SOURCE EFFICIENCY RELATIONS OF DIFFERENT ORGANIC MANURES ON QUALITY, PRODUCTIVITY AND SHELF LIFE OF OKRA [*Abelmoschus esculentus* (L.) Moench.]

By

P. K. SMITHA NANDINI

THESIS

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DECLARATION

I hereby declare that the thesis entitled '**Source efficiency relations of different organic manures on quality, productivity and shelf life of okra [*Abelmoschus esculentus* (L.) Moench.]**' is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
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P.K. SMITHA NANDINI

CERTIFICATE

Certified that the thesis entitled '**Source efficiency relations of different organic manures on quality, productivity and shelf life of okra [*Abelmoschus esculentus* (L.) Moench.]**' is a record of research work done independently by **Ms.P.K.Smitha Nandini**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Smt.Prasanna, K.P.
Chairperson
Advisory Committee
Department of Olericulture
College of Horticulture

Vellanikkara ,
5-12-1998

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Ms.P.K.Smitha Nandini**, a candidate for the degree of **Master of Science in Horticulture**, agree that the thesis entitled '**Source efficiency relations of different organic manures on quality, productivity and shelf life of okra [*Abelmoschus esculentus* (L.) Moench.]**' may be submitted by Ms.P.K.Smitha Nandini in partial fulfilment of the requirement for the degree.

Chairperson

Smt.Prasanna, K.P.
Assistant Professor
Department of Olericulture
College of Horticulture

Members

Dr.S.Rajan
Professor and Head i/c
Department of Olericulture
College of Horticulture
Vellanikkara

Dr.T.R.Gopalakrishnan
Associate Professor
KHDP, Vellanikkara

Dr.N.N.Potty Neelakandan Potty
Professor
Department of Agronomy
College of Horticulture
Vellanikkara

EXTERNAL EXAMINER

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Introduction

INTRODUCTION

Okra is one of the most important fruit vegetables, with productivity of 15 MT in Kerala. It is grown throughout the tropics and warmer parts of temperate zone. Okra is specially valued for its tender and delicious fruits. The average nutritive value of the fruit is 3.21 which is higher than tomato, eggplant and most of the cucurbits (Grubben, 1977). This is a rich source of calcium also.

Okra is commercially grown in different states like Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka, Haryana and Punjab. The crop is valued for its tender fruits. However to a limited extent it finds its use in canned, dehydrated or frozen forms. Dry seeds of okra contain 18-20 per cent oil and 20-23 per cent crude protein. Okra has a vast potential as one of the foreign exchange earner crops and accounts for about 60 per cent of the export of fresh vegetables excluding potato, onion, garlic etc.

The crop being a major earner of foreign currency the emphasis should be given for higher productivity of the crop. This calls for improved varieties and improved production technology. production technology involves the careful use of fertilizers and manures and by the use of appropriate plant protection measures.

Improved varieties resistant to major pests and diseases have to be produced for high yield. Most serious disease affecting the productivity of okra is yellow vein mosaic which is reported to cause losses between 50 to 90 per cent. Several varieties resistant to YVM have been developed by different research stations. Some of the important varieties are Arka Anamika, Arka Abhay, Parbhani Kranthi etc.

Now-a-days a major transition is taking place in the world agricultural scenario that is encouraging organic farming. Since the introduction of organic fertilizers, the cultivators are aware of the adverse effects of the continuous use of heavy doses of chemical fertilizers on physical and chemical properties of soil. Taking into consideration the decreasing soil fertility, the increasing vulnerability of crops to pests and diseases, and fertilizer use reaching the point of near no response, the idea of organic farming came into existence. Under organic farming, mainly organic manures that are locally available are being used to maintain soil fertility. Pests and diseases could be controlled by biological means and through use of botanical pesticides. Production of vegetables in organic way inculcate a great deal of interest in both producers and consumers, as they are devoid of poisonous chemicals. Hence the present study was undertaken in the Department of Olericulture, College of Horticulture, Vellanikkara with the following objectives.

1. To find out the effect of various forms of organic manures and their levels on productivity, quality and shelf life of okra.
2. To find out the effect of various organic manures and their levels on quality of seeds.
3. To calculate economics of organic manuring in okra.

Review of Literature

REVIEW OF LITERATURE

Okra is one of the most important vegetables grown in India. Organic cultivation is one of the important topics of discussion during present time. The present study was conducted to investigate the effect of different sources of nutrients on yield, quality and shelf life of okra. The available literature on the effects of organic manures on vegetables are reviewed below.

2.1 Growth components

Sumiati(1988) reported that brocoli seedlings grown in jiffy pot with 1:1 mixture of stable manure + soil supplemented with NPK + metal K have highest plant height, root length, leaf area index, net assimilation rate and relative growth rate.

Jablonska-Ceglarck (1990) found that plants grown in soil enriched with rye straw performed equally or better than plants grown in soil supplied with FYM.

Sorin and Tanaka (1991) observed that in pot trials with spinach seedlings, growth was increased by the application of dried cattle manure, sawdust or bark composted with chicken manure at 15 g per pot containing 500 g soil, but was decreased by application of 5 g rice or barley straw.

Browald (1992) found that phosphorus as bone ash and chicken manure or compost increased shoot dry weight in common bean. Trace element uptake was generally increased more by manure and compost than by superphosphate. P utilization efficiency was decreased by higher rates of manure and compost and increased by higher rates of superphosphate.

Lu and Edward (1994) reported that poultry litter at 26 g per kg of soil damaged or killed collard plants with in 7 days after transplanting.

Gagnon and Berrouald (1994) found that organic fertilizers produced best growth and significantly increased dry weight by 57-83 per cent compared to nonfertilised control.

2.2 Earliness and fruit characters

Ivanic (1957) observed that nitrogen delayed flowering and prolonged growing season in chillies. Gill *et al.* (1974) found that nitrogen dose alone increased the mean number of days required for first flowering from 47.17 to 51.70 days. Kunju (1970) reported that there was no significant difference in number of days required for the first flower opening, due to any of the treatments, in a trial with three levels of nitrogen, phosphorus and potassium. Khan and Suryanarayana (1977) noted that nitrogen application made little difference in reducing the flowering time in chillies.

Prezotti *et al.* (1989) found that the application of poultry manure appreciably increased the yield and augmented fruit size in tomato.

Silva and Vizzotto (1989) noted that longest fruits and the highest yields were obtained for tomato by applying $N:P_2O_5:K_2O$ at 104:259:104 kg ha^{-1} + poultry manure at 20 t ha^{-1}.

Singogo *et al.* (1991) reported that the addition of cattle manure increased total weight of melons ha^{-1} in comparison with complete fertilizer at 0, 70, 100 and 135 kg N ha^{-1}.

2.3 Yield

Schewemmer (1975) reported that application of organic fertilizers super manurial 3 plus and humobil resulted in highest humus contents in the soil at the end of 3 year trial period and increased yields by about 6.5 per cent over those obtained with mineral fertilization in celery and red cabbage.

Luzzati *et al.* (1975) observed that organic fertilization increased total root mineral content and leaf calcium in vegetable crops.

Preitas *et al.* (1981) observed that applications of NPK fertilizers and farm yard manure increased the soil organic matter, nutrient levels and tomato production.

Linardakis and Tsikalas (1984) noted that when farmyard manure was applied to tomato at the rate of 10 m^3 per 100 m^2, plants receiving farmyard manure gave highest yield in all the years.

Khaflewsk (1984) reported that the application of liquid manure (drained from cowdung) at 50-100 m^3 ha^{-1} or farmyard manure at 20-60 t ha^{-1} increased the marketable yields in cucumber by 13.8 per cent and 16.9 per cent respectively.

Asiegbu and Uzo (1984) observed that number of fruits per plant decreased as planting density rose and increased with farmyard manure application in aubergine. In the case of onion, the percentage of grade one bulbs increased with farmyard manure application.

Anez and Tavira (1984) found that when nitrogen (0, 100 and 200 kg ha^{-1}) or poultry manure (0, 20 or 40 m^3 ha^{-1}) was applied to lettuces (cv. Great lakes) the yields increased from 0.65 to 0.89 and 0.90 kg per plant with N at 0, 100 and 200 kg ha^{-1} respectively and from 0.66 to 0.88 and 0.90 kg per plant with poultry manure at 0, 20 and 40 m^3 ha^{-1} respectively.

Florescu and Chirala (1985) reported that in greenhouse cucumber production, the best results were obtained with pig compost at 40 t ha^{-1} as basal application and at 20 t ha^{-1} as top dressing.

Omori and Sugimoto (1978) opined that the yield of many of the vegetable crops increased in proportion to the quality of cattle manure and chicken manure applied to the crops.

Subhan (1987a) reported that 20, 30, 40 or 50 t ha^{-1} of rice straw compost, corn stem compost or animal manure had no significant difference in the yield of tomato.

Americana (1987) found that treatment with cornstover combined with fertilizing with cattle manure was found most profitable treatment in tomato crop.

According to Ragimova (1987) FYM at 20 t ha^{-1} with $N:P_2O_5:K_2O$ at 90:90:60 kg ha^{-1} with Mn + Cu + Mo produced the highest yield in cucurbits.

Subhan (1987b) reported that composted maize straw, sheep manure and composted rice straw at 25, 15 and 30 t ha^{-1} respectively gave the highest head weight per plant and yield ha^{-1} in cabbage.

Guadi *et al.* (1988) found that application of stable manure at the rate of 10 t ha^{-1} increased fresh yield of garlic from 12.2 kg per 4.5 m^2 in the control of 15.2 kg per 4.5 m^2.

Abusaleha and Shanmugavelu (1988) reported that application of 20 kg N ha^{-1} as ammonium sulphate and 20 kg N ha^{-1} as poultry manure gave the best results and higher yield of 18.019 t ha^{-1} in bhindi variety Pusa Sawani.

Jose *et al.* (1988) studied the efficacy of organic vs. inorganic form of N in brinjal. They found that highest yield of 51 t ha^{-1} was obtained from plants receiving 50 kg N ha^{-1} either as poultry manure or as urea.

Subhan (1988) reported that organic manures like maize stover or composted rice straw increased plant diameter at 60 days after planting. Application of 25 or 30 t ha^{-1} of cattle manure gave the largest cabbages and highest yield per plot.

Segovia (1988) observed that in the case of melons in tunnels yields were highest in plants treated with cattle manure at 80 t ha^{-1} and poultury manure at 10 t ha^{-1}.

Zhang *et al.* (1988) studied the effects of combined use of inorganic and organic fertilizer on the yield and quality of tomato and they found that soyabean meal supplied with inorganic nutrients increased the growth and yield.

Hilman and Suwandi (1989) reported that the highest yield of 2.16 kg per plant was obtained with sheep manure at 30 t ha^{-1} in tomato. According to Subhan (1989) in cabbage highest gross yields of 101.7 and 101.4 t ha^{-1} were obtained with maize compost at 30 t ha^{-1} and rice compost at 20 t ha^{-1} respectively. Prezotti *et al.* (1989) observed that the application of poultry manure increased the yield and fruit size of tomato cultivar kada.

Silva and Vizzotto (1989) reported that the highest yield of 53 t ha^{-1} of good quality tomato fruits was obtained with 103.5 kg N + 258.8 kg P_2O_5 + 103.5 kg K_2O + 20 t poultry manure per ha, but without poultry manure the yield declined to 46.2 t ha^{-1}. Bohme *et al.* (1989) found that long term use of organic substrates in vegetable growing in greenhouse increased the yield over the years.

Lu and Bai (1989) reported that processed chicken manure application increased the yield of cauliflower and rape by 21.8 per cent and 153.4 per cent respectively compared with control.

Galbiati and Castellane (1990) found that yield obtained from onion cultivar Piralopes were 23.8, 21.8 and 17.7 t ha^{-1} with mineral, organic and no fertilization respectively.

Bohec (1990) noted that maximum yield was obtained in celery, lettuce and leek when grown on land with annual application of FYM, composted urban waste or composted sewage sludge when compared to control without added organic matter.

Nicoulaud *et al.* (1990) studied the yield and nutrient uptake by lettuce as affected by lime, mineral and organic fertilization and they found that poultry manure increased both dry matter yield and nutrient uptake. Yields were highest with poultry manure application at 36 or 24 t ha^{-1}.

Rao in 1991 reported that sawdust and swine compost could increase the yield of vegetables from 2 t ha^{-1} to 2.38 t ha^{-1} in acidic soil. Huang and Zhao (1991) found that earth worm cast applied at 1.3 t ha^{-1} increased cucumber and tomato yields by 42 and 61 per cent respectively. Lucerne (*Medicago sativa*) plus manure gave the highest fruit yield for muskmelon and this was similar to the yield from the highest rate of synthetic fertilizer (Singogo *et al.*, 1991). According to Caicio *et al.* (1991) greatest increase in plant growth and fruit yields were obtained in California Wonder Sweet pepper by the incorporation of sorghum alone or in combination with *Dolichos lablab*. Florescu *et al.* (1991) found that composted urban waste at 30 t ha^{-1} gave the highest yield for cucumbers compared to 50 t ha^{-1} and FYM at 50 t ha^{-1}.

Ranganna *et al.* (1991) reported that biogas spent sludge application resulted in higher mean yields than FYM application for chilli, French bean etc.

Gardini *et al.* (1992) studied the effect of poultry manure and mineral fertilizers on the yield of crops and found that highest yield of tomatoes and spinach were obtained with poultry manure + mineral fertilizers at the highest nutrient content.

Kropiz (1992) found that highest average yields in cabbages, onions and carrots were obtained from plots receiving FYM + NPK, compared to inorganic fertilizers alone. According to Panditha and Bhah (1992) 1:1:1 ratio of sand, soil and FYM gave the highest yield of marketable spears per hectare (22.4 q ha^{-1}) in asparagus compared with 14.38 q ha^{-1} for unamended plots.

Hernandez *et al.* (1992) found that yield of lettuce obtained with fresh sewage sludge and composted wastes were significantly greater than control.

The yield of tomato was greatest with FYM @ 19.01 t ha^{-1} followed by coir pith, compared to control plot without these two manures (Ahmed, 1993). Warman (1993) reported that the yield of tomato increased with the increasing levels of liquid pig manure, poultry manure or cattle manure in glass house. Sharaifa and Hattar in 1993 observed that the highest yield for the two cropping systems (sole crop and intercrop) were obtained in response to the highest poultry manure addition. Crops evaluated were maize, soybean and watermelon. Rubeiz *et al.* (1993) reported that yields did not differ significantly between layer and broiler poultry manure application as N fertilizer for cabbage.

Hochmuth *et al.* (1993) found that yield obtained with highest rate of poultry manure (high, medium, low based on estimated available N) and 1.0 and 1.4 t ha^{-1} of conventional NPK fertilizer were the same as those with the highest rate of manure.

Brown *et al.* (1993) noted that an increase in the application rate of broiler litter generally resulted in a linear increase in yield of commercial snap bean.

Hsichingfang and Kuonan (1994) found that the yields of sweet pepper were significantly higher with the organic manures than with chemical fertilizer.

According to Faria *et al.* (1994) yields of all vegetable crops increased with the rate of chicken manure compost and spent mushroom compost compared to plots receiving mineral fertilizer.

Maynard (1994a) found that yield of capsicums, tomatoes and cauliflowers were equal or greater for the plots applied with chicken manure compost than control (plots receiving NPK fertilizers). Spent mushroom compost produced the yields equal to those of control in aubergins, tomatoes and spring cauliflowers.

According to Maynard (1994b) yields of all vegetables increased with increasing rates of compost application (chicken manure compost and spent mushroom compost). Yields were higher in plots amended with chicken manure compost than spent mushroom compost.

Brown *et al.* (1995) reported that in tomato markettable yield of 65 t ha^{-1} was obtained with broiler litter while the commercial fertilizer applied plots recorded only 52 t ha^{-1}. Maynard (1995) found that application of 25 t $acre^{-1}$ municipal solid waste increased the average yield of fruits in tomato compared to unamended plot. The average number of tomatoes per plant and average weight of each tomato were greater from the compost amended plot.

According to Kamiyama *et al.* (1995) the yield in cabbages and sweet corn were highest when chemical fertilizers were applied with farmyard manure.

Singh and Singh (1995) reported that highest bulb yield of onion was obtained from plants fertilized with farmyard manure + 40 kg N + 60 kg P ha^{-1}

Sellen *et al.* (1995) found that organic yields were significantly lower than those from conventional production system for cabbage, tomatoes and spanish onion.

2.4 Fruit quality

Olivera *et al.* (1985) reported that termite nest alone at 50-100 g per plant or in association with chicken manure at 530 g per plant increased the weight of lettuce plants and improved crop quality.

Silva (1986) found that farmyard manure increased the head weight of cabbage cv. Gloria. Doikova *et al.* (1986) studied the effect of fertilization on the productivity, total nitrogen and nitrate content of capsicums and they found that highest total nitrogen and nitrate content was in the green fruits especially when FYM was used as a source of nitrogen.

Perchova and Prugar (1986) reported that in a 3 year trial with lettuce cv. May King, farmyard manure at 0 or 60 t ha^{-1} and inorganic N at 0, 80 or 160 kg ha^{-1} were applied in various combinations. FYM positively affected nitrification process in the soil and nitrate accumulation in the crop. These effects were influenced by FYM quality and the growing conditions in different cropping year.

Termine *et al.* (1987) found that in turnips and leeks drymatter content, ascorbic acid and mineral content were not affected by the application of different organic manure like blood meal, sheep manure compost and wood chip compost.

Neyroud (1987) observed that fallowing and incorporation of green manures enhanced nitrogen and plant nitrate content in lettuce.

