both in main crop okra as well as in residual crop pea.
- Among organic integrations, treatment T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) in general proved superior over rest of organic integration treatments as well as sole applications with respect to improvement in growth, fruit and seed yield, fruit and

seed quality, nutrient uptake in okra, pod yield in pea and soil health. Next to T<sub>7</sub>, T<sub>15</sub> (PM 3t + VC 3t ha<sup>-1</sup>), T<sub>12</sub> (SM 10t + PM 3t ha<sup>-1</sup>), T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) and T<sub>17</sub> (VC 3t + BF 7 kg ha<sup>-1</sup>) proved superior with respect to all characters under study both in main crop okra as well as in residual crop pea.

- Among sole application of organics T<sub>4</sub> (PM 6 t ha<sup>-1</sup>) proved superior over rest of the individual organic sources with respect to improvement in growth, fruit and seed yield, fruit and seed quality, nutrient uptake in okra, pod yield in pea and soil health followed by T<sub>5</sub> (VC 6t ha<sup>-1</sup>) and T<sub>3</sub> (SM 20 t ha<sup>-1</sup>).
- In main crop okra, maximum net returns of Rs.1,25,140.80 ha<sup>-1</sup> were recorded with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>) followed by Rs. 1,24,186.80 ha<sup>-1</sup> recorded with T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>). Maximum returns Re<sup>-1</sup> invested of 3.63 was registered with T<sub>16</sub> (PM 3t + BF 7 kg ha<sup>-1</sup>) followed by 3.34 Re<sup>-1</sup> recorded with T<sub>7</sub> (FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>). Minimum BEP of 32.70 q ha<sup>-1</sup> was recorded with T<sub>7</sub> followed by T<sub>12</sub> (32.82 q ha<sup>-1</sup>), T<sub>15</sub> (32.85 q ha<sup>-1</sup>) and T<sub>16</sub> (32.89 q ha<sup>-1</sup>) and maximum BEP of 71.86 q ha<sup>-1</sup> was recorded with control. Maximum margin of safety 224.89 q ha<sup>-1</sup> was recorded with T<sub>24</sub> followed by T<sub>7</sub> (222.29 q ha<sup>-1</sup>), T<sub>15</sub> (215.36 q ha<sup>-1</sup>), T<sub>12</sub> (213.53 q ha<sup>-1</sup>) and T<sub>16</sub> (211.88 q ha<sup>-1</sup>) and minimum margin of safety 26.70 q ha<sup>-1</sup> was recorded with control. Lower values for relative shares of land (0.158), labour (0.093) and capital (0.072) were recorded with T<sub>25</sub>, T<sub>7</sub> and T<sub>16</sub>, respectively.

- In residual crop pea, T<sub>24</sub> recorded maximum net returns of Rs. 22,944.30 ha<sup>-1</sup> followed by Rs. 20, 594.30 and 19,704.30 ha<sup>-1</sup> recorded with T<sub>21</sub> and T<sub>7</sub>. Maximum returns Re<sup>-1</sup> invested of 1.59 was recorded with T<sub>24</sub> followed by 1.53 and 1.49 Re<sup>-1</sup> recorded with T<sub>21</sub> and T<sub>7</sub> respectively. Minimum BEP of 57.69 q ha<sup>-1</sup> was observed in T<sub>24</sub> followed by 58.70 and 59.42 q ha<sup>-1</sup> with T<sub>21</sub> and T<sub>7</sub> respectively. Maximum margin of safety 65.87 q ha<sup>-1</sup> was recorded with T<sub>24</sub> followed by 60.14 and 56.38 q ha<sup>-1</sup> with T<sub>21</sub> and T<sub>7</sub> respectively. Lower values for relative share of land (-0.125), labour (0.193) and capital (0.143) were observed with T<sub>25</sub> and T<sub>24</sub> respectively.
- In okra-pea rotation, maximum net returns of Rs. 1,44,215.10 ha<sup>-1</sup> were recorded with T<sub>7</sub> followed by Rs. 1,36,736.10 and Rs. 1,33,633.10 ha<sup>-1</sup> recorded with T<sub>16</sub> and T<sub>15</sub>. Maximum returns Re<sup>-1</sup> invested of 2.59 Re<sup>-1</sup> was recorded with T<sub>16</sub> followed by 2.56 Re<sup>-1</sup> recorded with T<sub>7</sub>.
- Okra-pea rotation suits well under Kashmir conditions.
- For harvesting sustainable, economic and quality yield in okra, a grower can adopt following nutrient schedule:

  - FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30: N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> or
  - PM 3 t or VC 3t or SM 3t + 60:30:30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>

- However, for production of organic okra, application of either FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup> or only PM 6t ha<sup>-1</sup> is recommended.
- A grower can raise pea as residual crop in okra-pea rotation by adopting following nutrient schedule:
  - FYM 3t + SM 2t + PM 0.5t + VC 0.6t + BF 7 kg ha<sup>-1</sup> + 60: 30: 30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> or
  - PM 3t + 60: 30: 30 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> or
  - FYM 6t + SM 4t + PM 1t + VC 1t + BF 7 kg ha<sup>-1</sup>.