Prezotti *et al.* (1987) found that application of poultry manure increased total productivity by 48 per cent and improved the proportion of large fruits in the total yield of tomato cv. Principe Gigantere. According to Subhan (1988) application of organic manures like cattle manure, composted maize stover and composted rice straw gave the largest cabbages and the highest yield. Meirproeger (1989) observed that compost from biogenic waste gave superior results for qualities like organoleptic quality, storage quality, contents of desirable nutrients like vitamin C and sugars and undesirable constituents in crops like tomato, beetroots and cabbages. Singh *et al.* (1989) reported that a combination of 120 kg N and 50 kg K_2O gave the tallest plants, highest bulb yield and highest per cent of TSS in the crop onion. In a second experiment green manuring greatly enhanced plant growth, bulb yield and percentage of TSS.

According to Lindner (1989) organically grown lettuce had a nitrate content of 14.2 per cent compared to 74.6 per cent. Montagu and Goh (1990) reported that colour of tomato fruits increased significantly on application of blood and bone compost.

Ogabdu and Easmon (1989) reported that when calcium ammonium nitrate at 0.3 kg per bed, 15:15:15 NPK compound fertilizers at 0.3 kg ha^{-1}, poultry manure at 2 kg per bed were applied to separate plots of eggplant cultivars, there was a significant reduction of moisture content and significant increase of crude fibre, titratable acidity and total protein content for all the three treatments. Tomati *et al.* (1990) reported that earthworm cast as growing medium increased protein synthesis in 3 day old lettuce and radish seedlings.

Florescu (1991) reported that cucumber fruits grown with urban waste compost had higher contents of vitamin C, carbohydrate, K and Mg, less drymatter and less acidity than fruits grown with FYM.

Pimpini *et al.* (1992) found that application of mineral fertilizers or poultry manure at a lower rate gave the best scores of processing suitability of potatoes. In processing tomatoes, the best scores of suitability for paste transformation were obtained with mineral fertilizers (33.3 per cent poultry manure and 66.7 per cent mineral fertilizer) at the higher rate and the plots receiving only mineral fertilizers produced fruits with too less favourable values of pH and electrical conductivity.

Annanurova *et al.* (1992) observed that in tomato addition of FYM to the basic NPK fertilizer increased the number and mean weight of fruits.

According to Vogtmann *et al.* (1993) composts prepared from kitchen and yard wastes positively affected food quality, improved storage performances and yielded superior sensory quality of tomatoes. Composts significantly reduced nitrates and improved the nitrate to vitamin C ratio of vegetables. In the treatment which received compost, yields were lower during the first two years but increased significantly after the third application.

Lacatur and Botez (1993) observed that high quality processing tomatoes were obtained with NPK at the rates of 300, 150 and 75 kg ha^{-1} plus 20 t FYM ha^{-1}.

Gentop (1994) found that samples of lettuces grown organically contained 948 ppm NO_3 which was 10 per cent less than the lettuces grown with conventional N fertilizers.

Auclair *et al.* (1995) reported that organically grown tomato fruits had higher Ca, Cu, Fe, P and Zn contents. Fruit vitamin C content was higher for hydroponically grown tomatoes.

2.5 Soil

Kinoshita *et al.* (1984) reported that application of sewage sludge raised soil pH and increased total N content, exchangeable Ca, Mg and P_2O_5 in the soil. Application of wool waste increased only the soil N content. Kaddous and Morga (1986) found that hydraulic conductivity, water retention, NPK and organic carbon increased with increasing rates of spend mushroom compost and farmyad manure. Farmyard manure significantly increased the levels of Zn and Mn in the plant tissues.

Kinoshita *et al.* (1986) found that soil N, P, K, Mg and Ca increased with the amount and number of applications of pig manure mixed with saw dust.

Chagas *et al.* (1987) found that green manuring did not affect soil pH, organic matter percentage, Ca, Mg, P and K contents during the growth of *Phaseolus valgaris*.

Vityakom and Seripong (1988) reported that cattle manure significantly increased the uptake of P and K but not Ca.

Deiz (1989) observed that nitrogen uptake by wheat was much greater in the manure, compost or peat treatments than in the inorganic control.

Yamada and Kamata (1989) found that application of cattle manure increased CEC, available P, Ca and K saturation, total carbon and N, available N, biomass carbon, porosity and decreased soil density and solid phase ratio.

According to Bohme *et al.* (1989) long term use of organic manures increased yield over the year and N, P and K requirement per kg of fruit tended to decrease with increasing yield.

Warman (1990) reported that pig manure increased Zn uptake and chicken and diary manures increased soil pH; thus reducing the availability of Mn, while pig manure had the opposite effect.

Choe *et al.* (1991) found that rice straw application improved bulk density and porosity of soil compared to compost and chemical fertilizers.

Nair and Peter (1991) observed that maximum colonization of VAM occurred in plots receiving FYM alone. Ahmed (1993) reported that composted coconut coirdust 15-20 t ha^{-1} improved the soil conditions, including soil strength and moisture retention capacity compared to the application of FYM at 10 t ha^{-1}.

Rubeiz *et al.* (1993) reported that physical properties of soil like bulk density, electrical conductivity, nitrate and P contents were not affected by layer and broiler poultry manure as a source of N fertilizer for cabbage production.

Kamiyama *et al.* (1995) reported that soil pH, CaO and MgO contents increased when fertilized with chemical fertilizers alone and in combination with FYM. Igbokwe *et al.* (1996) reported that soil extractable nutrient contents were generally high in organic farming system when marion tomatoes were grown in different farming systems.

2.6 Pest and diseases

Kinoshita *et al.* (1984) studied the effect of various amendments in suppressing clubroot (*Plasmodiophora brassicae*) in field grown Chinees cabbage. Amendments were composted bark, cattle manure, poultry manure, sewage sludge and composted wool waste. Disease severity was reduced by annual application of either sewage sludge at 5 t $10a^{-1}$ or in particular composted wool waste at 0.5 t $10a^{-1}$. Chindo and Khan (1986) found that nematode (*Meloidogyme incognita*) damage lessened with increasing levels of poultry manure in tomato. According to them the optimum rate of manure for nematode control and crop growth was found as 4 t ha^{-1}. Seo (1986) reported the effect of organic matter on the occurrence of fusarium wilt in cucumber. The disease was suppressed 30-35 per cent by the application of organic matter. Silva (1986) noted that application of ammonium sulphate and FYM increased the incidence of black rot in cabbage.

Tu and Chong (1987) studied the effect of solar energy and green manures on the control of southern blight of tomato. They found that no sclerotia of *Corticium rolfsii* could survive in the soil of plastic covered plot and no diseased tomato plants were found. Here the addition of green manure gave increased control compared with plastic covering alone. Prezotti *et al.* (1987) found that the best reduction of the incidence of blossom end rot was obtained with poultry manure + lime stone in tomato cv. Principe Gigantire.

According to Mutitu *et al.* (1988) FYM was fairly effective in controlling fusarium yellow caused by *F. oxysporum* f.sp. *phaseoli* on bean.

Duhaylongsod (1988) studied the effect of various organic amendments on the population of root knot and reniform nematodes in three week old tomato cv. VC-11-1. He found that fresh chicken manure, cow dung and composted saw dust caused the most initial and final reductions of *Rotylenchus reniformis*. Rice straw and saw dust reduced population of *Meloidogyne incognita*.

Fayad and Sweelam (1989) reported that the application of triple phosphate together with cattle manure reduced the nematode population in tomato crop. Stephan *et al.* (1989) studied the effect of organic amendments, nematicide and solar heating on root knot nematodes in egg plant and they found that fenamiphos and soil solarization significantly reduced the nematode population and increased yields, peatmoss was least effective.

Corrales *et al.* (1990) found that chicken manure and compost (sugarcane baggase, saw dust, ashes at 2:1:1) reduced the incidence of root rot in sweet pepper.

Gul *et al.* (1990) observed that in tomato, linseed oil cake, sesame oil cake, cotton oil cake, castor oil cake and mustard oil cake depressed the nematode population. Alam (1991) noted that saw dust of mango and ammonium sulphate significantly reduced the populations of plant parasitic nematodes on carrot, radish, table beet, turnip etc.

Hochmuth *et al.* (1993) reported that internal tip bürn of cabbage increased with the rate of manuring in 1990 but not in 1991 with poultry manure application. Green manuring with neem reduced the incidence of *Meloidogyne incognita* and it also reduced fungal disease *Rhizoctonia bataticola* and *R. solani* in tomato crop (Walia *et al.*, 1994).

Khan (1994) reported that inorganic amendments like groundnut cake, cotton seed, soyabean cake, poultry manure, sheep manure, cowdung, raw sewage sludge and cassava peelings brought about significant decrease in nematode *Pratylunchus brachyarus* in okra crop.

Stephan (1995) observed that in tomato horse manure significantly increased the yield and reduced the infection of *Meloidogyne incognita*.

Materials and Methods

MATERIALS AND METHODS

The present study was undertaken to find the out source efficiency relations of organic manures on the productivity and quality of okra (*Abelmoschus esculentus* (L.) Moench.

3.1 Experimental site

The experimental site is at the Vegetable Research farm, Department of Olericulture, College of Horticulture, Vellanikkara, Thrissur. This research farm is located at an altitude of 23 m above mean sea level and is situated at 10°32' N latitude and 76°16' E longitude. This region enjoys a typical warm humid tropical climate.

3.2 Season and weather conditions

Experiments were conducted during two seasons, September to December 1995 and May to August 1996. The meteorological data during the period of experimentation is furnished in Appendix I.

3.3 Crop variety

The okra variety Arka Anamika was used for this experiment. The seeds of this a high yielding yellow vein mosaic resistant variety was obtained from vegetable seed production complex, Department of Olericulture, College of Horticulture, Vellanikkara.

3.4 Manures and fertilizers

Farmyard manure, sunnhemp, groundnut cake, poultry manure and vermicompost were used as organic source of Nitrogen. Urea, Factomphos and

Muriate of Potash were used as inorganic source of nutrients. Percentage of nitrogen content in these organic manures are given in Appendix 2.

3.5 Experimental method

Experimental design adopted was Randomised Block Design with two replications. There were five rows with 10 plants each in such a way that each plot accomodated 50 plants. The layout of the experiment is given in Fig.1.

3.6 Treatments

The experiment consisted of 16 treatments

T_1 - Package of Practices Recommendation of KAU 1993 i.e. Fym @ 12 t ha^{-1} and NPK @ 50:8:25 kg ha^{-1}

T_2 - FYM equivalent to 50 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_3 - Poultry manure equivalent to 50 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_4 - Vermi compost equivalent to 50 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_5 - Groundnut cake equivalent to 50 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_6 - Sunnhemp equivalent to 50 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_7 - FYM equivalent to 75 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_8 - Poultry manure equivalent to 75 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_9 - Vermi compost equivalent to 75 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_{10} - Groundnut cake equivalent to 75 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_{11} - Sunnhemp equivalent to 75 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_{12} - FYM equivalent to 100 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_{13} - Poultry manure equivalent to 100 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_{14} - Vermi compost equivalent to 100 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_{15} - Groundnut cake equivalent to 100 kg N ha^{-1} + FYM @ 12 t ha^{-1}

T_{16} - Sunnhemp equivalent to 100 kg N ha^{-1} + FYM @ 12 t ha^{-1}

↑N

R_1

T_6	T_9	T_7	T_{11}	T_{13}	T_2	T_4	T_{16}
T_5	T_{10}	T_8	T_{12}	T_1	T_{14}	T_3	T_{15}

R_2

T_{10}	T_6	T_{15}	T_{14}	T_3	T_4	T_7	T_{11}
T_6	T_{13}	T_{12}	T_5	T_2	T_8	T_1	T_9

Fig.1. LAYOUT PLAN OF THE EXPERIMENTAL SITE

Size of plots:

Gross plot size	: 13.5 m^2
Net plot size	: 6.48 m^2
Spacing	: 60 cm x 45 cm
Replications	: 2

3.7 Field culture

The experimental area was ploughed and harrowed to obtain fine tilth. Plots of size 13.5 m^2 was laid out. Ridges and furrows were taken in such a way that furrows were set at 60 cm apart. Seeds were sown at 45 cm spacing in the furrows.

3.8 Manuring

Manures were applied as per the schedule of treatments. The amount of organic manures required to obtain half the dose of nitrogen as per the treatments were applied as basal. In addition to this FYM @ 12 t ha^{-1} was also applied as basal dose. The remaining half of organic manures were applied one month after sowing. In the case of control plot NPK fertilizers at 50:8:25 kg ha^{-1} + 12 t FYM ha^{-1} were applied as per the Package of Practice Recommendations (KAU, 1993). Raking was done after each application and irrigation was also given.

3.9 After cultivation

The crop was hand weeded regularly to keep them free of weeds. Daily irrigation was given for one week and thereafter irrigation was given once in two days. The second crop was irrigated for one week and then it did not require further irrigation due-to the onset of monsoon. During the first crop spraying with neem kernal suspension was done for the control of jassids. Indofil M-45 was sprayed for the control of cercospora leaf spot.

3.10 Harvesting

Fruits were harvested at the tender stage at 2 to 3 days interval.

3.11 Observations recorded

3.11.1 Growth components

3.11.1.1 Plant height at first harvest

Observations were recorded from 10 plants per plot. Plant height was measured at first harvest, from base to the growing tip of the plant, and expressed as cm.

3.11.1.2 Total Dry Matter (TDM)

This was measured as the dry weight produced per plant at each sampling and expressed as g per plant. Samples were taken at 15,30,45,60,75 and 90 DAS.

3.11.1.3 Relative Growth Rate (RGR)

This represents the increase in dry weight in time t_2 over dry weight at time t_1

$$RGR = \frac{\ln w_2 - \ln w_1}{t_2 - t_1} \quad g.\ g^{-1}\ day^{-1}$$

w_2 - Dry weight of plants at time t_2

w_1 - Dry weight of plants at time t_1

ln w_2 and ln w_1 are natural logarithm of w_2 and w_1

3.11.1.4 Net Assimilation Rate (NAR)

Total dry weight of plants at 15, 30, 45, 60, 75, 90 days after sowing were uprooted and dry weight of plants were found out along with fruits. (Same plants were used for Relative Growth Rate calculation). NAR was calculated using the formula given below. The procedure given by Watson (1958) and then modified by Buttery (1970) was followed for NAR calculation.

$$NAR = \frac{w_2 - w_1}{t_2 - t_1 \; \frac{(A_1 - A_2)}{2}} \; g\,m^{-2}\,day^{-1}$$

w_2 - Total dry weight of plants at time t_2

w_1 - Total dry weight of plants uprooted at t_1

A_2 - Leaf area in m^2 at time t_2

A_1 - Leaf area in m^2 at time t_2

3.11.2 Earliness and fruit characters

3.11.2.1 Index to earliness

This was calculated from the formula

$$IE = \frac{a_1 + a_2 + a_3 + \ldots + a_n}{c_1 + c_2 + c_3 + \ldots + c_n}$$

Where

a_i - Yield of treated plants on the i^{th} day

c_i - Yield of control plants on the i^{th} day

3.11.2.2 Days to 50 per cent flowering

Days to 50 per cent flowering was recorded based on visual observation. The day at which 50 per cent of the total plants started flowering was taken as days to 50 per cent flowering.

3.11.2.3 Length of fruit

Five fruits per treatment selected at random were measured and their average length calculated and expressed as cm.

3.11.2.4 Diameter of fruit

Five fruits per treatment were selected at random and their diameter was measured at the middle portion.

3.11.2.5 Weight of fruit

Five fruits per treatment selected at random and were measured for their weight and expressed as g.

3.11.3 Yield attributes

3.11.3.1 Yield per plant

The weight of fruits per plant was found after each harvest and total fruit yield per plant was then calculated and expressed in g.

3.11.3.2 Yield per plot

The weight of fruits per plot was found out after each harvest and finally total yield per plot was then calculated and expressed in g.

3.11.3.3 Number of harvests

Total number of harvest from each treatments were recorded.

3.11.3.4 Crop duration

Time taken for the completion of crop for each treatment was recorded separately and expressed as days.

3.11.4 Quality of produce

3.11.4.1 Mucilage

Twenty five gram fresh fruit sample was taken. 100 ml distilled water was added to the sample and kept for 24 hours. Then it was filtered through a muslin cloth into a flask. 50 ml of alcohol was added to the flask and then it was filtered through a preweighed filter paper. The filtrate along with the filter paper was dried and weighed. The percentage mucilage content was then calculated.

$$\text{Percentage of mucilage} = \frac{\text{Final weight}}{\text{Weight of the sample}} \times 100$$

3.11.4.2 Moisture

Moisture content was estimated gravimetrically by drying the sample in a hot air oven at 80°C. Drying was continued till the sample attained constant weight. Moisture content was expressed in percentage (Ranganna, 1977).

3.11.4.3 Fibre

The samples were first treated with acid and subsequently with alkali. The residue obtained after final filteration was weighed, incinerated, cooled and weighed again. The crude fibre content was given by the loss in weight and expressed as percentage (Sadasivam and Manickam, 1992).

3.11.4.4 Protein

Protein content was obtained by multiplying the content of nitrogen obtained by microkjeldahl method with a value of 6.25. This will give protein content (Sadasivam and Manickam, 1992).

3.11.4.5 Starch

Starch content was estimated by hydrolysing starch into simple sugars and measuring the quantity of simple sugars colorimetrically. The sample was treated with 80 per cent alcohol to remove sugars and then starch was extracted with perchloric acid. The starch was then hydrolysed to glucose and dehydrated to hydroxymethyl furfural. This compound formed a green coloured product with anthrone and it was read at 630 nm. Starch content was expressed in percentage (Sadasivam and Manickam, 1992).

3.11.4.6 Folic acid

Folic acid was extracted from food samples using mild alkaline buffer, oxidised with permanganate, and the resulting amine was diazotized. The diazotized compound was coupled with N-(1-Naphthyl) ethylene diamene and the colour developed was determined at 550 nm (Ranganna, 1977).

3.11.4.7 Vitamin C

Vitamin C content was estimated volumetrically by titration with 2,6-dichlorophenol-indophenol dye (A.O.A.C., 1960). The value was expressed as mg of ascorbic acid per 100 gram of fruits.

3.11.4.8 Pericarp thickness

Five fruits were randomely selected for each treatment and pericarp thickness was found out using screw gauge.