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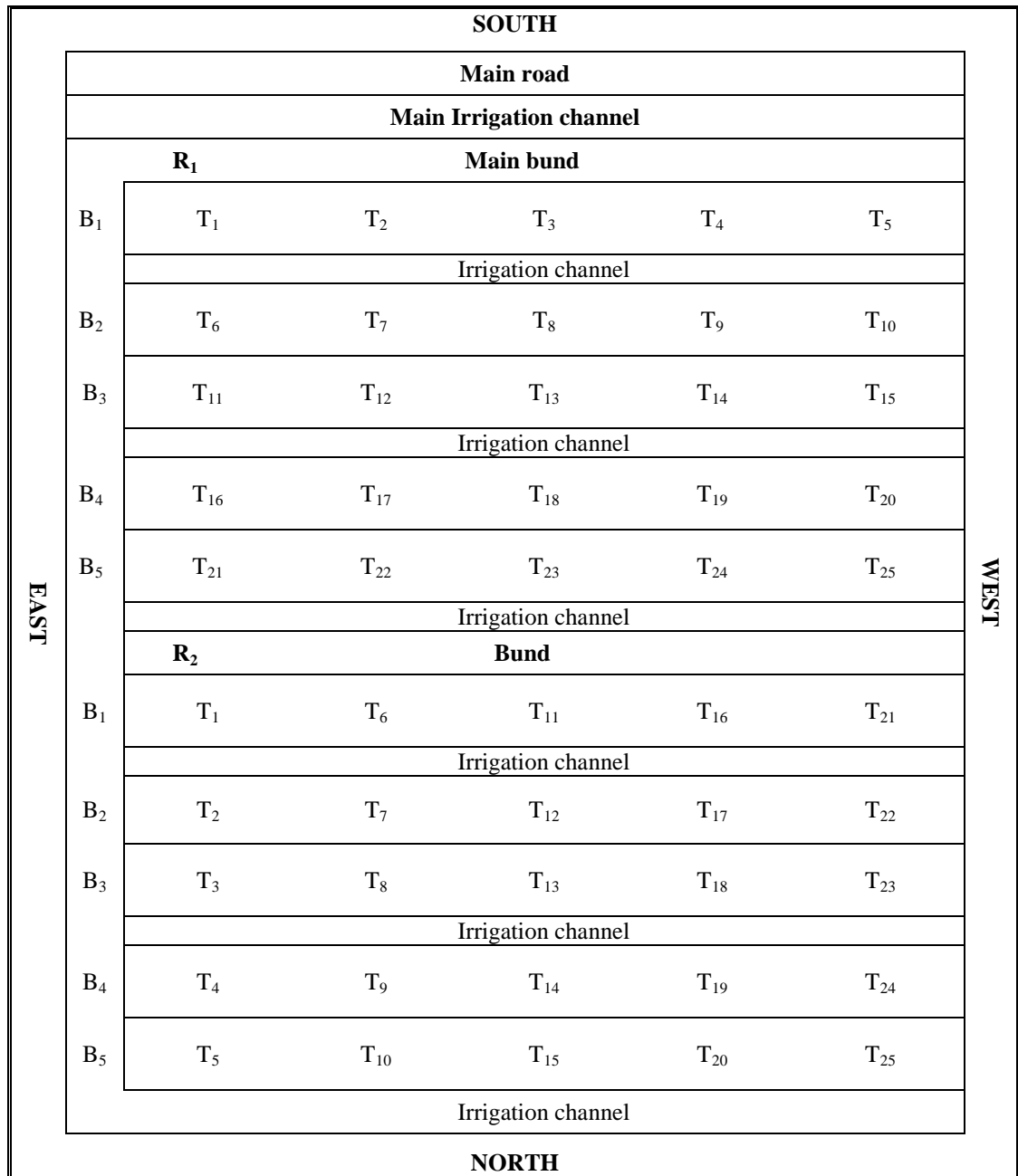
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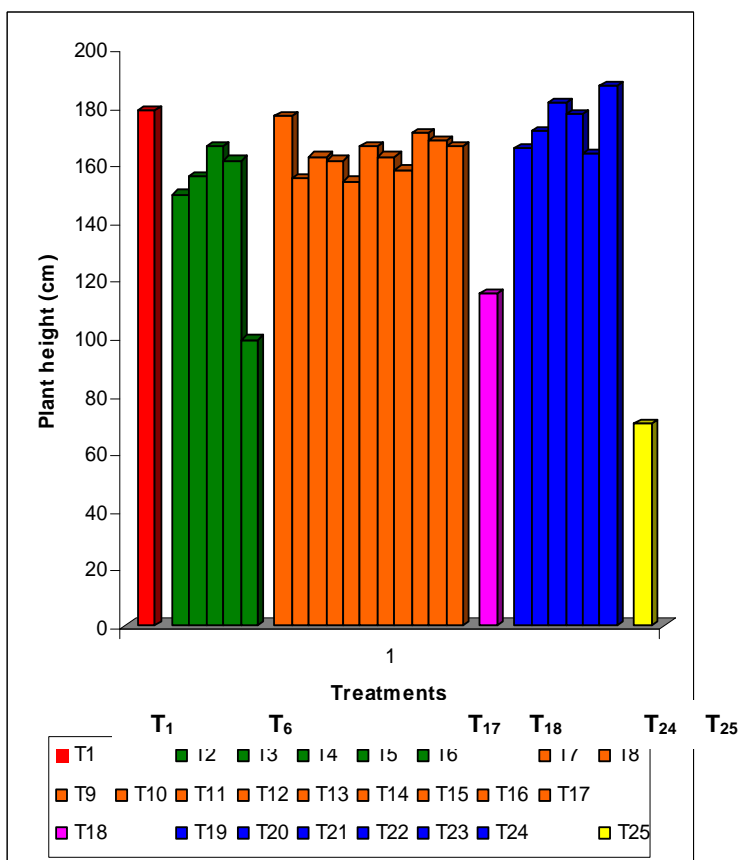
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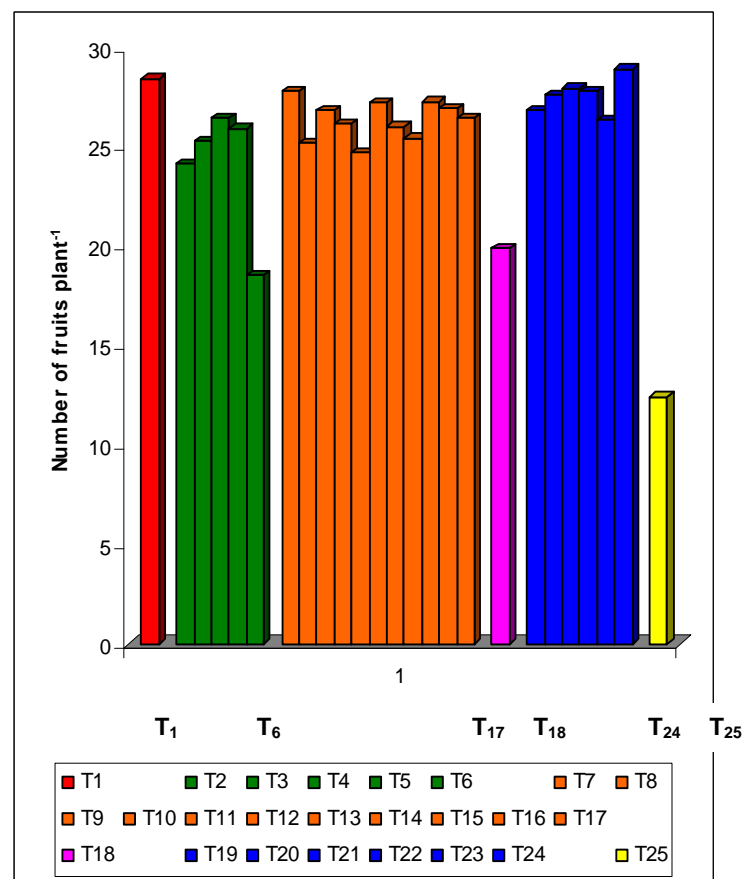
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**Fig. I: Lay out plan of experimental field**

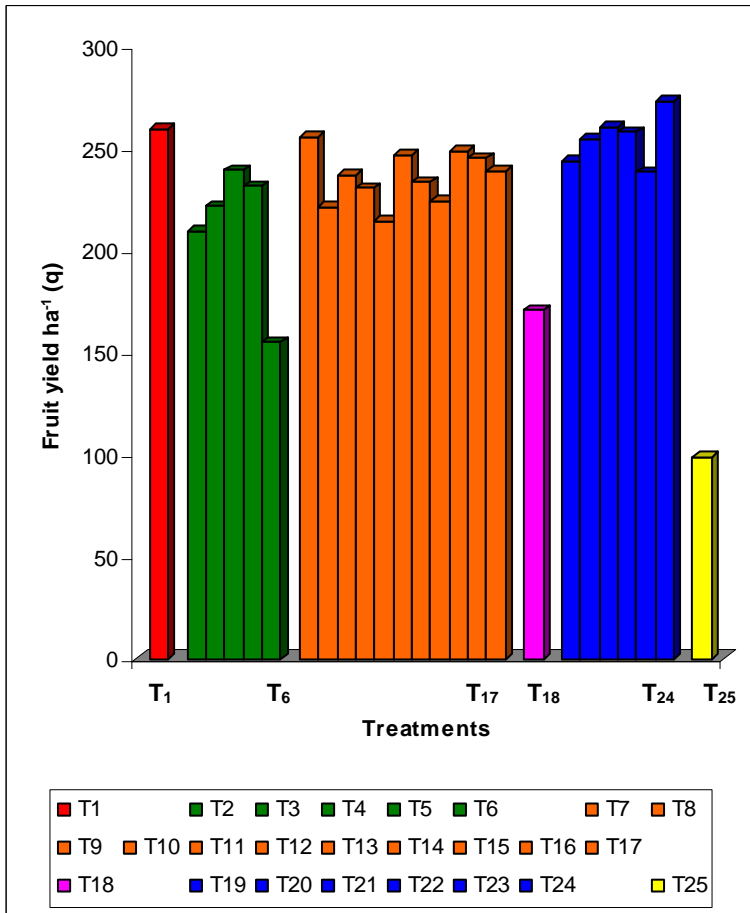


**Fig. II:** Depicting comparison among treatments with respect to plant height of okra (pooled over seasons)



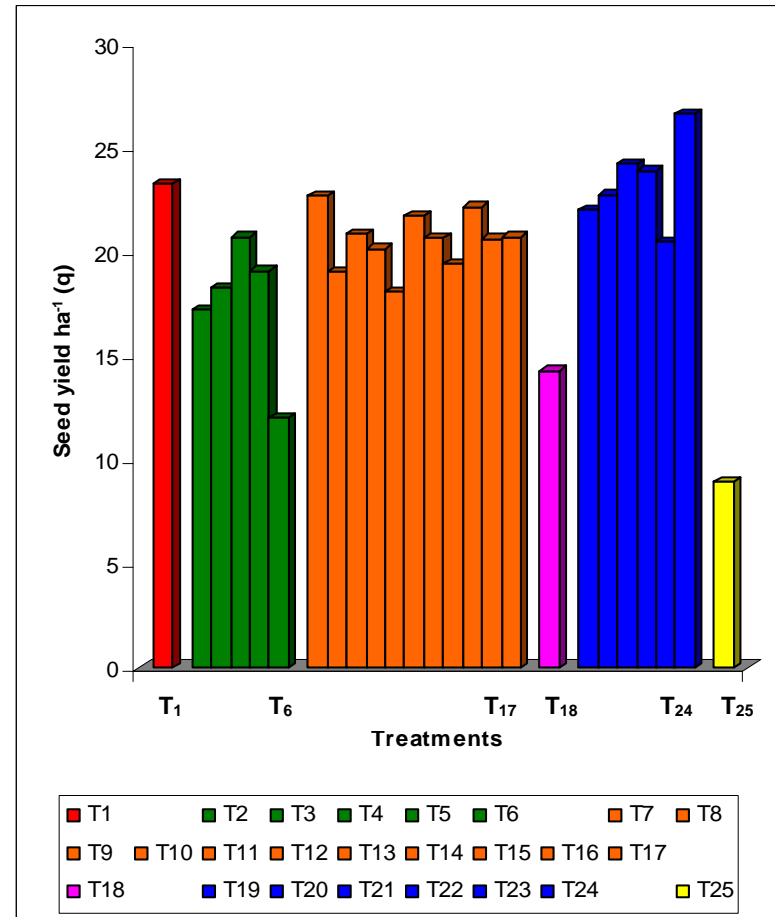
**Fig. III:** Depicting comparison among treatments with respect to number of fruit plant<sup>-1</sup> in okra (pooled over seasons)