3.11.4.9 Organoleptic test

All the samples were cooked by adding coconut oil and salt. Samples were cooked for a period of 10 minutes. Weight of sample used for cooking was 50 gm. Temperature for cooking was constant. Cooked samples were served to a semitrained tasting panel consisting of ten persons and they were asked to score the product on a nine point 'Hedonic scale' as given below for characters viz. taste, colour and overall acceptability.

Hedonic scale

Numerical designation	Word description
1	Like extremely
2	Like very much
3	Like moderately
4	Like slightly
5	Neither like nor dislike
6	Dislike slightly
7	Dislike moderately
8	Dislike very much
9	Dislike extremely

3.11.5 Percentage of unmarketable fruits after 3 and 5 days of storage:

Ten fruits were selected randomely for each treatment and they were stored in open air in a paper plate. Percentage of unmarketable fruits were recorded on the 3rd and 5th day of storage.

3.11.6 Seed characters

3.11.6.1 Number of seeds per fruit

Number of seeds per fruit was recorded by counting.

3.11.6.2 Weight of seeds per fruit

Weight of seeds per fruit were recorded and expressed in g.

3.11.6.3 Seed yield per plant

Weight of seeds per plant was found after harvesting dry fruits.

3.11.6.4 100 seed weight

Hundred seeds were randomely counted and the weight recorded, which was expressed in g.

3.11.6.5 Germination percentage

Fifty seeds were randomly selected and were sown in sand and irrigated daily. Germination percentage was recorded.

3.11.7 Soil property

Samples for analysing soil properties were taken three times, i.e., before first crop and then after first crop and again after second crop. These samples were represented as S1,S2 and S3 respectively.

3.11.7.1 Organic carbon

Walkley and Black method (Jackson, 1958) was used for the determination of organic carbon content of soil.

3.11.7.2 Total nitrogen

The microkjeldahl method (Jackson, 1958) was adopted for the determination of total N content of the soil.

3.11.7.3 pH

The soil pH was determined in a 1:2.5 soil water suspension using a pH meter.

3.11.8 Leaf, fruit and plant analysis

Leaf, fruit and total plant samples were taken at bearing stage and dried in hot air oven at 70°C $\pm$ 2°C. The dried samples were ground and then analysed for N, P, K, Ca, Mg and S.

Table 1. Details of analysis

Character	Extractant used	Method of estimation	References
N	Sulphuric acid digestion	Microkjeldahl method	Jackson (1958)
P	Nitric perchloric acid (2:1) digestion	Vanadomolybdate yellow colour method (Spectrophotometer)	Jackson (1958)
K	Nitric perchloric acid (2:1) digestion	Direct reading after dilution (Flame photometer)	Jackson (1958)
Ca	Nitric perchloric acid (2:1) digestion	Versanate method	Hesse (1971)
Mg	Nitric perchloric acid (2:1) digestion	Versanate method	Hesse (1971)
S	Nitric perchloric acid (2:1) digestion	Turbidimetry (Spectro photometer)	Hesse (1971)

3.11.9 Scoring of important pest and diseases

Ten plants were randomly selected and tagged. Once in a week, the observations on pests were taken from these plants.The number of mosaic affected plants in each treatment were counted and expressed as percentage.

3.11.10 Economics of cultivation

Yield data were transformed into monetary values based on current market price of Okra. Cost of inputs were separately worked out for each treatment. The returns due to the application of each treatment was then worked out.

3.11.11 Statistical analysis

Data pertaining to each character were tabulated separately and subjected to appropriate statistical analysis using the MSTATC package available at the Central Computer Facility of the College of Horticulture.

Résults

RESULTS

4.1 Growth components

Data relating to growth components namely plant height at first harvest, total dry matter, relative growth rate and net assimilation rate are presented in Table 2.

4.1.1 · Plant height at first harvest

During first crop, T_{13} recorded maximum plant height at first harvest (37.65 cm) followed by T_{10} (36.75 cm). T_4 recorded minimum plant height (24.86 cm). Treatments T_{13} and T_{10} are significantly different from T_{16} and T_4 which produced shortest plants.

During second crop also T_{13} is the treatment which recorded maximum plant height at first harvest (54.17 cm) followed by treatment T_8 (47.38 cm). Here also T_4 recorded the lowest plant height (30.88 cm). T_{13} is significantly different from T_2, T_{14}, T_6, T_5 and T_4.

4.1.2 Total dry matter

During first crop, maximum drymatter was recorded by the treatment recieving highest level of poultry manure T_{13} (34.42 g) followed by T_8(33.08 g). Treatments were not significantly different from control. There was significant difference for treatments T_{13} and T_8 from T_4, which showed minimum dry matter production.

Table 2. Effect of different sources and levels of nitrogen on growth components of okra

Treatments	Plant height at first harvest (cm)		Total dry matter (g)		RGR ($g\ g^{-1}\ day^{-1}$)				NAR ($g\ m^{-2}\ day^{-1}$)			
	Crop I	Crop II	Crop I	Crop II	15-30	30-45	45-60	60-75	15-30	30-45	45-60	60-75
T_1	36.600^{a}	40.070^{abc}	16.990^{ab}	21.700^{abc}	0.035^{abc}	0.055^{ab}	0.030^{a}	0.0010	0.0035^{a}	0.0015^{bc}	0.0065^{a}	-
T_2	28.750^{ab}	38.130^{bc}	15.250^{ab}	20.350^{bc}	0.035^{abc}	0.055^{ab}	0.025^{c}	0.0006	0.0002^{a}	0.0010^{c}	0.0020^{a}	-
T_3	34.000^{ab}	44.800^{abc}	26.210^{ab}	34.380^{abc}	0.025^{abc}	0.040^{b}	0.040^{a}	0.0001	0.0010^{a}	0.0035^{ab}	0.0050^{a}	0.00008
T_4	24.860^{b}	30.880^{c}	12.550^{b}	15.300^{c}	0.030^{abc}	0.035^{b}	0.040^{a}	0.0030	0.0010^{a}	0.0015^{bc}	0.0020^{a}	-
T_5	30.800^{ab}	41.350^{abc}	26.920^{ab}	30.200^{abc}	0.025^{abc}	0.065^{ab}	0.030^{a}	-	0.0006^{a}	0.0015^{bc}	0.0040^{a}	-
T_6	30.330^{ab}	36.050^{bc}	20.330^{ab}	25.700^{abc}	0.020^{abc}	0.050^{ab}	0.040^{a}	-	0.0007^{a}	0.0020^{abc}	0.0025^{a}	-
T_7	29.650^{ab}	40.280^{abc}	21.670^{ab}	28.250^{abc}	0.030^{abc}	0.045^{b}	0.040^{a}	0.0050	0.00055^{a}	0.0015^{bc}	0.0015^{a}	0.0005
T_8	32.420^{ab}	47.380^{ab}	33.080^{a}	43.080^{ab}	0.020^{abc}	0.050^{ab}	0.035^{a}	0.0080	0.00015^{a}	0.0040^{a}	0.0075^{a}	-
T_9	28.050^{ab}	41.950^{abc}	17.260^{ab}	23.500^{abc}	0.030^{abc}	0.055^{ab}	0.030^{a}	0.0005	0.0001^{a}	0.0030^{abc}	0.0030^{a}	-
T_{10}	36.750^{a}	40.050^{abc}	18.480^{ab}	21.730^{abc}	0.015^{bc}	0.045^{ab}	0.040^{a}	0.0001	0.0007^{a}	0.0025^{abc}	0.0020^{a}	0.003
T_{11}	28.000^{ab}	44.200^{abc}	16.000^{ab}	25.170^{abc}	0.045^{ab}	0.045^{b}	0.030^{a}	-	0.0007^{a}	0.0020^{abc}	0.0025^{a}	0.000068
T_{12}	28.550^{ab}	40.800^{abc}	17.590^{ab}	24.130^{abc}	0.020^{abc}	0.080^{a}	0.030^{a}	0.0008	0.0004^{a}	0.0020^{abc}	0.0030^{a}	0.0045
T_{13}	37.650^{a}	54.170^{a}	34.420^{a}	48.500^{a}	0.040^{ab}	0.055^{ab}	0.040^{a}	-	0.0004^{a}	0.0035^{ab}	0.0030^{a}	0.0037
T_{14}	27.850^{ab}	36.150^{bc}	15.610^{ab}	21.000^{abc}	0.045^{a}	0.050^{ab}	0.030^{a}	0.0009	0.0040^{a}	0.0020^{abc}	0.0040^{a}	0.00008
T_{15}	36.150^{a}	34.900^{bc}	23.470^{ab}	21.980^{abc}	0.035^{abc}	0.050^{ab}	0.020^{a}	0.0001	0.0003^{a}	0.0015^{bc}	0.0040^{a}	0.00003
T_{16}	25.150^{b}	46.870^{ab}	22.400^{ab}	34.000^{abc}	0.010^{c}	0.060^{ab}	0.030^{a}	0.0063	0.0008^{a}	0.0035^{a}	0.0035^{a}	-

Treatmants having same alphabet form one homogenous group

1

2

3

4

5

Plate 6. Treatment receiving FYM equivalent to 75 kg N/ha

Plate 7. Treatment receiving poultry manure equivalent to 75 kg N/ha

Plate 8. Treatment receiving vermicompost equivalent to 75 kg N/ha

Plate 9. Treatment receiving groundnut cake equivalent to 75 kg N/ha

Plate 10. Treatment receiving sunnhemp equivalent to 75 kg N/ha

6

7

8

9

Plate 11. Treatment receiving FYM equivalent to 100 kg N/ha

Plate 12. Treatment receiving vermicompost equivalent to 100 kg N/ha

Plate 13. Treatment receiving groundnut cake equivalent to 100 kg N/ha

Plate 14. Treatment receiving sunnhemp equivalent to 100 kg N/ha

11

12

13

14

During second crop also maximum drymatter was recorded by T_{13} (48.50 g) followed by T_8 (43.08 g) and minimum by T_4 (15.3 g). Treatments were not significantly different from control but treatment T_{13} was significantly different from T_2 and T_4.

4.1.3 Relative Growth Rate (RGR)

During 15-30 days after sawing (DAS) maximum relative growth rate was for T_{11} and T_{14} (0.045 g g^{-1} day^{-1}) followed by T_{13} (0.04 g g^{-1} day^{-1}) and minimum for T_{16} (0.01 g g^{-1} day^{-1}). During 30-45 DAS maximum RGR was for treatment T_{12} (0.08 g g^{-1} day^{-1}) followed by T_5 (0.065 g g^{-1} day^{-1}) and minimum for T_3 (0.04 g g^{-1} day^{-1}). During 45-60 DAS treatments did not show significant difference in RGR. RGR for different treatments at 50 kg N ha^{-1} is given in Fig.2.

4.1.4 Net Assimilation Rate (NAR)

During 15-30 DAS treatments did not show significant difference in NAR. During 30-45 DAS, T_8 showed maximum NAR (0.004) and minimum by T_2 (0.001). During 45-60 days treatments did not show any significant difference in NAR. NAR for different treatments at 50 kg N ha^{-1} is given in Fig.3.

4.2 Earnliness

4.2.1 Index to earliness

Data on Index to earliness is presented in Table 3. During first crop, highest value was for T_3(0.875) followed by T_{16} (0.765) and lowest value was for control (0.605). T_3 was significantly earlier than all other treatments. But this

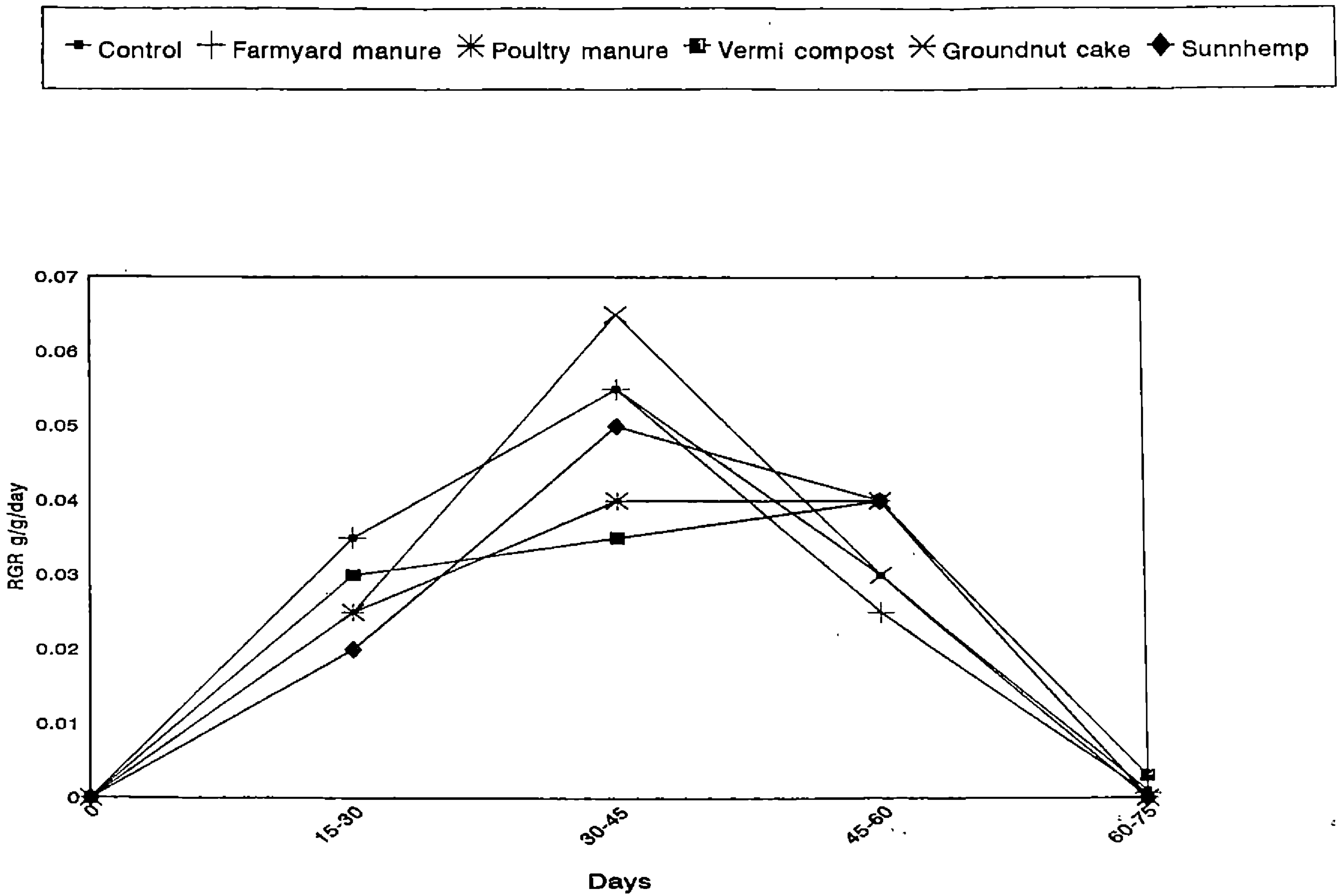

Fig.2. Relative Growth Rate as influenced by different sources of nitrogen

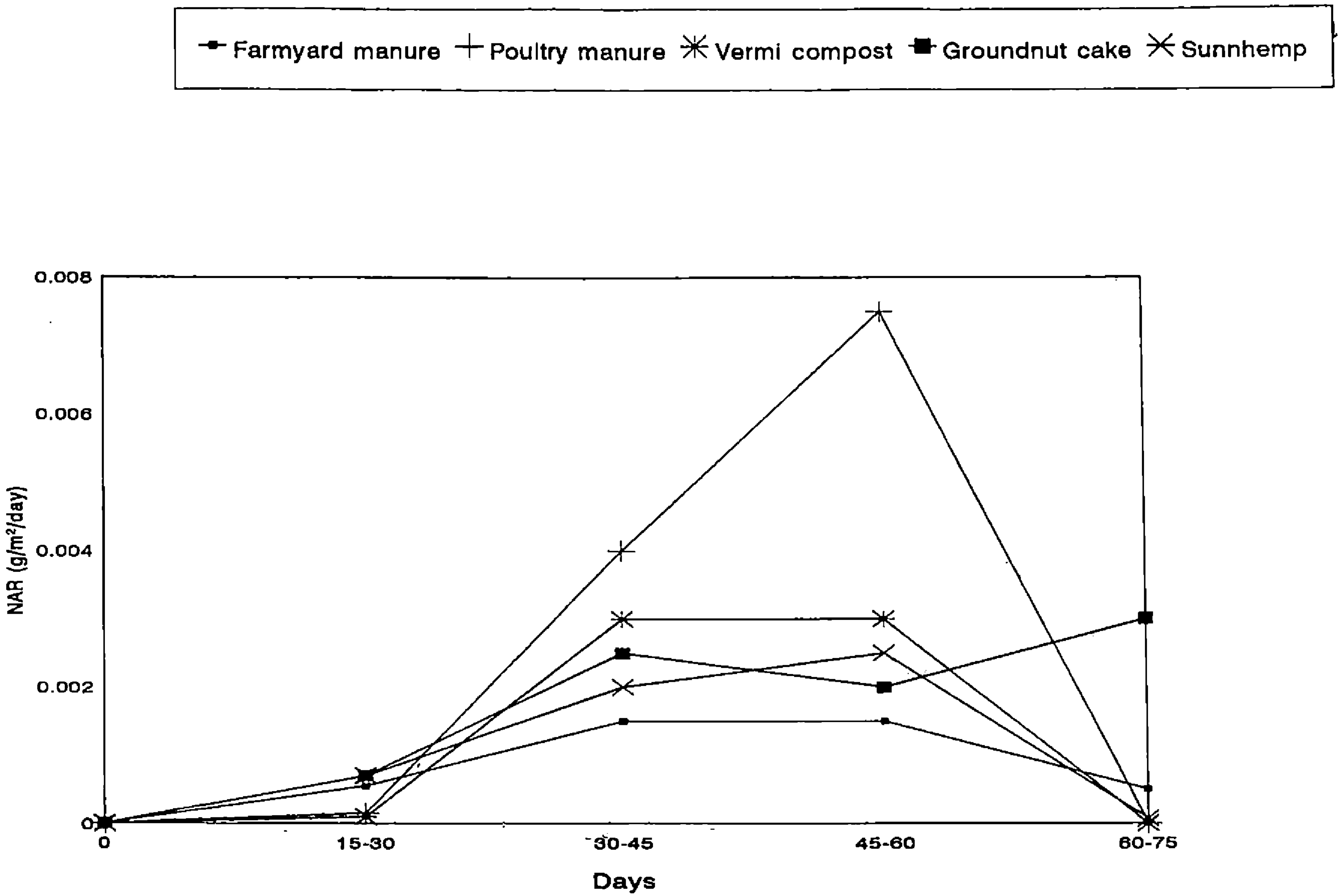

Fig.3. Net Assimilation Rate as influenced by different sources of nitrogen

Table 3. Effect of different sources and levels of nitrogen on earliness and fruit characters of okra