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

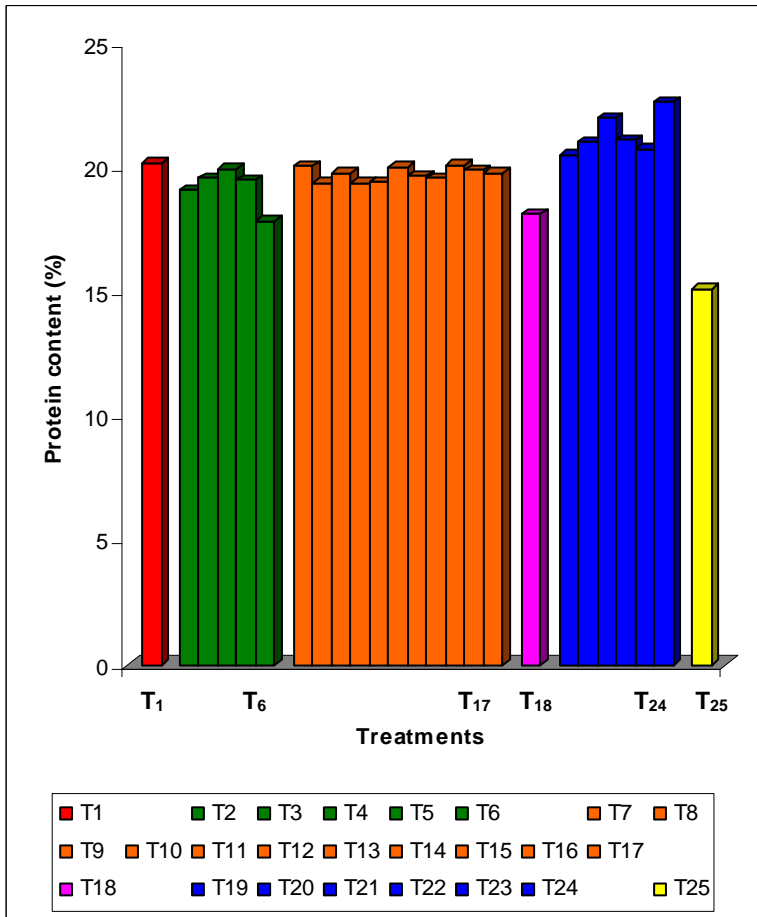


**Fig. IV:** Depicting comparison among treatments with respect to fruit yield  $ha^{-1}$  in okra (pooled over seasons)

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

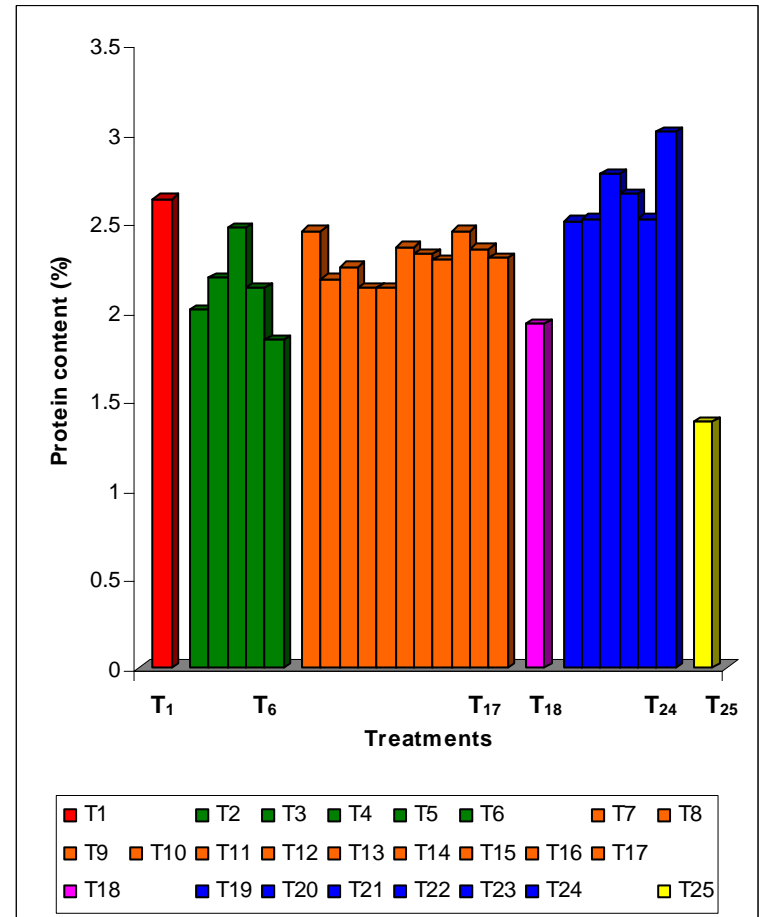


**Fig. V:** Depicting comparison among treatments with respect to seed yield  $ha^{-1}$  in okra (pooled over seasons)

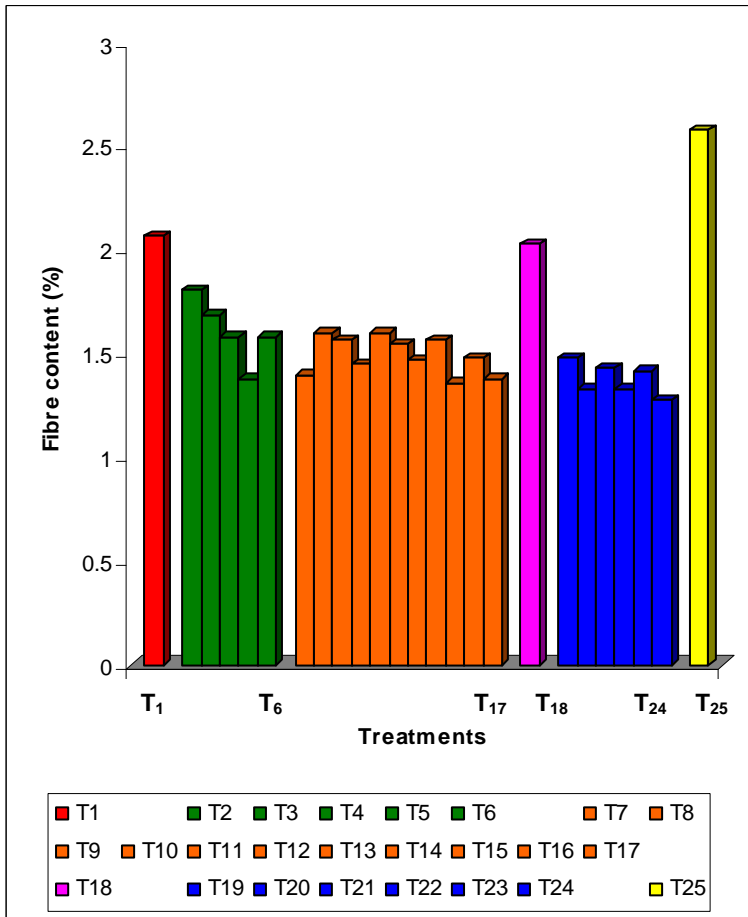


**Fig. VI:** Depicting comparison among treatments with respect to protein content of dry okra seeds (pooled over seasons)

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

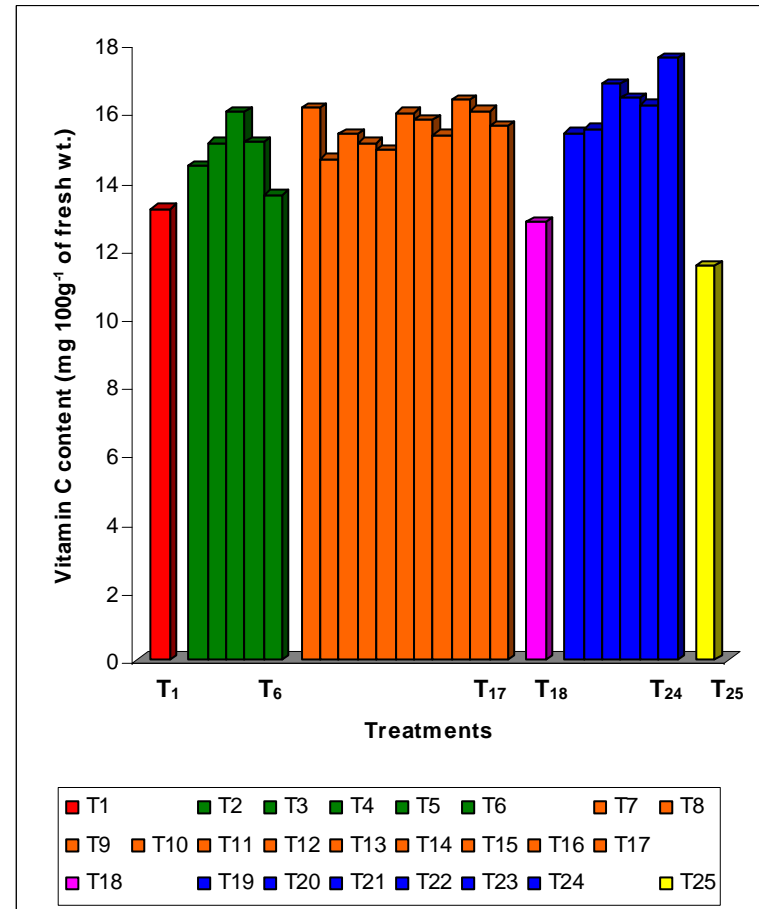


**Fig. VII:** Depicting comparison among treatments with respect to protein content of fresh okra fruits (pooled over seasons)