Treatments	Index to earliness		Days to 50% flowering		Fruit length (cm)		Fruit diameter (cm)		Fruit weight (g)	
	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
T_1	0.605^{a}	0.615^{a}	40.50^{a}(6.363)	43.00^{ab} (6.557)	15.93^{ab}	17.60^{a}	1.730^{ab}	1.81^{ab}	18.85^{ab}	22.98^{a}
T_2	0.635^{cd}	0.445^{a}	44.50^{a}(6.671)	44.50^{abc}(6.671)	14.98^{ab}	15.52^{ab}	1.730^{ab}	1.70^{cd}	17.50^{b}	20.80^{b}
T_3	0.875^{a}	0.605^{a}	41.50^{a}(6.439)	45.50^{a} (6.745)	15.77^{ab}	16.40^{ab}	1.760^{ab}	1.72^{bcd}	19.95^{ab}	20.90^{b}
T_4	0.700^{bcd}	0.550^{a}	42.50^{a}(6.518)	45.50^{a} (6.745)	15.00^{ab}	14.91^{b}	1.753^{ab}	1.70^{cd}	15.65^{b}	16.63^{c}
T_5	0.675^{bcd}	0.520^{a}	41.00^{a}(6.401)	44.00^{abc}(6.630)	15.19^{ab}	15.26^{b}	1.640^{bcd}	1.82^{ab}	17.15^{b}	22.10^{ab}
T_6	0.720^{bc}	0.530^{a}	44.00^{a}(6.633)	45.50^{a} (6.745)	17.59^{ab}	17.07^{ab}	1.850^{a}	1.76^{abc}	19.80^{ab}	21.85^{ab}
T_7	0.670^{bcd}	0.605^{a}	42.50^{a}(6.578)	45.00^{ab} (6.708)	15.51^{ab}	17.18^{ab}	1.800^{ab}	1.74^{abc}	19.10^{ab}	21.63^{ab}
T_8	0.750^{b}	0.535^{a}	40.50^{a}(6.358)	42.50^{abc}(6.516)	17.09^{ab}	16.32^{ab}	1.835^{a}	1.80^{ab}	21.95^{ab}	21.79^{ab}
T_9	0.655^{bcd}	0.605^{a}	42.50^{a}(6.518)	44.00^{abc}(6.633)	14.98^{ab}	15.86^{ab}	1.500^{d}	1.65^{cd}	16.14^{b}	20.86^{b}
T_{10}	0.685^{bcd}	0.525^{a}	44.00^{a}(6.633)	45.00^{ab} (6.708)	14.91^{ab}	16.31^{ab}	1.710^{abc}	1.85^{a}	21.45^{ab}	20.62^{b}
T_{11}	0.720^{bc}	0.615^{a}	42.50^{a}(6.518)	44.00^{abc}(6.633)	14.68^{ab}	16.11^{ab}	1.690^{abc}	1.65^{cd}	17.15^{b}	21.90^{ab}
T_{12}	0.740^{bc}	0.550^{a}	44.00^{a}(6.633)	44.50^{abc}(6.671)	15.65^{ab}	16.80^{ab}	1.558^{cd}	1.79^{ab}	17.90^{ab}	22.43^{ab}
T_{13}	0.695^{bcd}	0.570^{a}	41.50^{a}(6.439)	43.00^{abc}(6.556)	15.65^{ab}	16.93^{ab}	1.780^{ab}	1.73^{bcd}	16.35^{b}	21.73^{ab}
T_{14}	0.675^{bcd}	0.505^{a}	41.50^{a}(6.439)	42.00^{bc} (6.479)	15.09^{ab}	16.48^{ab}	1.700^{abc}	1.82^{ab}	17.80^{ab}	20.85^{b}
T_{15}	0.705^{bcd}	0.565^{a}	40.50^{a}(6.358)	41.50^{c} (6.441)	18.11^{a}	15.86^{ab}	1.650^{bcd}	1.72^{bcd}	23.95^{a}	20.78^{b}
T_{16}	0.765^{b}	0.645^{a}	42.50^{a}(6.518)	44.00^{abc}(6.633)	14.48^{b}	16.82^{ab}	1.762^{ab}	1.75^{abc}	16.03^{b}	22.62^{ab}

Treatmants having same alphabet form one homogenous group
Data in paranthesis are angular transformed values

difference was not seen in the second crop. During second crop, treatments showed no significant difference in Index to earliness.

4.2.2 Days to 50 per cent flowering

During first crop, treatments did not differ significantly in number of days to 50 per cent flowering (Table 3). Maximum days to 50 per cent flowering was for T_2 (44.5) followed by T_{12}, T_6 and T_{10} (44). Minimum days were for the treatment T_8 and T_{15} (40.5). During second crop, maximum days to 50 per cent flowering was observed in the treatment T_3, T_4 and T_6(45.5). All other treatments took less number of days to 50 per cent flowering. But it was also noticed that the number of days to 50 per cent flowering was more in the second crop irrespective of treatments.

4.3 Fruit characters

4.3.1 Fruit length

During first crop, T_{15} recorded maximum fruit length (18.11 cm) followed by T_6 (17.59 cm) (Table 3). The minimum fruit length was recorded by T_{16} (14.48 cm). Treatments were not significantly different from control.

During second crop, maximum fruit length was for T_1 (17.6 cm) followed by T_7 (17.18 cm). Significantly shorter fruits were produced by T_4 and T_5.

4.3.2 Fruit diameter

During first crop, T_6 recorded maximum fruit diameter (1.85 cm) followed by T_8 (1.835 cm). T_9 recorded least diameter (1.5 cm). T_{12} and T_9 are significantly different and recorded less diameter compared to control (Table 3).

During second crop the maximum diameter was for T_{10} (1.85 cm). All other treatments showed reduction in diameter and reduction was maximum for T_9 and T_{11} (1.65 cm).

4.3.3 Fruit weight

Data on fruit weight is presented in Table 3. During first crop, the maximum fruit weight was recorded by T_{15} (23.95 g) followed by T_8 (21.95 g). Minimum fruit weight was for T_4 (15.65 g). During second crop, T_1 recorded maximum fruit weight (22.98 g), followed by T_{16} (22.62 g). Here also significantly lower weight was recorded by T_4.

4.4 Yield attributes

Data relating to yield per plant, yield per plot, number of harvest and crop duration are presented in Table 4.

4.4.1 Yield per plant

The total yield per plant was influenced significantly due to treatments. During first crop, yield per plant was maximum for T_{13} i.e the treatment recieving highest level of poultry manure (189.6 g) followed by T_{15} (182.6 g) which were at par. Lowest yield was for T_9 (70.72 g). T_{13}, T_{15} and T_{10} were significantly superior treatments when compared to control. During second crop, the yield per plant was maximum for T_8 (163.13 g) followed by T_3 (154 g) and then by T_{13} (152.13 g). All these treatments were at par. Yield in kg ha^{-1} for different sources at levels of N is given in Fig.3.

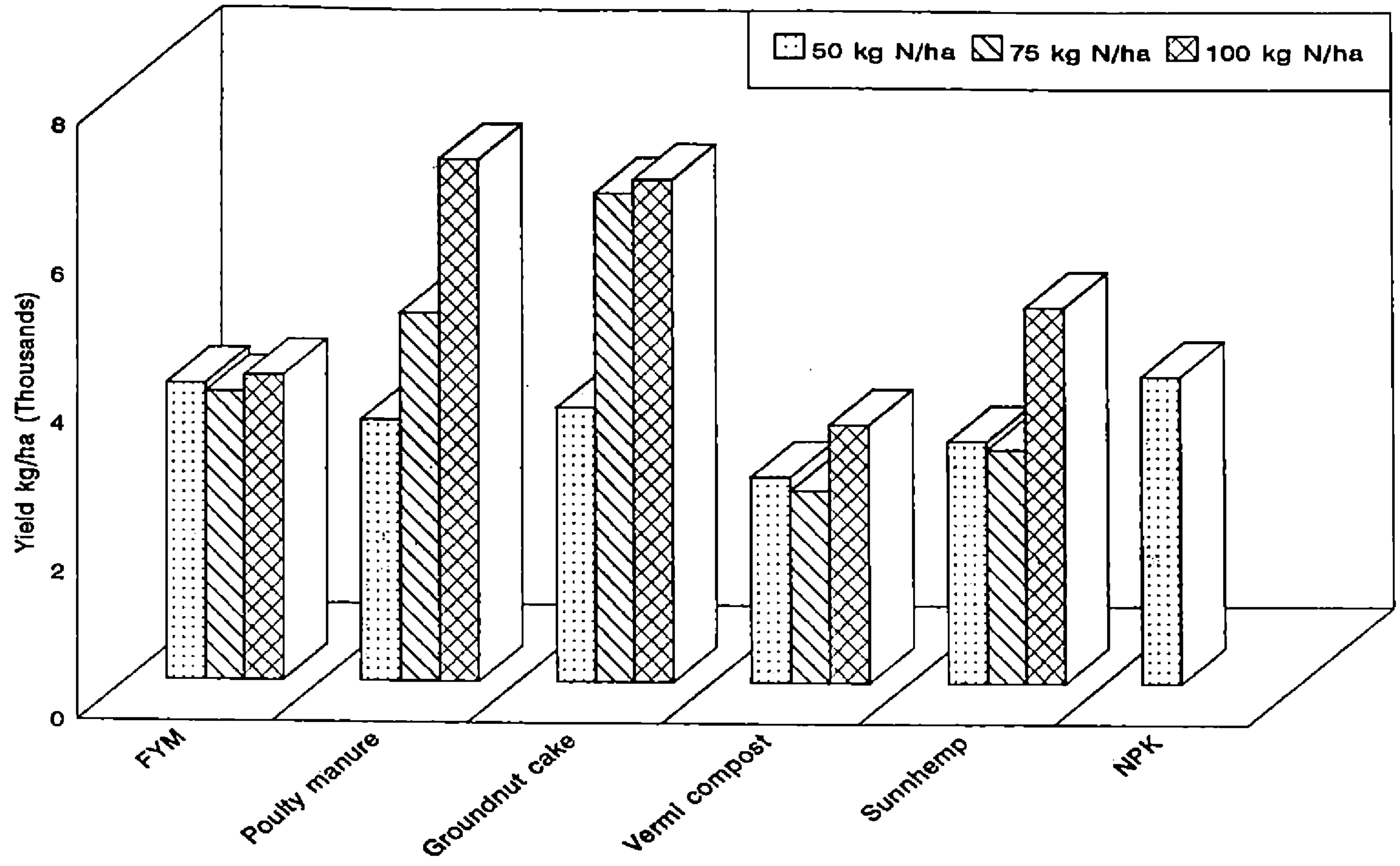

Fig.4. Yield as influenced by different sources and levels of nitrogen

Table 4. Effect of different sources and levels of nitrogen on yield attributes and duration of okra

Treatments	Yield per plant (g)		Yield per plot (g)		Number of harvest		Crop duration (days)	
	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
T_1	111.40^{bc}	91.10^{abc}	2623^{bcd}	2218.75^{abc}	13.0^{bc}	13.0^{a}	90.0^{abc}	95.0^{a}
T_2	107.80^{bc}	128.25^{abc}	2578^{bcd}	3132.50^{abc}	13.0^{bc}	14.0^{a}	90.0^{abc}	98.0^{a}
T_3	94.35^{bc}	154.00^{ab}	2835^{bcd}	3700.00^{ab}	14.0^{b}	15.0^{a}	93.5^{ab}	101.0^{a}
T_4	74.70^{c}	72.81^{c}	2029^{cd}	1768.75^{abc}	12.5^{bc}	13.0^{a}	87.5^{bc}	95.0^{a}
T_5	100.10^{bc}	80.40^{abc}	2518^{bcd}	1813.75^{c}	12.5^{bc}	14.0^{a}	88.0^{abc}	98.0^{a}
T_6	87.72^{c}	101.38^{abc}	2264^{cd}	2456.25^{abc}	12.5^{bc}	13.5^{a}	87.5^{bc}	96.5^{a}
T_7	104.50^{bc}	127.13^{abc}	2528^{bcd}	3071.25^{abc}	12.5^{bc}	15.0^{a}	87.5^{bc}	101.0^{a}
T_8	133.40^{b}	163.13^{a}	3541^{b}	3955.00^{a}	13.0^{bc}	15.0^{a}	90.0^{abc}	101.0^{a}
T_9	70.72^{c}	106.81^{abc}	1862^{d}	2585.00^{bc}	13.5^{bc}	14.5^{a}	92.0^{abc}	99.5^{a}
T_{10}	178.40^{a}	85.89^{bc}	4694^{a}	2138.00^{bc}	15.5^{a}	14.5^{a}	95.0^{a}	101.0^{a}
T_{11}	84.14^{c}	125.35^{abc}	2196^{cd}	3006.00^{abc}	14.0^{b}	14.0^{a}	85.0^{c}	99.5^{a}
T_{12}	110.40^{bc}	110.60^{abc}	2680^{bcd}	2687.50^{abc}	13.0^{bc}	14.5^{a}	89.5^{abc}	99.5^{a}
T_{13}	189.60^{a}	152.13^{ab}	4751^{a}	3700.00^{ab}	13.0^{bc}	14.0^{a}	90.0^{abc}	98.0^{a}
T_{14}	94.70^{bc}	70.56^{c}	2206^{cd}	1697.50^{c}	12.5^{bc}	13.5^{a}	87.5^{bc}	98.0^{a}
T_{15}	182.60^{a}	91.25^{abc}	4810^{a}	2250.00^{abc}	14.0^{b}	14.0^{a}	93.5^{ab}	98.0^{a}
T_{16}	136.10^{b}	130.50^{abc}	3087^{bc}	3187.50^{abc}	13.0^{bc}	15.0^{a}	89.5^{abc}	99.5^{a}

Treatmants having same alphabet form one homogenous group

4.4.2 Yield per plot

During first crop, yield per plot was maximum for T_{15} i.e treatment recieving highest level of groundnut cake (4810 g) followed by T_{13} (4751 g) and T_{10} (4694 g). These three treatments were significantly superior to control. Yield per plot was minimum for T_9 (1862 g). This shows that the plots which received maximum N yielded maximum fruits.

During second crop, yield per plot was maximum for T_8 (3955 g) followed by T_{13} (3700 g) which were at par.

4.4.3 Number of harvests

Statistical analysis of data revealed that application of different forms of organic matter influenced the number of harvests significantly. During first crop, the number of harvests was maximum for T_{10} (15.5) followed by T_3, T_{11} and T_{15} (14). T_{10} was significantly different from remaining treatments including control. During second crop, there was no significant difference in the number of harvests between treatments.

4.4.4 Crop duration

During first crop, crop duration was maximum for T_{10} (95 days) followed by T_{15} and T_3 (93.5 days) and shortest duration was recorded for T_{11} (85 days). Significant difference was noted between T_{10} and T_{11}. During second crop, treatments showed no significant difference in crop duration. Maximum duration was for T_3, T_7, T_8 and T_{10} (101 days) and least for T_4 (95 days). Irrespective of treatments all plots showed longer duration in the second crop.

4.5 Quality of produce

Data relating to quality of produce are presented in Table 5.,

4.5.1 Mucilage

Mucilage was found maximum for the treatment T_{13} (5.95%) followed by T_3 (5.80%). The treatments T_1 and T_{11} showed significantly lower mucilage content (5.3%) than T_{13}.

4.5.2 Moisture

During first crop, moisture content was maximum for the treatments T_{10} and T_{14} (95%) followed T_{13} (94.5%). Significantly lower moisture content was recorded by the control (92%). There was no significant difference in moisture content between other treatments.

During second crop, the treatments did not differ significantly for moisture content. As in first crop, the maximum moisture content was recorded for the treatment T_{14} (95.03%) followed by T_{13} (94.82%). The lowest moisture content was for T_9 (92.27%) followed by T_1 (92.38%).

4.5.3 Fibre

Application of different organic manures had not influenced fibre content of fruits significantly. Maximum fibre content was for the treatment T_9 (1.02%) and minimum was for T_2 (0.69%).