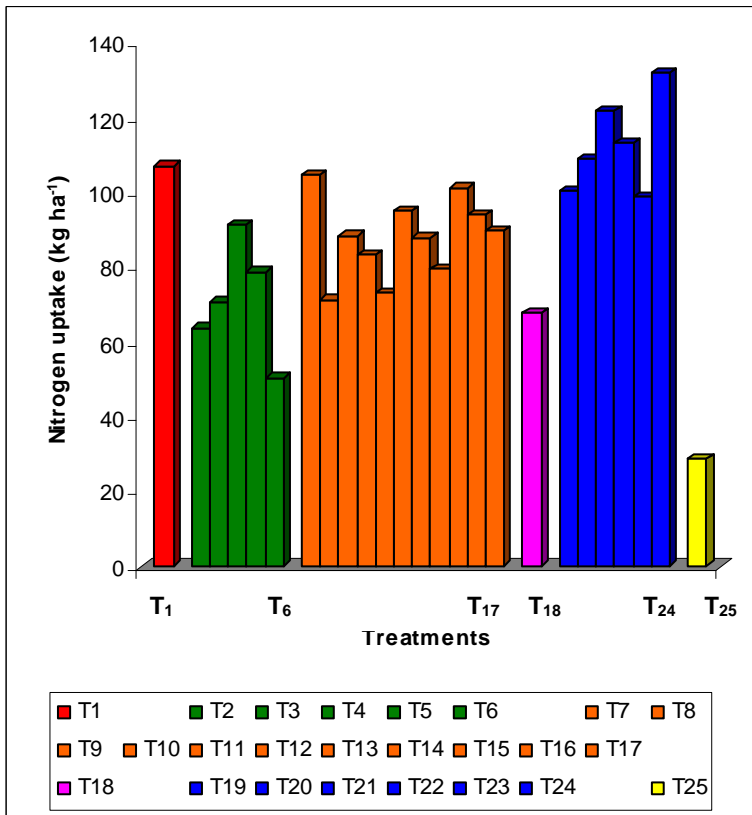


**Fig. VIII:** Depicting comparison among treatments with respect to fibre content of fresh okra fruits (pooled over seasons)

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

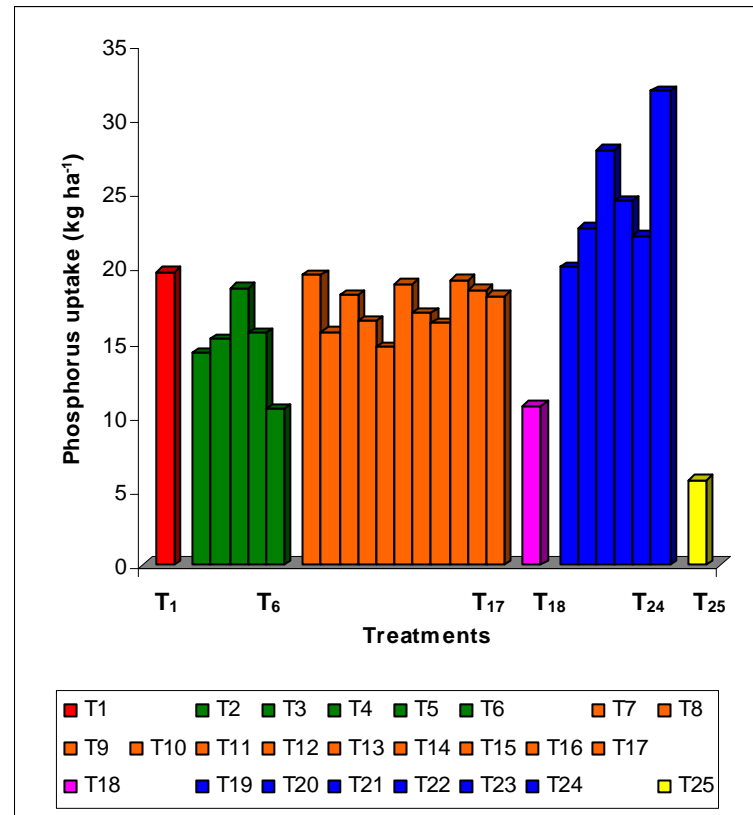


**Fig. IX:** Depicting comparison among treatments with respect to vitamin C content of fresh okra fruits (pooled over seasons)

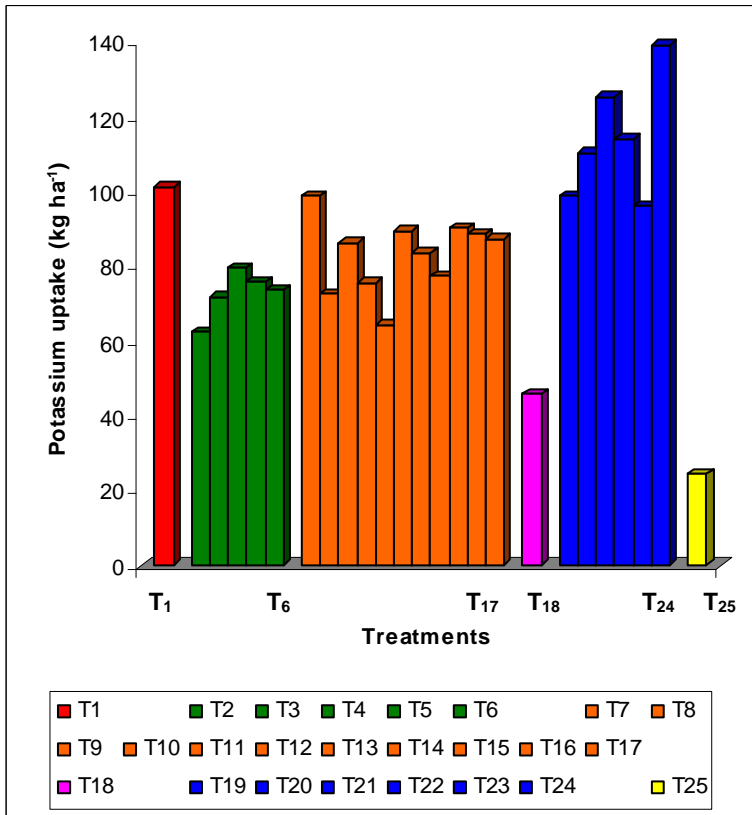


**Fig. X:** Depicting comparison among treatments with respect to nitrogen uptake by okra plants (pooled over seasons)

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

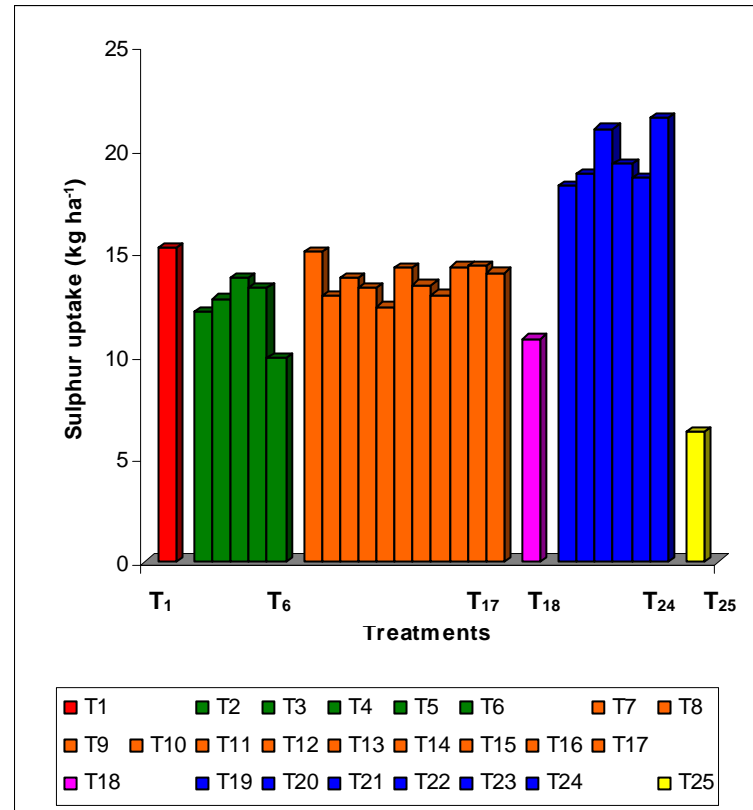


**Fig. XI:** Depicting comparison among treatments with respect to phosphorus uptake by okra plants (pooled over seasons)

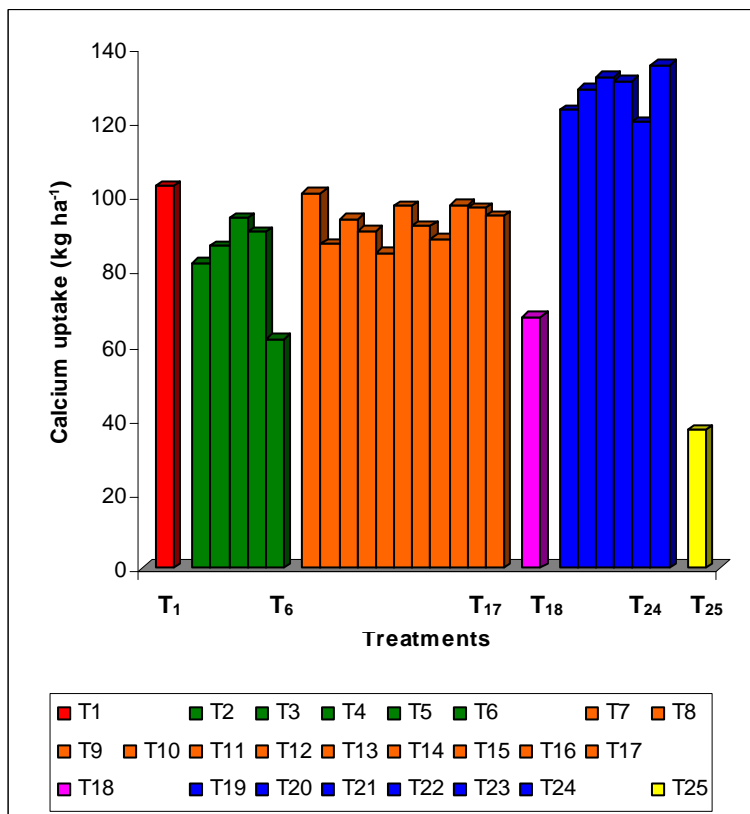


**Fig. XII:** Depicting comparison among treatments with respect to potassium uptake by okra plants (pooled over seasons)