Table 5. Effect of different sources and levels of nitrogen on fruit quality of okra

Treatment	Moisture (%)		Protein (%)		Vitamin C mg/100 g		Pericarp thickness (mm)		Mucilage (%)	Fibre (%)	Starch (mg/g)	Organoleptic test
	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II				
T_1	92.00^{b}	93.28^{a}	0.262^{abc}	0.291^{ab}	12.000^{a}	12.310^{a}	1.115^{a}	1.032^{a}	5.30^{a}	0.9625^{a}	0.930^{abc}	3.085^{abc}
T_2	93.75^{ab}	93.69^{a}	0.295^{a}	0.240^{cde}	10.140^{a}	9.755^{a}	1.045^{a}	1.038^{a}	5.54^{ab}	0.6850^{a}	0.965^{a}	3.330^{ab}
T_3	93.75^{ab}	93.74^{a}	0.249^{abc}	0.251^{cde}	9.315^{a}	9.230^{a}	1.085^{a}	1.036^{a}	5.80^{ab}	0.8050^{a}	0.625^{bcd}	3.165^{abc}
T_4	93.70^{ab}	93.40^{a}	0.272^{ab}	0.240^{cde}	9.615^{a}	9.230^{a}	1.090^{a}	1.045^{a}	5.60^{ab}	0.705^{a}	0.780^{abcd}	3.120^{abc}
T_5	94.25^{ab}	94.46^{a}	0.262^{abc}	0.265^{bcd}	13.500^{a}	14.260^{a}	1.195^{a}	1.048^{a}	5.40^{ab}	0.705^{a}	0.505^{d}	3.250^{ab}
T_6	93.50^{ab}	93.42^{a}	0.204^{abc}	0.229^{de}	9.755^{a}	9.240^{a}	1.180^{a}	1.035^{a}	5.60^{ab}	0.855^{a}	0.815^{abcd}	2.835^{abc}
T_7	94.20^{ab}	94.52^{a}	0.268^{ab}	0.248^{cde}	9.755^{a}	9.745^{a}	1.170^{a}	1.031^{a}	5.40^{ab}	0.700^{a}	0.495^{d}	3.585^{a}
T_8	93.70^{ab}	93.85^{a}	0.258^{abc}	0.259^{bcde}	12.110^{a}	12.310^{a}	1.085^{a}	1.045^{a}	5.60^{ab}	0.700^{a}	0.810^{abcd}	3.250^{ab}
T_9	92.75^{ab}	92.27^{a}	0.288^{abc}	0.222^{e}	11.230^{a}	11.280^{a}	1.210^{a}	1.055^{a}	5.60^{ab}	1.020^{a}	0.985^{a}	2.250^{c}
T_{10}	95.00^{a}	94.71^{a}	0.250^{abc}	0.298^{ab}	13.830^{a}	13.330^{a}	1.075^{a}	1.020^{a}	5.50^{ab}	0.740^{a}	0.480^{d}	2.915^{abc}
T_{11}	93.50^{ab}	93.38^{a}	0.278^{abc}	0.229^{de}	12.610^{a}	12.310^{a}	1.115^{a}	1.025^{a}	5.30^{b}	0.8250^{a}	0.760^{abcd}	2.670^{abc}
T_{12}	93.45^{ab}	93.33^{a}	0.200^{abc}	0.245^{cde}	10.780^{a}	10.770^{a}	1.085^{a}	1.065^{a}	5.40^{ab}	0.790^{a}	0.780^{abcd}	2.420^{bc}
T_{13}	94.50^{a}	94.82^{a}	0.229^{abc}	0.304^{a}	13.640^{a}	13.830^{a}	1.210^{a}	1.045^{a}	5.95^{a}	0.715^{a}	0.695^{abcd}	2.835^{abc}
T_{14}	95.00^{a}	95.03^{a}	0.189^{bc}	0.2293^{de}	12.780^{a}	12.820^{a}	1.070^{a}	1.040^{a}	5.40^{ab}	0.705^{a}	0.540^{d}	2.835^{abc}
T_{15}	93.50^{ab}	93.77^{a}	0.295^{a}	0.248^{cde}	10.270^{a}	9.745^{a}	1.380^{a}	1.040^{a}	5.40^{ab}	0.880^{a}	0.595^{cd}	2.750^{abc}
T_{16}	93.00^{a}	93.19^{a}	0.167^{c}	0.273^{abc}	10.250^{a}	9.480^{a}	1.105^{a}	1.070^{a}	5.60^{ab}	0.880^{a}	0.695^{abcd}	2.810^{abc}

Treatmants having same alphabet form one homogenous group

4.5.4 Protein

Significant difference was noted for protein content of fruits due to treatments. During first crop, treatments T_2 and T_9 (0.295%) contained maximum protein while T_{16} contained minimum protein (0.167%). There was no significant difference between remaining treatments. During second crop, T_{13} (0.304%) recorded maximum protein content. The minimum content was for T_6 , T_{11} and T_{14} (0.229%).

4.5.5 Starch

Starch content was significantly higher for the treatment T_9 (0.985 mg g^{-1}) followed by T_2 (0.965 mg g^{-1}), whereas the lowest starch content was recorded by the treatment T_{10} (0.48 mg g^{-1}).

4.5.6 Pericarp thickness

During first crop and second crop treatments did not differ significantly in pericarp thickness.

4.5.7 Organoleptic test

Maximum score was for the treatment T_7 (3.585) followed by T_2 (3.33). The lowest score was for T_9 (2.25).

4.5.8 Vitamin C

During both the seasons there was no significant difference in vitamin C content between the treatments. It was maximum for T_{10} (13.85 mg 100 g^{-1}) followed by T_{13} (13.64 mg/100 g) and least was for T_3 (9.315 mg/100 g) during first crop. During second crop T_5 recorded maximum vitamin C content (14.26 mg 100 g^{-1}) followed by T_{13} (13.83 mg 100 g^{-1}) and least was for T_4 (9.23 mg 100 g^{-1}).

4.5.9 Folic acid

Irrespective of the treatment differences, in all the fruits analysed for folic acid, the quantity was only in traces.

4.6 Percentage of unmarketable fruits after three and five days of storage

Data on percentage of unmarketable fruits on fifth day of storage is presented in Table 6. In both the crops, all the fruits were marketable on the third day of storage. On the fifth day of storage T_{12} showed maximum percentage of unmarketable fruits (77.5%) followed by T_{14} and T_{16} (75%) in the first crop. During second crop T_1 showed maximum unmarketable fruits (77.5%) followed by T_{13} (72.5%).

4.7 Moisture loss during storage

Percentage of moisture loss recorded for the fruits is presented in Table 7. Treatments showed significant difference in weight loss on second day of storage. T_{12} showed maximum weight loss (5.895%) followed by T_{15} (5.455%). Weight loss in T_6 and T_9 were minimum (4.55%). But all the treatments were on par with control.

On third day weight loss was maximum for T_2 (10.96%) followed by T_4 (10.87%) and T_9 recorded least weight loss (8.995%). But treatments showed no significant difference from control.

Table 6. Effect of different sources and levels of nitrogen on percentage of unmarketable fruits on 5th day of storage

Treatments	Crop I	Crop II
T_1	57.5[cde]	77.5[a]
T_2	50.0[e]	55.0[c]
T_3	55.0[de]	67.5[b]
T_4	50.0[e]	70.0[b]
T_5	57.5[cde]	70.0[b]
T_6	55.0[de]	70.0[b]
T_7	50.0[e]	70.0[b]
T_8	55.0[de]	70.0[b]
T_9	50.0[e]	70.0[b]
T_{10}	65.0[abcd]	71.5[ab]
T_{11}	60.0[cde]	67.5[b]
T_{12}	77.5[a]	70.0[b]
T_{13}	62.5[bcde]	72.5[ab]
T_{14}	75.0[ab]	67.5[b]
T_{15}	70.0[abc]	67.5[b]
T_{16}	75.0[ab]	70.0[b]

Treatmants having same alphabet form one homogenous group

Table 7. Effect of different sources and levels of nitrogen percentage of moisture loss during storage of fruits

Treatments	2nd day	3rd day	4th day	5th day
T_1	4.685[b]	10.210[abcd]	22.830[a]	33.150[a]
T_2	5.280[ab]	10.960[a]	22.990[a]	33.430[a]
T_3	4.895[ab]	9.600[abcd]	21.060[a]	29.790[a]
T_4	5.250[ab]	10.870[ab]	22.330[a]	32.760[a]
T_5	5.395[ab]	9.360[bcd]	21.950[a]	30.170[a]
T_6	4.050[b]	9.885[abcd]	21.080[a]	30.740[a]
T_7	4.965[ab]	10.650[abc]	22.760[a]	33.280[a]
T_8	4.850[b]	9.670[abcd]	19.510[a]	28.350[a]
T_9	4.550[b]	8.995[d]	18.490[a]	27.220[a]
T_{10}	4.600[b]	9.270[cd]	19.630[a]	28.670[a]
T_{11}	4.945[ab]	10.220[abcd]	19.020[a]	26.770[a]
T_{12}	5.895[a]	10.650[abc]	22.970[a]	29.740[a]
T_{13}	4.950[ab]	9.720[abcd]	19.900[a]	29.050[a]
T_{14}	4.965[ab]	10.770[abc]	22.450[a]	33.400[a]
T_{15}	5.455[ab]	9.850[abcd]	20.850[a]	29.620[a]
T_{16}	4.800[ab]	9.300[bcd]	19.600[a]	29.050[a]

Treatmants having same alphabet form one homogenous group

On fourth and fifth day of storage, there was no significant difference in weight loss due to treatments.

4.8 Seed characters

Data on different seed characters namely seed yield per plant, number of seeds per fruit, weight of seeds per fruit, 100 seed weight and germination percentage are presented in Table 8.

4.8.1 Number of seeds per fruit

During first crop, number of seeds were maximum for the treatment T_8 (45) followed by T_{10} (41.45). Treatments did not differ significantly from each other. During second crop also the treatments did not show significant difference in number of seeds. The maximum number of seeds were recorded by the treatment T_6 (48.16) and minimum by T_4 (39).

4.8.2 Weight of seeds per fruit

Treatments showed no significant difference in weight of seeds in both the crops.

4.8.3 Seed yield per plant

During first crop, seed yield per plant was maximum for the treatment T_{10} (191 g) which was significantly superior followed by T_{15} (175 g). The least seed yield per plant was for the treatment T_2 (69.15 g). During second crop seed yield per plant was significantly higher for the treatment T_{13} (225.7 g) followed by T_{11} (154.8 g) and control recorded minimum seed yield (93.92 g).

Table 8. Effect of different sources and levels of nitrogen on seed characters of okra

Treatment	Seed yield (g plant^{-1})		No. of seeds/fruit		Weight of seed/fruit (g)		100 seed weight (g)		Germination percentage			
	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I		Crop II	
T_1	91.50^{c}	93.92^{e}	37.23^{ab}	44.92^{a}	2.135^{a}	1.345^{a}	7.600^{a}	5.025^{ab}	94.50^{cdef}	(1.336)	96.00^{ab}	(1.376)
T_2	69.15^{e}	115.50^{bcde}	31.53^{ab}	42.42^{a}	1.544^{a}	1.362^{a}	6.150^{ab}	4.900^{ab}	98.00^{abc}	(1.434)	97.75^{ab}	(1.435)
T_3	122.00^{bc}	98.30^{de}	39.10^{ab}	42.10^{a}	1.940^{a}	1.720^{a}	6.465^{ab}	5.250^{ab}	99.25^{ab}	(1.485)	99.50^{a}	(1.500)
T_4	70.45^{c}	99.50^{cde}	34.78^{ab}	39.00^{a}	1.400^{a}	1.470^{a}	5.170^{b}	5.000^{ab}	93.50^{defg}	(1.315)	93.00^{bc}	(1.309)
T_5	88.15^{c}	125.80^{bcde}	31.40^{ab}	46.92^{a}	1.790^{a}	1.755^{a}	7.200^{a}	5.500^{ab}	93.50^{def}	(1.323)	93.00^{abc}	(1.323)
T_6	90.80^{c}	144.00^{bcde}	36.40^{ab}	48.16^{a}	2.020^{a}	1.965^{a}	6.425^{ab}	5.750^{a}	92.00^{efg}	(1.285)	92.00^{bc}	(1.286)
T_7	96.38^{c}	142.20^{bcd}	36.71^{ab}	46.93^{a}	2.250^{a}	1.705^{a}	6.450^{ab}	5.150^{ab}	92.50^{efg}	(1.297)	91.00^{bc}	(1.270)
T_8	129.60^{abc}	133.00^{bcde}	45.00^{a}	43.10^{a}	2.150^{a}	1.625^{a}	6.120^{ab}	4.800^{ab}	99.50^{a}	(1.500)	99.50^{a}	(1.500)
T_9	88.13^{c}	128.60^{bcde}	40.00^{ab}	43.65^{a}	2.170^{a}	1.610^{a}	5.750^{ab}	5.500^{ab}	90.50^{fg}	(1.258)	90.00^{bc}	(1.251)
T_{10}	191.00^{a}	125.90^{bcde}	41.45^{ab}	42.13^{a}	1.935^{a}	1.545^{a}	6.800^{ab}	5.125^{ab}	94.00^{def}	(1.324)	99.00^{abc}	(1.327)
T_{11}	79.95^{c}	154.80^{b}	34.00^{ab}	45.59^{a}	1.555^{a}	1.915^{a}	6.150^{ab}	5.730^{a}	97.00^{abcd}	(1.348)	96.75^{ab}	(1.412)
T_{12}	86.80^{c}	146.60^{bc}	39.20^{ab}	41.95^{a}	1.790^{a}	1.420^{a}	6.305^{ab}	5.250^{ab}	95.00^{cdef}	(1.350)	94.00^{abc}	(1.327)
T_{13}	97.30^{c}	225.70^{a}	37.70^{ab}	46.20^{a}	1.580^{a}	1.720^{a}	4.900^{b}	4.250^{b}	91.50^{fg}	(1.276)	84.00^{c}	(1.162)
T_{14}	89.00^{c}	106.30^{cde}	37.80^{ab}	43.00^{a}	1.520^{a}	1.585^{a}	6.750^{ab}	5.225^{ab}	95.50^{cdef}	(1.366)	95.00^{ab}	(1.356)
T_{15}	175.00^{abc}	116.00^{bcde}	40.91^{ab}	40.50^{a}	2.225^{a}	1.675^{a}	6.500^{ab}	5.225^{ab}	96.00^{bcde}	(1.387)	95.75^{ab}	(1.392)
T_{16}	94.00^{c}	143.50^{bcd}	34.43^{ab}	45.55^{a}	1.564^{a}	1.430^{a}	6.075^{ab}	5.100^{ab}	87.50^{g}	(1.211)	84.00^{c}	(1.162)

Treatmants having same alphabet form one homogenous group
Data in paranthesis are angular transformed values

4.8.4 100 seed weight

During first crop, the 100 seed weight was maximum for the treatment T_1 (7.6 g) followed by T_5 (7.2 g). The minimum 100 seed weight was noted for the treatment T_{13}.

During second crop, 100 seed weight was maximum for T_6 (5.75 g) followed by T_{11} (5.73 g). As in first crop, the minimum 100 seed weight was for the treatment T_{13} (4.25 g). Treatments T_6 and T_{11} were significantly different from T_{13}.

4.8.5 Germination percentage

During first crop, the germination percentage was maximum for the treatment T_8 (99.5%) followed by T_3 (99.25%). The inferior treatment was T_{16} (87.5%) which was significant also. During second crop also germination percentage was maximum for the treatment T_3 and T_8 (99.5%). The lowest germination percentage was recorded by T_{16} and T_{13} (84%). These two treatments were significantly lower in germination. Other treatments were at par. In both the crops, the highest levels of nitrogen resulted in a reduction in germination percentage of seeds.

4.9 Soil property

Data presented in Table 9 represent the values of soil organic carbon, total nitrogen and soil pH.

4.9.1 Organic carbon

There was no significant difference in soil organic carbon between treatments in any of the three soil samples; that is the samples taken before starting

Table 9. Effect of different sources and levels of nitrogen on soil prooperties

Treatments	pH			Total N (%)			Organic carbon (%)		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
T_1	4.825^{a}	4.675^{a}	4.945^{bc}	0.860^{abc}	0.910^{d}	0.960^{b}	1.455^{a}	1.465^{a}	1.380^{a}
T_2	4.625^{a}	4.700^{a}	5.975^{a}	1.260^{a}	0.910^{d}	1.085^{ab}	1.740^{a}	1.470^{a}	1.655^{a}
T_3	4.725^{a}	5.150^{a}	5.575^{ab}	1.110^{abc}	1.015^{c}	0.790^{b}	1.740^{a}	1.275^{a}	1.710^{a}
T_4	4.850^{a}	4.700^{a}	4.850^{c}	0.845^{abc}	0.980^{cd}	0.870^{b}	1.350^{a}	1.260^{a}	1.290^{a}
T_5	4.450^{a}	4.625^{a}	5.075^{bc}	0.965^{abc}	0.720^{d}	0.980^{ab}	1.635^{a}	1.365^{a}	1.320^{a}
T_6	4.675^{a}	5.550^{a}	5.200^{bc}	0.675^{c}	0.790^{d}	1.050^{ab}	1.325^{a}	1.170^{a}	1.410^{a}
T_7	4.450^{a}	4.325^{a}	5.050^{bc}	1.050^{abc}	1.435^{a}	0.975^{ab}	1.380^{a}	1.395^{a}	1.545^{a}
T_8	5.050^{a}	4.700^{a}	4.950^{bc}	0.820^{abc}	0.895^{d}	0.980^{ab}	1.740^{a}	1.125^{a}	1.575^{a}
T_9	4.450^{a}	4.525^{a}	5.050^{bc}	0.705^{bc}	0.860^{d}	0.960^{b}	1.260^{a}	1.290^{a}	1.170^{a}
T_{10}	5.025^{a}	4.525^{a}	5.075^{bc}	1.015^{abc}	1.410^{a}	1.010^{ab}	1.710^{a}	1.500^{a}	1.605^{a}
T_{11}	4.805^{a}	4.700^{a}	5.550^{ab}	1.125^{abc}	0.860^{d}	1.110^{ab}	1.310^{a}	1.530^{a}	1.570^{a}
T_{12}	4.700^{a}	4.750^{a}	4.900^{bc}	0.875^{abc}	0.685^{d}	1.120^{ab}	1.305^{a}	1.110^{a}	1.380^{a}
T_{13}	4.900^{a}	4.770^{a}	5.300^{bc}	1.225^{ab}	1.295^{b}	1.340^{a}	1.605^{a}	1.365^{a}	1.500^{a}
T_{14}	4.825^{a}	5.150^{a}	5.150^{bc}	1.015^{abc}	0.780^{d}	0.910^{b}	1.305^{a}	1.590^{a}	1.515^{a}
T_{15}	4.975^{a}	4.450^{a}	5.000^{bc}	0.810^{abc}	0.855^{d}	0.880^{b}	1.440^{a}	1.380^{a}	1.455^{a}
T_{16}	4.475^{a}	4.775^{a}	5.150^{bc}	1.050^{abc}	0.890^{d}	0.940^{b}	1.470^{a}	1.530^{a}	1.550^{a}

Treatmants having same alphabet form one homogenous group

the experiment, then after the first crop and then again after the second crop. The paired 't' test conducted for the differences in organic carbon between the three samples also showed no significant difference.