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

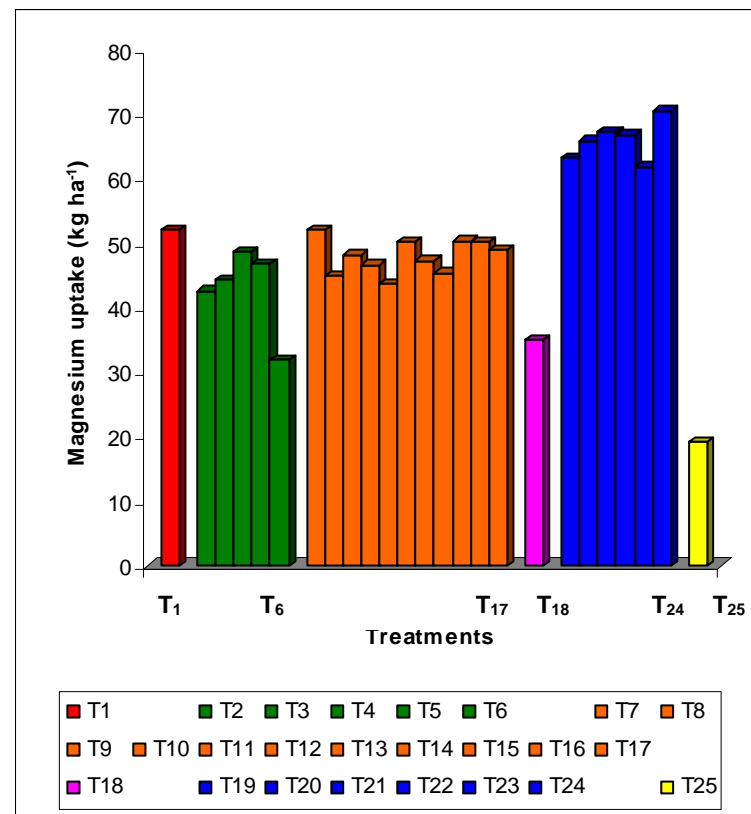


**Fig. XIII:** Depicting comparison among treatments with respect to sulphur uptake by okra plants (pooled over seasons)

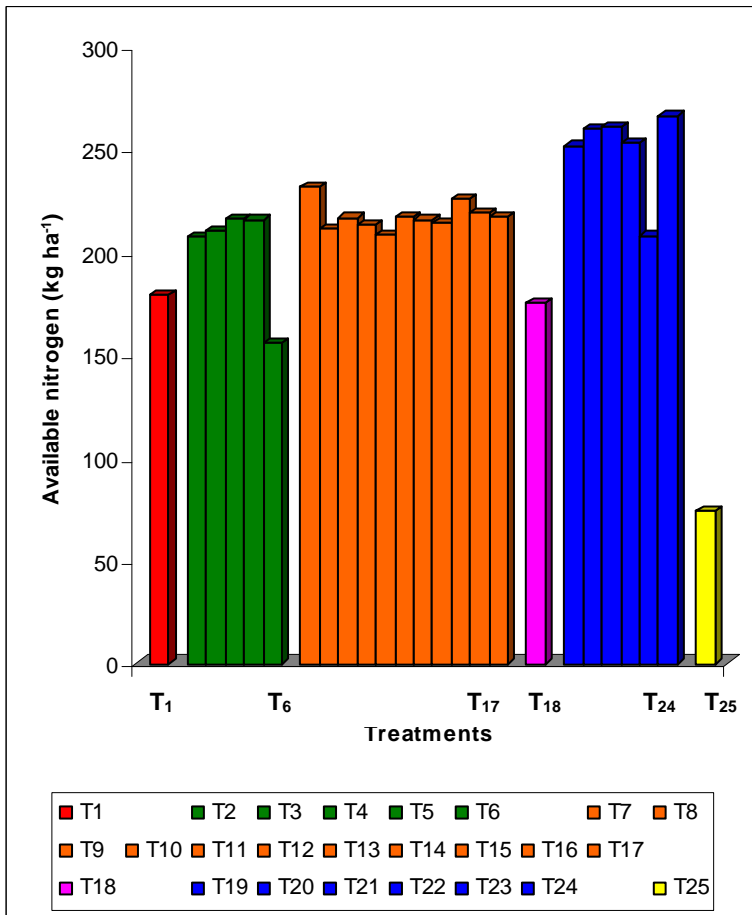


**Fig. XIV:** Depicting comparison among treatments with respect to calcium uptake by okra plants (pooled over seasons)

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

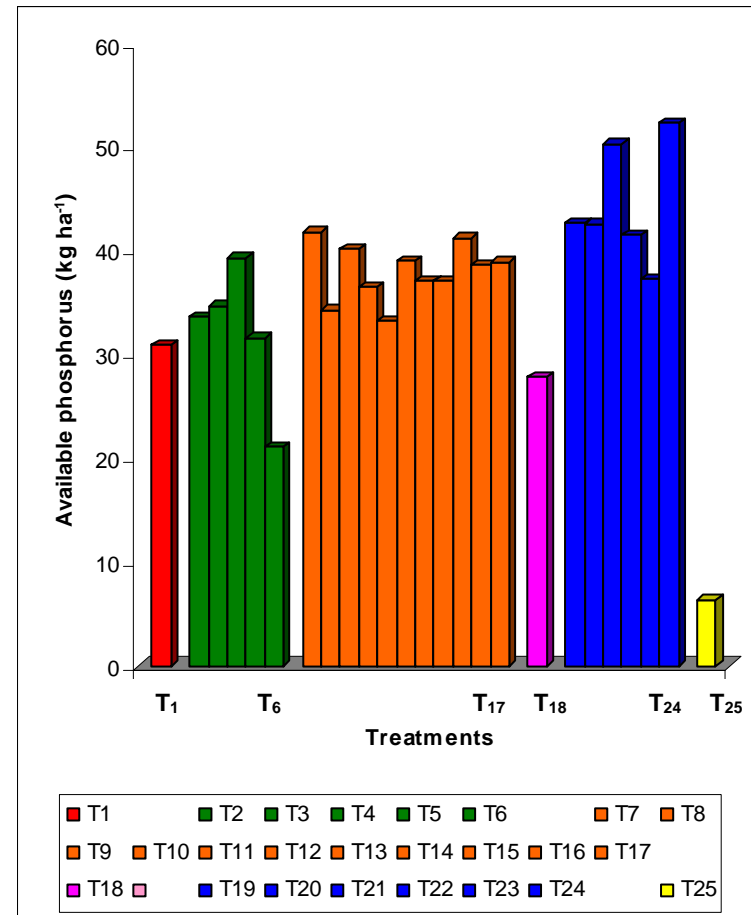


**Fig. XV:** Depicting comparison among treatments with respect to magnesium uptake by okra plants (pooled over seasons)

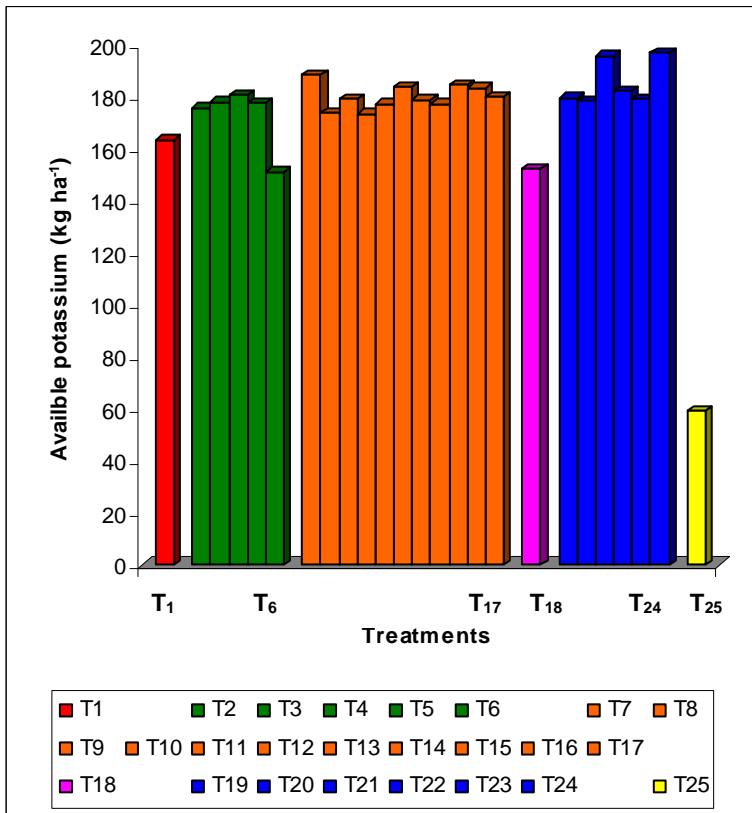


**Fig. XVI:** Depicting comparison among treatments with respect to available nitrogen in the soil after the harvest of rabi 2005-2006 residual crop pea

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

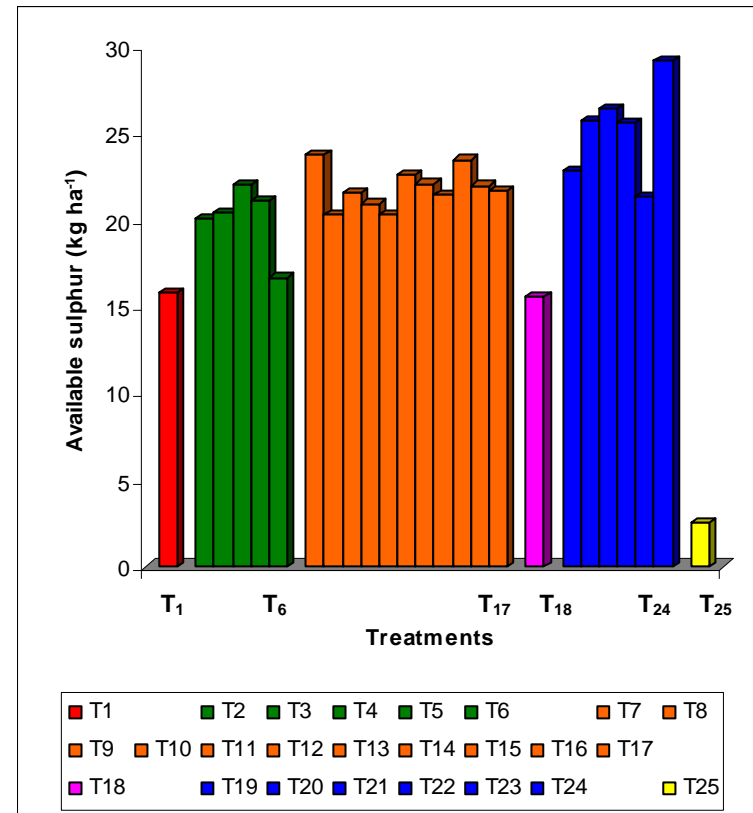


**Fig. XVII:** Depicting comparison among treatments with respect to available phosphorus in the soil after the harvest of rabi 2005-2006 residual crop pea

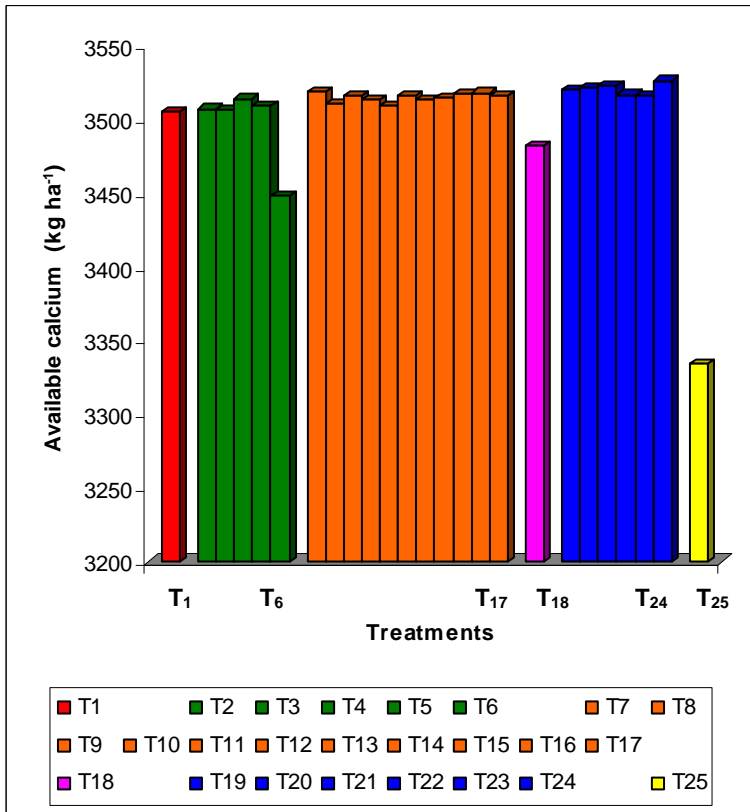


**Fig. XVIII:** Depicting comparison among treatments with respect to available potassium in the soil after the harvest of rabi 2005-2006 residual crop pea

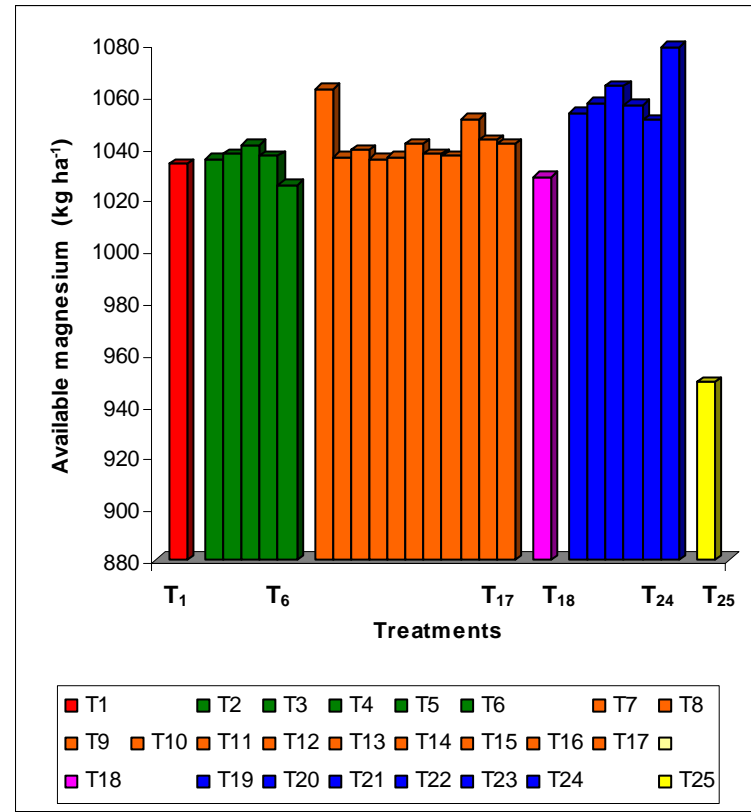
T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.