4.9.2 Total nitrogen

Repeated application of different organic manures for two seasons cannot influence the nitrogen content of soil significantly. The significant difference observed due to treatments is mainly because of the difference in the basic level of nitrogen in soil before starting the first crop. Paired t test done for the difference in soil N between the three soil samples revealed that there was no significant increase or decrease in soil N due to the application of different manures.

4.9.3 pH

For sample I and II treatments did not differ significantly from each other. For sample III the highest pH was for the treatment T_2 (5.975) followed by T_3 (5.575) and lowest for T_4 (4.85). The treatment T_2 was significantly different from control, while and remaining treatments were not significantly different from control.

4.10 Leaf analysis

4.10.1 Nitrogen

During first crop, leaf nitrogen content was maximum for the treatment T_{15} (2%) followed by T_{14} (1.92%) (Table 10). The treatments did not differ significantly from each other. During second crop also treatments did not differ significantly in leaf nitrogen content. Then also T_{15} recorded maximum nitrogen

Table 10. Effect of different sources and levels of nitrogen on N, P, K, Ca, Mg and S content of leaves of okra

Treatment	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		S(%)	
	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
T_1	1.680^{a}	2.520^{a}	0.905^{a}	0.560^{b}	2.650^{b}	1.863^{a}	0.62^{b}	0.92^{ab}	0.524^{ab}	0.322^{cd}	1.425^{a}	1.790^{ab}
T_2	1.660^{a}	2.485^{a}	0.850^{a}	0.840^{a}	2.525^{b}	1.988^{a}	1.58^{ab}	0.34^{b}	0.495^{ab}	0.422^{abc}	1.990^{a}	2.035^{a}
T_3	1.715^{a}	2.800^{a}	0.860^{a}	0.740^{ab}	3.025^{ab}	1.650^{a}	1.58^{ab}	0.84^{ab}	0.458^{abc}	0.320^{cd}	1.935^{a}	1.520^{ab}
T_4	1.690^{a}	2.380^{a}	0.799^{a}	0.655^{ab}	2.650^{b}	1.998^{a}	1.76^{ab}	0.36^{b}	0.334^{cd}	0.363^{bcd}	1.670^{a}	1.705^{ab}
T_5	1.610^{a}	2.695^{a}	0.746^{a}	0.740^{ab}	2.870^{ab}	1.750^{a}	1.24^{ab}	0.64^{ab}	0.430^{abc}	0.444^{ab}	1.550^{a}	1.595^{ab}
T_6	1.555^{a}	2.450^{a}	0.850^{a}	0.700^{ab}	3.200^{ab}	2.253^{a}	0.81^{b}	0.78^{ab}	0.475^{abc}	0.379^{abcd}	1.640^{a}	1.925^{ab}
T_7	1.570^{a}	2.765^{a}	0.904^{a}	0.610^{ab}	3.100^{ab}	2.400^{a}	1.20^{ab}	1.52^{a}	0.463^{abc}	0.365^{abcd}	1.810^{a}	1.715^{ab}
T_8	1.680^{a}	2.730^{a}	0.905^{a}	0.660^{ab}	2.700^{b}	1.713^{a}	1.62^{ab}	0.96^{ab}	0.379^{bcd}	0.372^{abcd}	1.770^{a}	1.285^{b}
T_9	1.700^{a}	2.380^{a}	0.985^{a}	0.690^{ab}	3.050^{ab}	2.060^{a}	0.62^{b}	1.04^{ab}	0.540^{a}	0.283^{d}	1.705^{a}	1.560^{ab}
T_{10}	1.785^{a}	2.705^{a}	0.795^{a}	0.565^{b}	3.500^{a}	1.688^{a}	1.32^{ab}	1.26^{ab}	0.509^{ab}	0.303^{cd}	1.640^{a}	1.595^{ab}
T_{11}	1.750^{a}	2.310^{a}	0.745^{a}	0.765^{ab}	3.075^{ab}	2.250^{a}	0.52^{b}	0.52^{b}	0.443^{abc}	0.336^{bcd}	1.450^{a}	1.770^{ab}
T_{12}	1.680^{a}	2.590^{a}	0.772^{a}	0.860^{a}	2.500^{b}	1.963^{a}	0.52^{b}	0.24^{b}	0.463^{abc}	0.482^{a}	1.615^{a}	1.825^{ab}
T_{13}	1.640^{a}	2.765^{a}	0.941^{a}	0.550^{b}	3.200^{ab}	1.738^{a}	1.11^{ab}	0.92^{ab}	0.379^{bcd}	0.311^{cd}	1.815^{a}	1.300^{b}
T_{14}	1.920^{a}	2.310^{a}	0.956^{a}	0.725^{ab}	2.950^{ab}	1.913^{a}	1.18^{ab}	0.80^{ab}	0.475^{abc}	0.404^{abc}	1.945^{a}	1.595^{ab}
T_{15}	2.000^{a}	2.835^{a}	0.728^{a}	0.560^{b}	2.900^{ab}	1.800^{a}	2.12^{a}	1.18^{ab}	0.266^{d}	0.324^{d}	1.200^{a}	1.470^{ab}
T_{16}	1.755^{ab}	2.425^{a}	0.925^{a}	0.580^{b}	3.125^{ab}	1.900^{a}	1.24^{ab}	0.88^{ab}	0.331^{cd}	0.312^{cd}	1.805^{a}	1.600^{ab}

Treatmants having same alphabet form one homogenous group

content. But during that crop leaf nitrogen was more in all the treatments when compared to the first crop.

4.10.2 Phosphorus

During first crop, leaf phosphorus content was maximum for T_9 (0.985%) followed by T_{14} (0.956%) (Table 10) and remaining treatments were not significantly different from each other. During second crop, the P content was maximum for T_{12} (0.86%) followed by T_2 (0.84%) and the minimum P content was for T_{13} (0.55%). The treatments T_{12} and T_2 were superior in P content compared to control and remaining treatments were not significantly different from control.

4.10.3 Potassium

During first crop, potassium content was maximum for the treatment T_{10} (3.5%) followed by T_{13} (3.27%). The least potassium content was for T_{12} (2.57%) (Table 10). Treatment T_{10} was significantly superior to control. During second crop, the K content was maximum for the treatment T_7 (2.4%) followed by T_6 (2.25%). The lowest content was for the treatment T_3 (1.65%). The treatments did not differ significantly from control.

4.10.4 Calcium

During first crop, calcium content was maximum for treatment T_{15} (2.12%) followed by T_4 (1.76%) (Table 10). The lowest content of calcium was recorded by the treatment T_{12} and T_{11} (0.52%). Treatments T_4 and T_{15} were significantly superior to control while remaining treatments were not. During second crop, the maximum content of calcium was for the treatment T_7 (1.52%)

followed by T_{10} (1.26%). Here also the least content of calcium was for the treatment T_{12} (0.24%). The treatments did not differ significantly from control.

4.10.5 Magnesium

Data on magnesium content of leaf sample was presented on Table 10. During first crop, magnesium content was maximum for treatment T_9 (0.54%) followed by treatment T_1 (0.524%). The lowest content of Mg was for treatment T_{15} (0.266%). Treatments T_4, T_{16} and T_{15} were inferior than control and all others were at par. During second crop, leaf Mg content was maximum for the treatment T_{12} (0.482%) and minimum for T_9 (0.283%). Treatments T_{12} and T_5 were superior than control and other treatments were not significantly different from control.

4.10.6 Sulphur

During first crop, the treatments were not significantly different from each other in sulphur content (Table 10) and during second crop treatment T_2 (2.035%) recorded maximum sulphur content followed by T_6 (1.925%). The least sulphur content was for the treatment T_8 (1.285%). Treatments were not significantly different from control. The treatment T_2 was significantly different from T_{13} and T_8.

4.11 Fruit analysis

Data relating to fruit analysis are presented in Table 11.

4.11.1 Nitrogen

Fruit nitrogen content was maximum for the treatment T_{15} i.e. treatment recieving highest level of groundnut cake (2.845%) followed by treatment T_2 (2.835%). The minimum content of nitrogen was for the treatment T_{16} (1.605%).

Table 11. Effect of different sources and levels of nitrogen on N, P, K, Ca, Mg and S content of fruits of okra

Treatments	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		S (%)	
	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
T_1	2.500^{abc}	2.800^{abc}	0.920^{ab}	0.565^{abc}	3.300^{a}	3.200^{ab}	0.080^{a}	0.04^{c}	0.097^{bc}	0.049^{bcdef}	1.243^{ab}	0.730^{abcd}
T_2	2.835^{a}	2.310^{def}	0.890^{ab}	0.690^{a}	4.125^{a}	3.250^{ab}	0.120^{a}	0.08^{abc}	0.094^{ab}	0.050^{bcde}	1.386^{a}	0.835^{ab}
T_3	2.400^{abc}	2.415^{def}	0.850^{abc}	0.540^{abcd}	3.800^{a}	3.075^{abc}	0.075^{a}	0.10^{ab}	0.087^{ab}	0.047^{ef}	1.068^{ab}	0.540^{e}
T_4	2.615^{ab}	2.310^{def}	0.855^{abc}	0.560^{abcd}	8.825^{a}	3.050^{abc}	0.085^{a}	0.10^{ab}	0.090^{ab}	0.048^{def}	1.145^{ab}	0.715^{abcd}
T_5	2.520^{abc}	2.550^{bcde}	0.800^{abc}	0.535^{abcd}	3.550^{a}	2.925^{abc}	0.080^{a}	0.12^{a}	0.070^{bc}	0.051^{abcde}	1.089^{ab}	0.785^{ab}
T_6	1.960^{b}	2.170^{ef}	0.750^{abc}	0.595^{a}	3.725^{a}	3.050^{abc}	0.080^{a}	0.07^{bc}	0.070^{bc}	0.054^{abc}	0.835^{ab}	0.859^{a}
T_7	2.580^{ab}	2.380^{def}	0.920^{ab}	0.555^{abcd}	4.150^{a}	3.075^{abc}	0.100^{a}	0.06^{bc}	0.095^{ab}	0.049^{cdef}	1.175^{ab}	0.792^{ab}
T_8	2.485^{abc}	2.495^{cdef}	0.910^{ab}	0.530^{abcd}	4.300^{a}	3.025^{abc}	0.100^{a}	0.08^{abc}	0.104^{a}	0.049^{bcdef}	1.150^{ab}	0.605^{de}
T_9	2.765^{abc}	2.135^{f}	0.940^{a}	0.500^{cd}	4.050^{a}	3.125^{abc}	0.130^{a}	0.12^{a}	0.088^{ab}	0.045^{f}	1.100^{ab}	0.615^{cde}
T_{10}	2.405^{abc}	2.870^{abc}	0.840^{abc}	0.510^{ab}	3.850^{a}	3.300^{a}	0.100^{a}	0.08^{abc}	0.089^{ab}	0.056^{a}	1.111^{ab}	0.760^{abc}
T_{11}	2.380^{abc}	2.205^{ef}	0.820^{abc}	0.490^{d}	4.100^{a}	2.825^{bc}	0.080^{a}	0.06^{bc}	0.089^{ab}	0.049^{cdef}	1.165^{ab}	0.695^{bcd}
T_{12}	2.450^{abc}	2.355^{def}	0.830^{abc}	0.520^{bcd}	4.025^{a}	3.075^{abc}	0.080^{a}	0.08^{abc}	0.076^{ab}	0.049^{cdef}	1.100^{ab}	0.745^{abcd}
T_{13}	3.205^{abc}	2.920^{ab}	0.730^{bc}	0.520^{bcd}	3.375^{a}	2.825^{bc}	0.080^{a}	0.08^{abc}	0.088^{ab}	0.055^{ab}	0.735^{b}	0.685^{bcde}
T_{14}	2.200^{abc}	2.205^{ef}	0.890^{ab}	0.530^{abcd}	3.500^{a}	3.075^{abc}	0.120^{a}	0.08^{abc}	0.090^{ab}	0.050^{abcde}	1.249^{ab}	0.795^{ab}
T_{15}	2.845^{a}	3.000^{a}	0.685^{c}	0.535^{abcd}	3.575^{a}	2.925^{abc}	0.080^{a}	0.10^{ab}	0.072^{b}	0.053^{abcd}	0.890^{ab}	0.695^{bcd}
T_{16}	1.605^{c}	2.625^{bcd}	0.765^{abc}	0.510^{cd}	3.650^{a}	2.700^{c}	0.080^{a}	0.10^{ab}	0.073^{b}	0.054^{abc}	0.945^{ab}	0.760^{abc}

Treatmants having same alphabet form one homogenous group

The treatments were not significantly different from control. Treatment T_{15} and T_2 had significantly higher nitrogen content than T_6 and T_{16}.

During second crop, fruit N content was maximum for treatment T_{15} (3.00%) followed by treatment T_{13} (2.92%). The least content of N was for the treatment T_9 (2.135%).

4.11.2 Phosphorus

During first crop, the fruit phosphorus content was maximum for the treatment T_9 (0.94%) followed by T_1 (0.92%). The least content of P was for the treatment T_{15} (0.685%). Treatment T_{15} contained less P and it was significantly inferior to the control, and remaining treatments were not significantly different from each other.

During second crop, the P content was maximum for the treatment T_2 (0.6%) followed by T_6 (0.595%). The treatment which had lowest P content was T_{11} (0.49%) which was significantly different and inferior to the control.

4.11.3 Potassium

During first crop, there was no significant difference between treatments in K content. During second crop K content was maximum for treatment T_{10} (3.3%) followed by T_2 (3.25%). The treatment with lowest content of K was T_{16} (2.7%), which was lower than control.

4.11.4 Calcium

During first crop, there was no significant difference in fruit calcium due to treatments. Here treatment T_9 (0.13%) recorded highest value of calcium content.

During second crop calcium content was highest for treatment T_5 and T_9 (0.12%) and least content of calcium was recorded by control (0.04%). All treatments were superior in calcium content when compared to control.

4.11.5 Magnesium

During first crop, the magnesium content was maximum for the treatment T_8 (0.104%). The lowest content of magnesium was for T_5 (0.070%). Treatments did not differ significantly from control. The magnesium content in the treatment T_8 was significantly higher than the treatments T_{16}, T_{15} and T_5. During second crop the magnesium content was maximum for the treatment T_{10} (0.056%) followed by T_{13} (0.055%). The lowest content of magnesium was for the treatment T_9 (0.045%). Treatment T_{10} was superior than control while other treatments were at par.

4.11.6 Sulphur

During first crop, treatments did not differ significantly from each other. During second crop, the sulphur content was maximum for the treatment T_6 (0.859%) followed by treatment T_2 (0.835%). The treatment containing least sulphur was T_3 (0.540%), which was significantly inferior to the control.

4.12 Total plant analysis

The data relating to total plant analysis is presented in Table 12.

4.12.1 Nitrogen

The maximum nitrogen content was recorded by the treatment T_{15} i.e treatment recieving higher level of ground nut cake (1.715%) followed by T_{11} (1.640%). The content of nitrogen was found to be minimum in T_3 (1.120%). Treatment T_{15} was superior to T_3 and control. During second crop, the treatment T_{13}

Table 12. Effect of different sources and levels of nitrogen on N, P, K, Ca, Mg and S content of total plant of okra

Treatments	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		S (%)	
	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
T_1	1.295^{bcd}	1.650^{abc}	0.1960^{a}	0.4700^{a}	1.650^{a}	2.825^{a}	0.56^{b}	0.520^{b}	0.403^{c}	0.481^{def}	0.870^{a}	1.217^{abc}
T_2	1.540^{abcd}	1.310^{bc}	0.2640^{a}	0.2930^{de}	1.588^{a}	2.575^{ab}	0.74^{ab}	0.620^{abc}	0.672^{ab}	0.541^{c}	1.371^{a}	1.287^{ab}
T_3	1.120^{d}	1.610^{abc}	0.2920^{a}	0.3750^{abcde}	1.763^{a}	1.860^{cdef}	0.82^{ab}	0.800^{abc}	0.474^{bc}	0.988^{a}	0.985^{a}	0.785^{cde}
T_4	1.540^{abcd}	1.555^{abc}	0.4540^{a}	0.4300^{abc}	1.370^{a}	1.935^{bcdef}	0.90^{ab}	0.710^{abc}	0.460^{c}	0.441^{efg}	0.880^{a}	0.635^{de}
T_5	1.295^{bcd}	1.470^{abc}	0.2305^{a}	0.4075^{abcd}	1.563^{a}	1.885^{bcdef}	0.80^{ab}	0.705^{abc}	0.490^{bc}	0.464^{defg}	1.120^{a}	1.505^{a}
T_6	1.495^{ab}	1.645^{abc}	0.3385^{a}	0.3556^{abcde}	1.613^{a}	2.550^{abc}	0.74^{ab}	0.700^{abc}	0.660^{ab}	0.350^{h}	1.255^{a}	0.900^{bcde}
T_7	1.435^{abcd}	1.365^{abc}	0.2740^{a}	0.4750^{a}	1.388^{a}	2.070^{bcdef}	0.88^{ab}	0.760^{abc}	0.540^{bc}	0.510^{cde}	0.665^{a}	1.175^{abc}
T_8	1.155^{d}	1.195^{c}	0.3150^{a}	0.3100^{cde}	1.763^{a}	2.285^{abcde}	0.82^{ab}	1.040^{a}	0.518^{bc}	0.432^{fg}	1.430^{a}	1.111^{abcd}
T_9	1.315^{bcd}	1.705^{abc}	0.2980^{a}	0.4100^{abcd}	1.575^{a}	1.485^{f}	1.00^{a}	0.705^{abc}	0.586^{abc}	0.848^{b}	0.935^{a}	0.970^{bcde}
T_{10}	1.225^{cd}	1.575^{abc}	0.2475^{a}	0.3550^{abcde}	1.588^{a}	1.735^{ef}	1.00^{a}	0.960^{ab}	0.520^{bc}	0.524^{cd}	1.265^{a}	1.390^{ab}
T_{11}	1.640^{ab}	1.725^{ab}	0.3080^{a}	0.4400^{ab}	1.813^{a}	1.920^{bcdef}	0.82^{ab}	0.810^{abc}	0.440^{c}	0.402^{gh}	1.090^{a}	0.957^{bcde}
T_{12}	1.520^{abcd}	1.795^{ab}	0.4530^{a}	0.4300^{abc}	1.813^{a}	1.875^{bcdef}	1.03^{a}	0.690^{abc}	0.596^{abc}	0.447^{efg}	1.145^{a}	1.155^{abc}
T_{13}	1.435^{abcd}	1.880^{a}	0.3220^{a}	0.3520^{abcde}	1.763^{a}	2.460^{abcd}	0.73^{ab}	0.760^{abc}	0.460^{c}	0.456^{defg}	1.175^{a}	1.010^{bcde}
T_{14}	1.330^{bcd}	1.800^{ab}	0.2810^{a}	0.2950^{de}	1.500^{a}	2.075^{bcdef}	0.74^{ab}	0.470^{bc}	0.436^{c}	0.446^{efg}	0.740^{a}	1.150^{abc}
T_{15}	1.715^{a}	1.750^{abc}	0.2930^{a}	0.3400^{bcde}	1.663^{a}	1.785^{def}	0.68^{ab}	0.340^{c}	0.749^{a}	0.444^{efg}	1.165^{a}	0.990^{bcde}
T_{16}	1.610^{abc}	1.855^{ab}	0.2420^{a}	0.2800^{e}	1.638^{a}	2.450^{abcd}	0.71^{ab}	0.705^{abc}	0.394^{c}	0.403^{gh}	0.640^{a}	0.910^{bcde}

Treatmants having same alphabet form one homogenous group

recorded maximum nitrogen content i.e treatment recieving higher level of poultry manure (1.880%) followed by treatment T_{16} (1.855%). The lowest nitrogen content was observed in the treatment T_8 (1.195%). The treatments T_{13} and T_{16} were not significantly different from control (1.650%). But the treatment T_{13} was significantly different from T_2 and T_8. There was slight increase in nitrogen content in the second crop than the first crop. Similarly, even though not significant, there was slight increase in nitrogen in the treatments supplied with higher levels of nitrogen.

4.12.2 Phosphorus

During first crop, there was no significant difference in phosphorus content of total plant. The maximum content of phosphorous was for the treatment T_4 (0.454%) followed by T_{12} (0.453%) and minimum was for control (0.196%). During second crop, the Phosphorus content was maximum for the treatment T_7 (0.475%) and minimum phosphorus content was for the treatment T_{16} (0.280%). Treatments T_{15}, T_8, T_{14}, T_2 and T_{16} were inferior to T_7 and control. Remaining treatments were not significantly different from each other.

4.12.3 Potassium

During first crop, the treatments were not significantly different from each other in potassium content. During second crop, the maximum potassium content was for treatment T_1 (2.825%) followed by T_2 (2.575%). The least content of potassium was for the treatment T_9 (1.485%). The treatment T_1 contained significantly higher level of potassium than T_3, T_{15}, T_{10} and T_9.

4.12.4 Calcium

During first crop, calcium content was maximum for the treatments T_{12} (1.030%). The lowest content calcium was for the treatment T_1 (0.560%). During second crop, the maximum content of calcium was recorded for the treatment T_8 (1.040%) followed by treatment T_{10} (0.960%). Treatment T_{15} (0.340%) recorded minimum calcium content in total plant.

4.12.5 Magnesium

During first crop, magnesium content was maximum for the treatment T_{15} (0.749%) followed by T_2 (0.672%). Minimum content of magnesium was for the treatment T_{16} (0.394%). The treatment T_{15} was significantly superior to almost all treatments. During second crop, the maximum content of magnesium was for the treatment T_3 (0.988%) followed by T_9 (0.848%). The least content of magnesium was for the treatment T_{11} (0.402%). Treatments T_3 and T_9 were significantly superior to control whereas the treatments T_{16}, T_{11} and T_6 contained less magnesium when compared to control.

4.12.6 Sulphur

During first crop, the treatments showed no significant difference in sulphur content. During second crop the maximum content of sulphur was recorded by the treatment T_5 (1.505%) followed by T_{10} (1.390%). While T_4 recorded minimum sulphur content (0.635%) which was significantly lower than control.

4.13 Uptake of nutrients

The data relating to the uptake of nutrients are given in Table 13.

4.13.1 Nitrogen

During first crop the uptake of N showed significant difference. The N uptake was maximum for T_{10} (22.8 kg ha^{-1}) followed by T_{13} (17.84 kg ha^{-1}) and was minimum for T_4 (7.235 kg ha^{-1}). During second crop also treatments showed significant difference. The uptake of N was maximum for T_{13} (26.12 kg ha^{-1}) followed by T_3 (20.63 kg ha^{-1}) and was minimum for T_4 (8.84 kg ha^{-1}) during second crop.

4.13.2 Phosphorus

During first and second crop treatments showed significant difference. During first crop P uptake was maximum for T_4 (6.73 kg ha^{-1}) followed by T_{13} (4.095 kg ha^{-1}) and was lowest for T_2 (1.505 kg ha^{-1}). During second crop P uptake was maximum for T_{13} (6.44 kg ha^{-1}) followed by T_7 (4.94 kg ha^{-1}) and was lowest for T_2 (2.22 kg ha^{-1}).

4.13.3 Potassium

During first crop K uptake was maximum for T_{16} (23.77 kg ha^{-1}) followed by T_{13} (22.36 kg ha^{-1}) and was lowest for T_4 (6.22 kg ha^{-1}). During second crop the K uptake was maximum for T_{13} (32.33 kg ha^{-1}) followed by T_5 (20.65 kg ha^{-1}) and was lowest for T_4 (1.895 kg ha^{-1}).

Table 13. Effect of different levels and sources of nitrogen on the uptake of nutrients (kg ha^{-1})

Treatments	N		P		K		Ca		Mg		S	
	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
T_1	8.025^{b}	12.420^{b}	3.305^{ab}	3.825^{ab}	18.320^{bc}	2.340^{c}	3.475^{a}	5.095^{cd}	2.520^{b}	3.865^{bc}	5.505^{c}	10.010^{ab}
T_2	8.570^{b}	9.630^{b}	1.505^{b}	2.220^{b}	8.635^{c}	1.945^{c}	3.925^{a}	4.595^{cd}	3.790^{b}	4.070^{bc}	4.890^{c}	9.860^{ab}
T_3	11.150^{ab}	20.630^{ab}	5.515^{ab}	4.760^{ab}	17.080^{abc}	2.365^{c}	7.165^{a}	1.975^{d}	4.605^{ab}	12.560^{a}	9.640^{c}	9.945^{ab}
T_4	7.235^{b}	8.840^{b}	6.730^{a}	2.405^{b}	6.225^{c}	1.895^{c}	5.125^{a}	0.550^{d}	2.125^{b}	2.660^{c}	4.110^{bc}	3.605^{b}
T_5	12.470^{ab}	16.120^{b}	2.385^{ab}	4.625^{ab}	15.820^{abc}	20.650^{c}	10.100^{a}	4.575^{cd}	2.375^{b}	5.175^{bc}	11.000^{abc}	15.580^{ab}
T_6	13.380^{ab}	15.500^{ab}	2.410^{ab}	3.395^{ab}	11.720^{bc}	13.060^{b}	5.375^{a}	1.445^{d}	4.970^{ab}	3.320^{bc}	9.050^{bc}	3.830^{b}
T_7	11.620^{ab}	14.010^{ab}	2.375^{ab}	4.940^{ab}	11.550^{bc}	10.880^{bc}	7.770^{a}	7.930^{cd}	4.300^{b}	5.325^{bc}	5.350^{c}	12.980^{ab}
T_8	13.580^{ab}	19.080^{ab}	4.000^{ab}	4.875^{ab}	22.070^{ab}	20.350^{b}	10.49	16.330^{b}	6.370^{ab}	6.855^{bc}	18.060^{a}	17.640^{a}
T_9	12.100^{ab}	15.080^{ab}	1.895^{b}	3.620^{ab}	10.340^{bc}	12.870^{b}	7.110^{a}	6.085^{cd}	3.735^{b}	7.350^{bc}	5.680^{c}	8.375^{ab}
T_{10}	22.800^{a}	12.740^{b}	1.685^{b}	2.875^{b}	10.860^{bc}	13.890^{b}	7.650^{a}	7.575^{cd}	3.535^{b}	4.215^{bc}	8.740^{bc}	11.320^{ab}
T_{11}	9.670^{b}	9.645^{b}	1.805^{b}	4.195^{ab}	10.440^{bc}	18.050^{b}	4.650^{a}	7.550^{cd}	2.620^{b}	3.740^{bc}	6.240^{c}	8.845^{ab}
T_{12}	9.835^{b}	15.580^{ab}	2.945^{ab}	3.760^{ab}	11.360^{bc}	17.700^{b}	7.660^{a}	6.130^{cd}	3.880^{b}	3.985^{bc}	7.275^{bc}	10.160^{ab}
T_{13}	17.840^{ab}	26.120^{a}	4.095^{ab}	6.440^{a}	22.360^{ab}	32.330^{a}	7.170^{a}	28.300^{a}	5.735^{ab}	8.140^{b}	14.370^{ab}	18.170^{a}
T_{14}	7.565^{b}	13.830^{ab}	3.460^{ab}	3.615^{ab}	8.655^{c}	16.160^{b}	4.125^{a}	10.540^{bc}	2.485^{b}	3.480^{bc}	4.265^{c}	9.010^{ab}
T_{15}	14.310^{ab}	14.060^{ab}	2.215^{b}	2.810^{b}	13.400^{abc}	14.670^{b}	7.743^{a}	2.815^{cd}	6.495^{ab}	3.320^{bc}	7.815^{bc}	8.040^{ab}
T_{16}	13.950^{ab}	12.850^{b}	3.115^{ab}	3.165^{ab}	23.770^{a}	17.400^{b}	5.850^{a}	1.330^{d}	10.950^{a}	5.050^{bc}	5.355^{c}	11.490^{ab}

Treatmants having same alphabet form one homogenous group

4.13.4 Calcium

During first crop Ca uptake did not show significant difference. Ca uptake was maximum for T_8 (10.49 kg ha^{-1}) followed by T_5 (10.1 kg ha^{-1}) and was lowest for T_1 (3.475 kg ha^{-1}). During second crop Ca uptake was maximum for T_{13} (28.3 kg ha^{-1}) followed by T_8 (16.33 kg ha^{-1}) and was lowest for T_4 (0.55 kg ha^{-1}).

4.13.5 Magnesium

Treatments showed significant difference in Mg content for both the crops. During first crop the maximum Mg uptake was for T_{16} (10.95 kg ha^{-1}) followed by T_{15} (6.495 kg ha^{-1}) and was lowest for T_4 (2.125 kg ha^{-1}). During second crop the maximum Mg uptake was for T_3 (12.56 kg ha^{-1}) followed by T_{13} (8.14 kg ha^{-1}) and was lowest for T_4 (2.66 kg ha^{-1}).

4.13.6 Sulphur

During first crop the maximum S uptake was for T_8 (18.06 kg ha^{-1}) followed by T_{13} (14.37 kg ha^{-1}) and was lowest for T_4 (4.11 kg ha^{-1}). During second crop the maximum S uptake was for the treatment T_{13} (18.17 kg ha^{-1}) followed by T_8 (17.64 kg ha^{-1}) and was lowest was for T_4 (3.61 kg ha^{-1}).

4.14 Scoring of important pest and diseases

4.14.1 Diseases

4.14.1.1 Yellow vein mosaic

During crop I, T_{10} and T_{14} showed maximum number of mosaic affected plants (4) (Table 14). While minimum plants were affected in T_4. Treatments were

Table 14. Effect of different sources and levels of nitrogen on disease incidence (%)

Treatments	Mosaic (%)	
	Crop I	Crop II
T_1	3^a	4^{ab}
T_2	7^a	3^{ab}
T_3	6^a	3^{ab}
T_4	3^a	2^{ab}
T_5	3^a	1^b
T_6	3^a	2^{ab}
T_7	3^a	3^{ab}
T_8	5^a	1^b
T_9	3^a	3^{ab}
T_{10}	8^a	6^a
T_{11}	7^a	3^{ab}
T_{12}	4^a	2^{ab}
T_{13}	5^a	5^{ab}
T_{14}	8^a	5^{ab}
T_{15}	3^a	4^{ab}
T_{16}	4^a	1^d

Treatmants having same alphabet form one homogenous group

not significantly different during first crop. During second crop, incidence of mosaic was less but treatments showed significant difference. Here the incidence was significantly lower in T_5 than T_{10}, T_{13}, T_{14} and T_{15}. Maximum number of mosaic infected plants were recorded in T_{10} (3) followed by T_{13} and T_{14} (2.5).

4.14.1.2 Cercospora leaf spot

Irrespective of treatments, all the plants were affected by cercospora leaf spot during both the crop. During both the seasons, the incidence was noticed only after 50 days of sowing and hence the yield was less affected.

4.14.2 Pests

4.14.2.1 Jassids

Data on Jassid incidence is presented on Table 15. The pest incidence was neglegible up to 40th DAS. So the count was taken from 42 DAS. The treatments did show significant difference in Jassid incidence per leaf. It was maximum for T_{15} (3.39 per leaf) followed by T_6 (3.375 per leaf) and minimum for T_{16} (1.7 per leaf) followed by T_{12} (1.805 per leaf).

Fourty nine DAS also treatments showed no significant difference in jassid population. Here T_1 showed maximum jassid incidence (4.7 per leaf) followed by T_{10} (4.42 per leaf). Minimum incidence was recorded by T_{16} (1.81 per leaf).

Treatments were not significantly different at 55 DAS also. During this time T_{10} showed maximum jassid attack (5.295 per leaf) followed by T_8 (4.565 per

Table 15. Effect of different sources and levels of nitrogen on jassid population

Treatments	Group I						
	42 DAS	49 DAS	55 DAS	61 DAS	67 DAS	74 DAS	81 DAS
T_1	2.560^{a}	4.700^{a}	4.418^{a}	1.635^{b}	4.065^{a}	2.635^{abc}	1.800^{a}
T_2	2.380^{a}	3.985^{a}	3.300^{a}	2.405^{b}	2.550^{ab}	1.960^{bc}	1.700^{a}
T_3	2.760^{a}	3.660^{a}	4.015^{a}	2.035^{a}	3.630^{ab}	2.515^{abc}	1.410^{a}
T_4	2.465^{a}	3.720^{a}	3.372^{a}	2.645^{ab}	2.715^{ab}	2.650^{abc}	1.730^{a}
T_5	2.300^{a}	2.890^{a}	3.575^{a}	1.600^{b}	3.430^{ab}	3.785^{a}	2.160^{a}
T_6	3.375^{a}	2.665^{a}	3.510^{a}	3.395^{ab}	2.950^{ab}	2.730^{abc}	1.920^{a}
T_7	2.190^{a}	3.500^{a}	3.530^{a}	1.740^{b}	3.020^{ab}	1.880^{bc}	1.850^{a}
T_8	2.560^{a}	3.980^{a}	4.565^{a}	2.380^{b}	3.385^{ab}	3.430^{ab}	2.215^{a}
T_9	2.875^{a}	2.185^{a}	2.865^{a}	2.755^{ab}	3.485^{ab}	2.255^{abc}	2.290^{a}
T_{10}	3.160^{a}	4.420^{a}	5.295^{a}	3.295^{ab}	3.265^{ab}	3.600^{a}	1.855^{a}
T_{11}	2.870^{a}	2.950^{a}	3.395^{a}	3.310^{ab}	2.715^{ab}	3.100^{abc}	1.465^{a}
T_{12}	1.805^{a}	3.670^{a}	3.250^{a}	4.660^{a}	2.365^{ab}	2.395^{abc}	1.415^{a}
T_{13}	2.360^{a}	3.500^{a}	3.160^{a}	3.210^{ab}	3.585^{ab}	2.385^{abc}	1.635^{a}
T_{14}	2.440^{a}	3.815^{a}	4.260^{a}	2.100^{b}	2.940^{ab}	1.945^{bc}	1.875^{a}
T_{15}	3.390^{a}	4.045^{a}	4.135^{a}	3.450^{ab}	3.015^{ab}	2.835^{abc}	2.100^{a}
T_{16}	1.700^{a}	1.810^{a}	2.830^{a}	1.850^{b}	1.950^{b}	1.580^{c}	1.418^{a}

Treatmants having same alphabet form one homogenous group

leaf) and was least for T_{16} (2.83 per leaf). Treatments T_{10} and T_8 were more susceptible to jassid incidence than control.

Sixty one DAS treatments showed significant difference in jassid incidence. T_{12} recorded maximum incidence of jassids (4.66 per leaf), followed by T_{15} (3.45 per leaf). Lowest incidence was for the treatment T_5 (1.6 per leaf). T_{12} was significantly different and susceptible to jassid incidence compared to control. T_5 recorded less incidence of jassids compared to control but not statistically significant.

Sixty seven DAS T_1 showed maximum incidence (4.065 per leaf) followed by T_3 (3.63 per leaf) and T_{16} showed least incidence of jassids.