**Fig. XIX:** Depicting comparison among treatments with respect to available sulphur in the soil after the harvest of rabi 2005-2006 residual crop pea

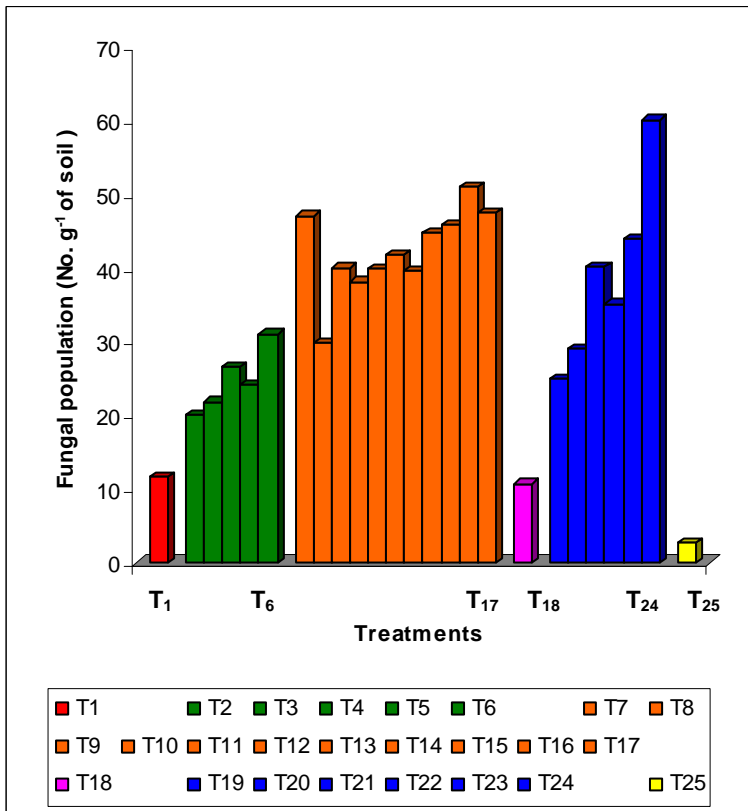


**Fig. XX:** Depicting comparison among treatments with respect to available calcium in the soil after the harvest of rabi 2005-2006 residual crop pea



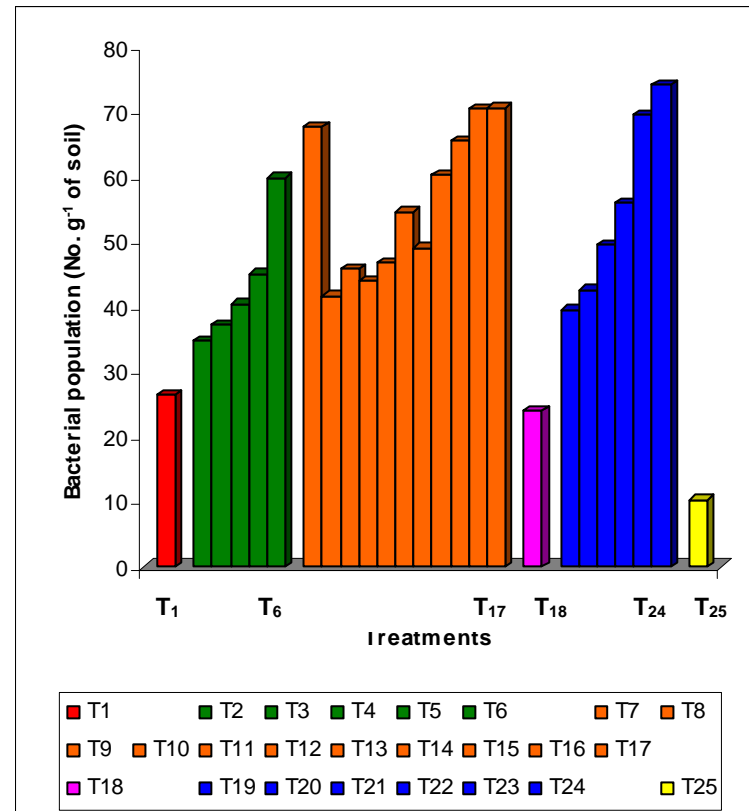
**Fig. XXI:** Depicting comparison among treatments with respect to available magnesium in the soil after the harvest of rabi 2005-2006 residual crop pea

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

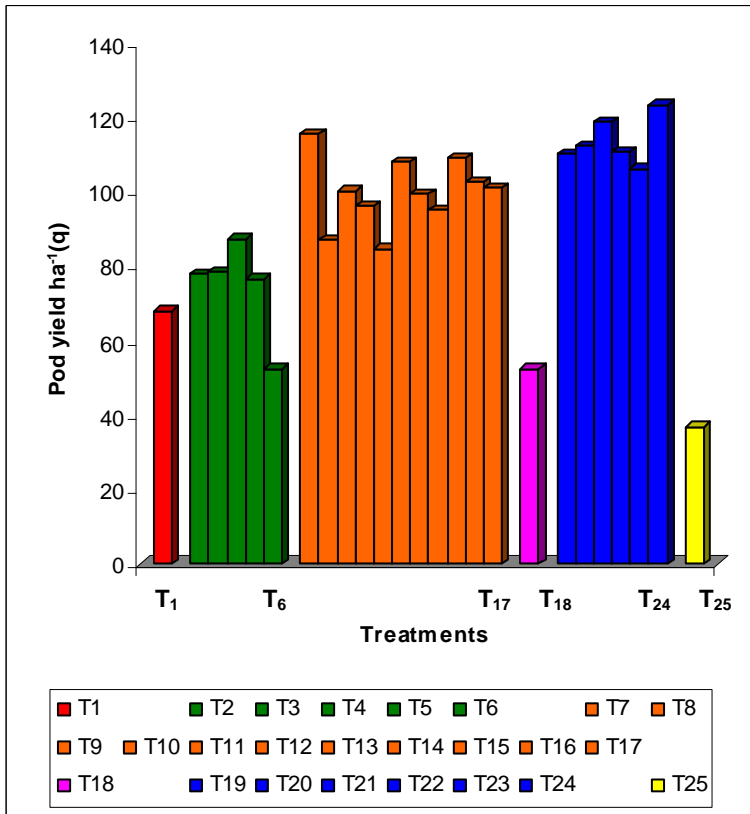


**Fig. XXII:** Depicting comparison among treatments with respect to fungal population in the soil after the harvest of rabi 2005-2006 residual crop pea

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

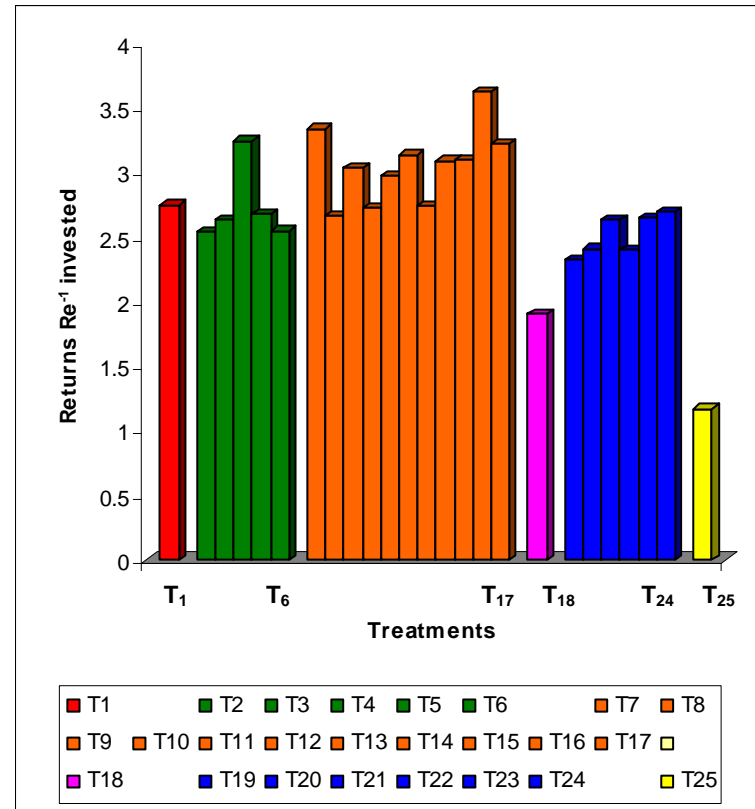


**Fig. XXIII:** Depicting comparison among treatments with respect to bacterial population in the soil after the harvest of rabi 2005-2006 residual crop pea

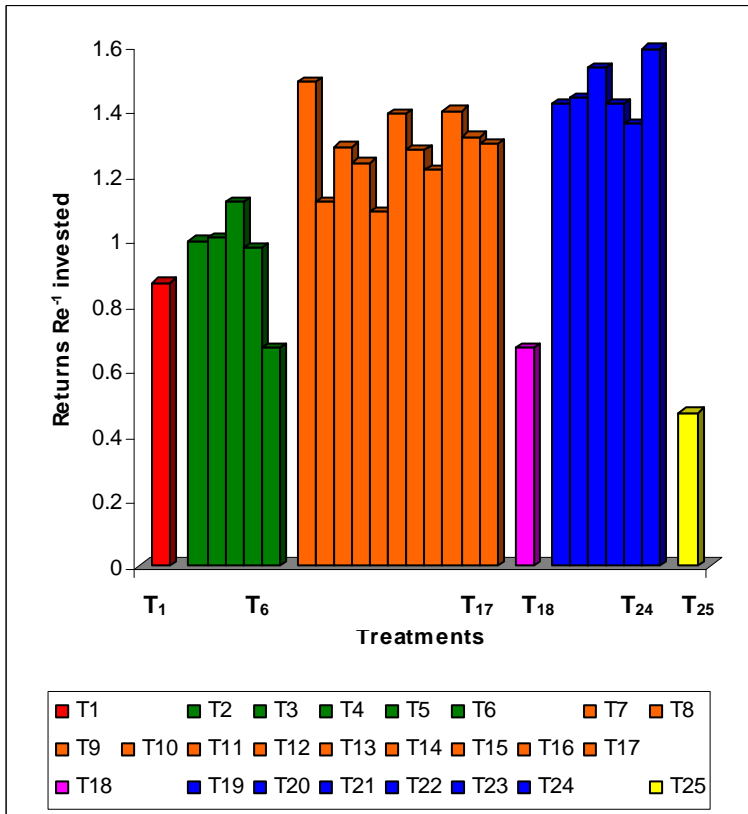


**Fig. XXIV:** Depicting comparison among treatments with respect to pod yield ha<sup>-1</sup> in residual crop pea (pooled over seasons)

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.

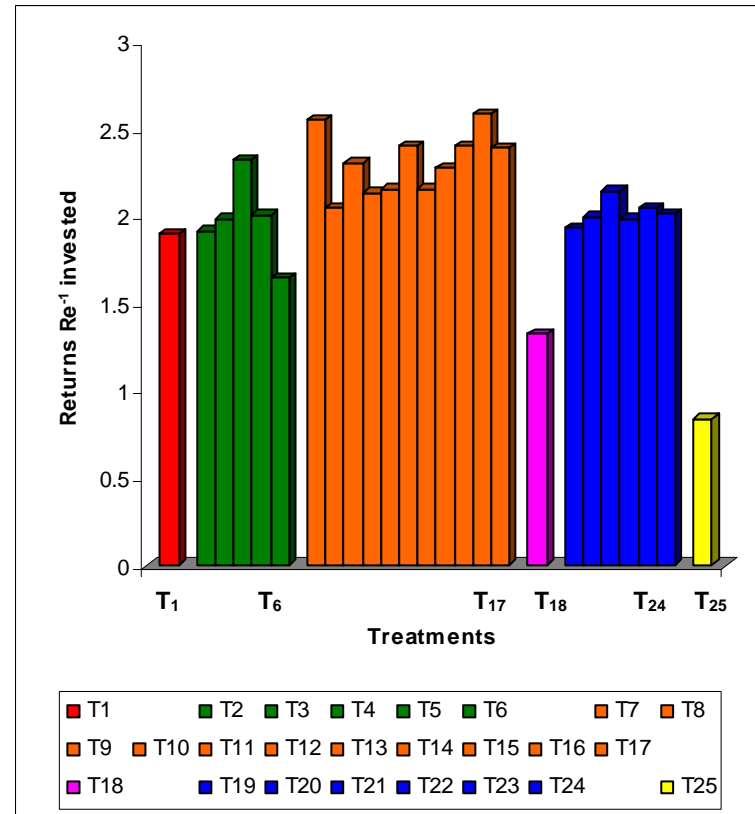


**Fig. XXV:** Depicting comparison among treatments with respect to returns Re<sup>-1</sup> invested in okra



**Fig. XXVI:** Depicting comparison among treatments with respect to returns  $Re^{-1}$  invested in residual crop pea

T<sub>1</sub>: RFD, T<sub>2</sub> – T<sub>6</sub>: Organics, T<sub>7</sub> – T<sub>17</sub>: Integration of organics, T<sub>18</sub>: 50% RFD, T<sub>19</sub> – T<sub>24</sub>: Integration of organics and inorganics and T<sub>25</sub>: Control.



**Fig. XXVII:** Depicting comparison among treatments with respect to returns  $Re^{-1}$  invested in okra-pea rotation

## Meteorological data during the period of experimentation

Kharif 2004								
Month	Temperature ( $^{\circ}$ C)			Relative humidity (%)			Total precipitation (mm)	Total sunshine (hrs)
	Max.	Min.	Mean	Max.	Min.	Mean		
May 2004	26.21	11.19	18.70	72.50	47.50	<b>60.00</b>	23.40	93.30
June	27.72	13.88	20.80	79.70	52.46	<b>66.08</b>	29.60	216.40
July	27.40	16.60	22.00	79.90	56.29	<b>68.09</b>	97.40	217.50
August	29.09	16.02	22.55	82.90	58.74	<b>70.82</b>	28.20	236.40
September	28.51	11.12	19.81	79.00	51.70	<b>65.35</b>	2.20	253.90
October	19.80	5.84	12.82	90.31	56.35	<b>73.33</b>	7.10	170.10
Total	158.73	74.65	116.68	484.31	323.04	<b>403.67</b>	187.90	1187.60
<b>Mean</b>	<b>26.45</b>	<b>12.44</b>	<b>19.44</b>	<b>80.70</b>	<b>53.84</b>	<b>67.27</b>	<b>31.31</b>	<b>197.93</b>
Rabi 2004-2005								
November	16.81	0.81	8.81	88.46	52.86	<b>70.66</b>	28.10	175.20
December	2.26	-.87	4.19	88.93	72.48	<b>80.70</b>	72.50	84.90
January 2005	6.31	-.47	2.92	91.93	68.09	<b>80.06</b>	99.50	68.00
February	5.28	-.41	2.43	92.10	76.78	<b>84.44</b>	275.50	19.00
March	13.54	4.19	8.86	83.32	65.48	<b>74.40</b>	61.00	103.30
April	19.95	5.63	12.56	71.23	46.83	<b>59.03</b>	39.40	186.50
May	20.78	8.47	14.62	80.19	61.35	<b>70.77</b>	92.90	168.20
Total	91.93	17.35	54.39	596.16	443.87	<b>520.06</b>	668.90	805.10
<b>Mean</b>	<b>13.13</b>	<b>2.47</b>	<b>7.77</b>	<b>85.16</b>	<b>63.41</b>	<b>74.29</b>	<b>95.55</b>	<b>115.01</b>

<b>Kharif 2005</b>								
June	28.99	12.49	20.74	67.41	46.45	<b>56.93</b>	12.50	278.40
July	28.61	16.60	22.60	81.32	64.09	<b>72.70</b>	140.70	201.00
August	30.40	15.53	22.96	78.67	54.93	<b>66.80</b>	40.60	278.80
September	29.16	12.78	20.97	83.03	54.63	<b>68.83</b>	22.60	251.50
October	22.91	5.08	13.99	88.41	54.32	<b>71.36</b>	19.60	225.80
Total	140.07	62.48	101.26	398.84	274.42	<b>336.62</b>	235.80	1235.50
<b>Mean</b>	<b>28.01</b>	<b>12.49</b>	<b>20.25</b>	<b>79.76</b>	<b>54.88</b>	<b>67.32</b>	<b>47.16</b>	<b>247.10</b>
<b>Rabi 2005-2006</b>								
November	15.43	0.73	8.08	87.13	50.86	<b>68.99</b>	11.20	159.20
December	9.79	-3.19	3.30	89.67	74.03	<b>81.85</b>	0.00	114.90
January 2006	4.07	-1.82	1.12	92.19	84.06	<b>88.12</b>	159.10	34.90
February	12.25	2.55	7.40	90.71	72.75	<b>81.73</b>	53.20	91.10
March	16.92	3.57	10.24	84.51	61.96	<b>73.23</b>	66.20	136.90
April	2.94	5.69	13.31	71.30	45.16	<b>58.23</b>	55.50	220.60
May	28.27	11.45	19.86	74.22	53.06	<b>63.64</b>	38.60	283.60
Total	17.67	18.98	63.31	589.73	441.88	<b>515.79</b>	383.810	1041.20
<b>Mean</b>	<b>15.38</b>	<b>2.71</b>	<b>9.04</b>	<b>84.24</b>	<b>63.12</b>	<b>73.68</b>	<b>54.82</b>	<b>148.74</b>

**Source:** Agro-Meteorological observatory, Division of Agronomy, SKUAST-K, Shalimar Campus, Srinagar

## Appendix II

### Nutrient composition of organics and inorganic fertilizers used

Source	Nutrient composition (%)		
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
<b><u>Organic</u></b>			
Farm yard manure (FYM)	0.40	0.20	0.20
Sheep manure (SM)	0.60	0.30	0.03
Poultry manure (PM)	2.00	1.20	1.20
Vermi compost (VC)	2.00	1.00	1.00
<b><u>Biofertilizers</u></b>			
<i>Azospirillum</i>	Assumed to substitute 50% N		
<i>Phosphobacteria</i>	Assumed to substitute 50% P <sub>2</sub> O <sub>5</sub>		
<b><u>Inorganics</u></b>			
Urea	46.00	-	-
Super phosphate single	-	16.00	-
Muriate of potash	-	-	60.00

**Appendix III****Purchase rates of organics and inorganic fertilizer**

<b>Source</b>	<b>Rate Rs. t<sup>-1</sup></b>
Farm yard manure (FYM)	500.00
Sheep manure (SM)	800.00
Poultry manure (PM)	1,500.00
Vermi compost (VC)	3,000.00
Biofertilizer	40,000.00
Urea	5,445.00
Super phosphate single	7,000.00
Muriate of potash	5,355.00

**Appendix IV**

**Whole sale rates of okra and pea**

<u>Okra</u>	
Organic	Rs.700.00 q <sup>-1</sup>
Inorganic	Rs. 500.00 q <sup>-1</sup>
Pea	Rs. 500.00 q <sup>-1</sup>