4.15 Economics of cultivation

Economics of application of organic manures on okra was worked out during first crop. Maximum income of Rs. 34203 was obtained by the application of highest level of groundnut cake (100 kg N ha^{-1}) followed by highest level of poultry manure (100 kg N ha^{-1}) i.e., Rs.33784. The net income after deducting the cost of cultivation was maximum for highest level of poultry manure (Rs.17854) followed by poultry manure at 75 kg N ha^{-1} (Rs.10295).

During second crop the maximum income was for highest level of groundnut cake (Rs.21378) followed by highest level of poultry manure (Rs.21115). The net income was maximum for highest level of poultry manure (Rs.6545) followed by poultry manure at 50 kg N ha^{-1} (Rs.115).

Table 16. Economics of application of organic manures on okra (Ist season and 2nd season)

Treatments	1st season					2nd season				
	Cost of cultivation	Gross return	Net return	B/C ratio	Percentage increase over control	Cost of cultivation	Gross return	Net return	B/C ratio	Percentage increase over control
T_1	12412	15763	3351	1.270	-	11052	11658	606	1.05	-
T_2	15510	18333	2823	1.180	-15.76	14150	11457	-2692	0.80	-544.20
T_3	13845	20160	6315	1.470	89.00	12485	12600	115	1.01	-81.02
T_4	14260	14427	167	1.010	-95.00	12900	9016	-3884	0.69	-740.00
T_5	18600	17907	-691	0.960	-99.00	17240	11191	-6048	0.65	-1098.00
T_6	15184	16099	915	1.060	-72.69	13824	10062	-3762	0.73	-890.00
T_7	17385	17976	591	1.034	-82.36	16025	11234	-4791	0.70	-890.59
T_8	14885	25179	10295	1.690	207.00	13525	15736	2211	1.16	264.85
T_9	15510	12067	-3441	0.780	-202.00	14150	8275	-5875	0.58	-1069.47
T_{10}	22060	33379	11319	1.510	237.00	20700	20862	162	1.01	-73.26
T_{11}	16856	15360	-1496	0.910	-144.64	15496	9759	-5737	0.63	-1046.60
T_{12}	19260	19057	-203	0.990	-106.00	17900	11910	-5990	0.66	-1088.45
T_{13}	15930	33784	17854	2.120	432.00	14570	21115	6545	1.45	980.00
T_{14}	16760	18381	1621	1.090	-51.62	15400	9804	-5596	0.64	-1023.40
T_{15}	25460	34203	8743	1.340	160.91	24100	21378	-2722	0.88	-549.10
T_{16}	18576	21951	3375	1.180	0.716	17216	13719	-3497	0.79	-677.06

Discussion

DISCUSSION

5.1 Growth components

The study revealed that during both the seasons plant height at first harvest was maximum for highest level of poultry manure (100 kg N ha^{-1}) the higher uptake of nitrogen have resulted in higher plant hight in this treatment. The works of Sorin and Tanaka (1991) agrees with this finding where in seedling growth of spinach were increased by the application of dried cattle manure sawdust or bark composted with chicken manure.

Dry matter content of plants recorded highest value at the highest level of poultry manure which is in conformity with the findings of Browaldh (1992) in common bean. According to Eno (1966) nitrogen released from poultry manure also contains uric acid having 60 per cent nitrogen, which changes rapidly to ammoniacal form and hence efficiently utilised for better plant growth. Generally plant height and dry matter increased with increased levels of nitrogen. The increase in plant height is attributed to the rapid meristamatic activity in plants due to nitrogen as reported by Crowther (1935). The increase in plant height is attributed to an increased uptake of N which is a constituent of protein and a component of protoplasm. This should have affected the chlorophyll content of leaves resulting in an increased synthesis of carbohydrates. These results agree with the findings of Ozaki and Ray (1957).

During 15-30 DAS, Net Assimilation Rate (NAR) was not affected by different sources of nutrients. Compared to the control, the NAR of plants supplied with organic manures were less. This might be due to the slow release of nutrients by the organic manures than the chemical fertilisers. This was also reported by Poopathi (1994) in tomato. During 30-45 DAS the NAR was affected by the organic manures, and plants supplied with poultry manure showed high NAR compared to other sources. This was in conformity with the findings of Sorin and Tanaka (1991), that sawdust or bark composted with chicken manure increased growth of spinach seedlings. During 45-60 DAS the NAR did not differ much according to the sources of nutrients. This might be due to the transition stage to reproductive phase.

During 15-30 DAS the Relative Growth Rate (RGR) was maximum for the highest dose of sunnhemp and poultry manure (100 kg N ha^{-1}). During 30-45 DAS FYM at highest level (100 kg N ha^{-1}) recorded highest value. Which is in line with the findings of Sorin and Tanaka (1991).

5.2 Earliness and fruit characters

Singnificant difference in index to earliness was expressed only in the first crop. Poultry manure at the rate of 50 kg N ha^{-1} produced the earliest crop. Remaining treatments did not differ much. Days to fifty per cent flowering was also not affected by different sources and levels of nitrogen during first crop. During the second crop treatments T_{14} and T_{15} showed minimum number of days to fifty per cent flowering. This was in conformity with the findings of Nair (1988), that higher rates of nitrogen along with FYM increased the earliness in chilly var. KAU cluster.

Fruit length of bhindi fruits were not influenced by the different levels of nitrogen. This was in confirmity with the findings of Murthy and Murthy (1955), Kunju (1970) and Nair (1988). Fruit diameter is not in influenced by the increase in nitrogen level. Application of increasing levels of N had increased the fruit weight in the two crops under investigation. Wallace (1971) had stated that N is the most important element and any system of crop production requires its application. So the higher level of nitrogen application and its increased uptake had resulted in the increase in fruit weight. This was also reported by Singogo *et al.* (1991) and Anna nurova *et al.* (1992).

5.3 Yield attributes

Yield per plant was maximum for higher levels of poultry manure (189.68) and groundnut cake (182.68). More number of fruits per plant in higher fruit weight had contributed for the increased yield per plant with higher levels of nitrogen. Higher yield by Poultry manure application was reported by many workers (Prezotti *et al.*, 1989, Gardini *et al.*, 1992, Brown *et al.*, 1995). Yield per plot was also increased with increased levels of poultry manure and groundnut cake. Higher content of P and K in the poultry manure and groundnut cake compared to other organic manure used in the experiment might have also contributed to the higher yield. Phosphorus is essential for better root growth and potassium is essential for increased yields of the crops (Tisdale *et al.*, 1995).

Number of harvests and crop duration were significant during the first crop, but this was levelled off by the second crop. Crop duration and number of harvest were more for second crop (May-August 1996). This might be due to of the increased vegetative growth and increased life period of plant during rainy season. Higher moisture content in the soil might have increased the uptake of nitrogen as reported by Kumar (1986)

5.4 Quality of fruits

Different sources and levels of Nitrogen did not produce significant difference in mucilage and fibre content of fruit. Difference in starch content was not in linear with the level of nitrogen. This was in conformity with the findings of Yoshida *et al.* (1984) that there was no significant difference in fruit quality parameters of tomatoes grown organically and inorganically. Organoleptic quality of fruits produced with different sources of N did not differ significantly. However FYM equivalent to 50 kg N ha^{-1} and 75 kg N ha^{-1} recorded better acceptence. This was in conformity with Meir-Proeger (1989). Moisture content, pericarp thickness and vitamin C content was not different significantly according to the sources and levels of nitrogen (Termine *et al.*, 1987).

Protein content was higher in treatments supplied with FYM, vermicompost and poultry manure. These three enzyme digested processed manures may contain their own enzyme residues which confer a superiority over ground nut cake and sunnhemp which are unprocessed organic manures, comparatively high concentration of nitrogen and calcium in poultry manure need high moisture for full expression and hence high protein was observed in the second crop only.

5.5 Percentage of unmarketable fruits on third and fifth day of storage

Irrespective of the treatments all the fruits were marketable even after three days of storage but on fifth day of storage the number of unmarketable fruits were increased at higher level of manures (100 kg N ha^{-1}) In the second crop application of chemical fertilizers as well as the higher dose of groundnut cake (75 kg N ha^{-1}) and sunnhemp (75 kg N ha^{-1}) increased the number of unmarketable fruits. This was in confirmity with the findings of Joseph (1985) that highest rotting percentage was observed for treatments which received higher dose of nitrogen.

5.6 Seed characters

Higher levels of groundnut cake and poultry manure produced higher seed yield per plant. This is mainly due to the increase in production of fruits. This was in conformity with the findings of Pandey (1994) that the increase in nitrogen rates increased seed yield. Potassium content increases the seeds per plant as it is, essential for filling of pod. There was indirect addition of pottassium from poultry manure and groundnut cake. The higher content of potassium might be the reason for higher seed yield per plant (Tisdale *et al.*, 1995). Increased number of seeds per fruit and number of fruits per plant contributed to higher seed yield per plant. Pandey *et al.* (1994) reported better seed production with higher dose of nitrogen. 100 seed weight was not significantly changed with different levels and different sources of organic matter. This finding was in conformity with the findings of Pandey *et al.*(1994) that 100 seed weight is not affected by nitrogen levels. Germination percentage differed significantly for different levels of nitrogen and different sources during both the crops. Similar results was reported by Pandey (1994).

5.7 Soil property

Organic carbon content of soil did not show significant difference between treatments in three soil samples analysed. It did not show significant difference between samples also. Soil organic carbon could be increased only by long and continuous application of organic manures (Sharma *et al.*, 1984). Total nitrogen content of soil showed no significant difference between three samples. The difference observed between treatments might be due to difference in basic level of soil nitrogen before starting the crop. Total nitrogen content did not show increase after each crop for different sources and different levels of nitrogen. Organic manures, even if handled carefully looses a large proportion of nutrients by volatilization as ammonia and by leaching of nitrate. Shinde and Ghosh (1971) also reported that total nitrogen content of soil can be increased only by long term experiment with organic matter.

pH showed significant increase after two crops. Different levels of nitrogen and different sources of nitrogen did not show significant difference for first and second sample (after first crop). Third sample (after second crop) showed slight difference. In the third sample FYM and poultry manure added plots recorded higher values of pH. This was reported by Warman (1990).

5. Chemical analysis of leaf, fruit and total plant

Nitrogen levels of leaves were not significantly different for different levels of nitrogen.This was in confirmity with the study of Brillin (1984) that the levels of nitrogen in leaves were not affected by different levels of nitrogen application. This may be due to higher content of nitrogen in the soil as reported by Padmam (1992). During second crop there was slight increase in the nitrogen content of leaf for all treatments, which can be attributed to higher uptake of nitrogen due to the high moisture content of soil during the rainy season (Kumar, 1986).

P content of leaves was not highly significant. Different sources of nitrogen did not show significant effect on P content, so also different sources of nitrogen did not show significant effect on P content of leaves. This agrees with the findings of Brillin (1984) and Padmam (1992).

During first crop groundnut cake at the rate of 75 kg N ha^{-1} recorded higher K content in leaves, while it was not significant during second crop. Different sources of nutrients showed not much difference in K content.

Fruit analysis showed significant difference in N, P and Mg content. But the variation of nutrients in fruit was not related to the levels and sources of nitrogen applied. This may be due to the non significance of leaf nitrogen content. This was also reported by Brillin (1984). K, Ca and S content also didn't show any significant difference in fruit analysis. This non-significant effect of treatments may be due to the sufficient availability of these elements in the soil associated with different treatments.

Nitrogen content of total plant did not show an increasing trend according to the increase of nitrogen. The reason for this may be attributed to the non-significance of leaf N content due to different doses of nitrogen (Brillin, 1984) and the content of N in the soil was highly varying initially. P and K contents of total plant was also not affected by different sources and levels of manures under investigation during first crop. During second crop, P and K content of total plant showed significant difference. But not affected by source of nitrogen, there was slight increase in P and K content during second crop. Which may be due to higher uptake of nutrients when soil moisture content was high. This was also reported by Patel and Padalia (1980). Ca, Mg and S showed significant difference in total plant analysis. Even though this difference did not show any definite trend according to the sources of nutrients applied, the treatment receiving FYM recorded higher values at 50 kg N ha^{-1} and 75 kg N ha^{-1}.

5.9 Scoring of pest and disease

5.9.1 Disease

Mosaic incidence was not affected by different sources of manures during first crop. But during second crop the higher dose of organic manures (100 kg N ha^{-1}) increased the incidence of mosaic. This might be due to higher N content. Thus the higher incidence of pest and disease was found to be the direct effect of N (Kunnathadi, 1995).

5.9.2 Pest

The crop did not show difference in pest incidence but generally higher dose of groundnut cake (75 kg N ha^{-1} and 100 kg N ha^{-1}) recorded higher incidence during 42, 49 and 55 DAS. However, maximum jassid population was observed in the plots applied with higher levels groundnut cake and control plots.

During 61, 67 and 74 DAS different dose of groundnut cake and poultry manure showed maximum incidence of pest. The higher incidence of jassids might be due to higher vegetative growth of plants in these treatments. The higher incidence of pest due to higher dose of N was reported by Kunnathadi (1995). During 81 DAS the pest incidence was not influenced by N content. It may be because of the lignification of plant tissue by which the pest incidence will be reduced. Since biological pest and disease control measures were taken in the experiment, the data collected on this aspect can not have full reliability.

5.1 D Economics of cultivation

The gross income was maximum for different doses of groundnut cake during both the crop. However, net income was maximum for poultry manure for both the crops. This is because of high cost of groundnut cake.

It is well understood from the Table 16 that bhindi cultivation could be profitable with the application of poultry manure alone.

Summary

SUMMARY

The present investigation was conducted at the vegetable research farm, Department of Olericulture, College of Horticulture, Vellanikkara during September to December 1995 and May to August 1996 to study the source efficiency relations of different organic manures on quality, productivity and shelf life of okra. The experiment comprised of 16 treatments.

1. Among the growth components poultry manure at highest dose (100 kg N ha^{-1}) increased plant height at first harvest in both the crops. Relative Growth Rate increased by the higher dose of groundnut cake equivalent to 75 kg N ha^{-1} and 100 kg N ha^{-1} and during 45-60 DAS the maximum RGR for the FYM at 75 kg N ha^{-1}. During 30-45 DAS poultry manure at 75 kg N ha^{-1} recorded maximum Net Assimilation Rate.

2. Treatments did not show much difference in index to earliness and days to fifty per cent flowering. But treatments showed difference during first crop for index to earliness and during second crop days to fifty per cent flowering showed difference. Fruit diameter was maximum for poultry manure equivalent to 50 kg N ha^{-1} during first crop and groundnut cake equivalent to 75 kg N ha^{-1}. Fruit weight was also increased by groundnut cake equivalent to 75 kg N ha^{-1} during first crop and by control during second crop.

3. Yield per plot and yield per plant were maximum for different doses of poultry manure. Poultry manure equivalent to 100 kg N ha^{-1} recorded maximum yield per plant during first crop and poultry manure at 75 kg N ha^{-1} recorded maximum yield per plant during second crop. Yield per plot was maximum for groundnut cake equivalent to 100 kg N ha^{-1} during first crop

and during second crop poultry manure equivalent to 75 kg N ha^{-1} recorded maximum yield per plot. Number of harvests were significantly different during first crop. Groundnut cake equivalent to 75 kg N ha^{-1} recorded maximum number of harvests, as well as duration.

4. Mucilage content was higher for highest dose of poultry manure (100 kg N ha^{-1}). Moisture content was maximum for groundnut cake equivalent to 75 kg N ha^{-1} and vermicompost equivalent to 100 kg N ha^{-1}. Starch content was maximum for the treatment T_9 (vermicompost equivalent to 75 kg N ha^{-1}). When organoleptic test was conducted the maximum score was for farmyard manure equivalent to 75 kg N ha^{-1}. Protein content was varying for the two crops. FYM equivalent to 50 kg N ha^{-1} and vermicompost equivalent to 75 kg N ha^{-1} recorded maximum protein content during first crop and during second crop poultry manure equivalent to 100 kg N ha^{-1} recorded maximum protein. Fibre content, pericarp thickness and vitamin C content were affected by different sources and levels of nitrogen.

5. Irrespective of treatments all the fruits were marketable on third day of storage. Percentage of unmarketable fruits were maximum for control on 5th day of storage.

6. Seed yield per plant was maximum for groundnut cake equivalent to 75 kg N ha^{-1} and number of seeds were maximum for poultry manure equivalent to 75 kg N ha^{-1}. 100 seed weight was maximum for the control and germination percentage was maximum for poultry manure equivalent to 50 and 75 kg N ha^{-1}.

7. Organic carbon content and total nitrogen and pH were not affected by sources and levels of nitrogen under investigation. pH did not differ significantly from each other sample 1 and sample 2.

8. Leaf nitrogen content did not show significant difference for different treatments. Fruit nitrogen content was maximum for groundnut cake equivalent to 100 kg N ha^{-1} during both the crops. The nitrogen content of total plant was also maximum for groundnut cake equivalent to 100 kg N ha^{-1} during first crop and for poultrymanure equivalent to 100 kg,N ha^{-1} during second crop. The uptake of nitrogen was maximum for groundnut cake 75 kg N ha^{-1} during first crop and for poultry manure 100 kg N ha^{-1} during second crop.

9. Leaf P content was maximum for vermicompost equivalent to 75 kg N ha^{-1} during first crop and was for FYM equivalent to 100 kg N ha^{-1} during second crop. Fruit P content was maximum for vermicompost equivalent to 75 kg N ha^{-1} during first crop and was for FYM equivalent 50 kg N ha^{-1} during second crop. Total plant P content was maximum for vermicompost equivalent to 50 kg N ha^{-1} during first crop and was for FYM equivalent to 75 kg N ha^{-1} during second crop. The P uptake was maximum for vermicompost at 50 kg N ha^{-1} during first crop and was for poultry manure at 100 kg N ha^{-1}.

10. Leaf K content was maximum for groundnut cake 75 kg N ha^{-1} for the first crop and was for FYM 75 kg N ha^{-1} during second crop. Fruit K was maximum for vermicompost 50 kg N ha^{-1} during first crop and was for FYM 50 kg N ha^{-1} during second crop. Total plant K content did not show significant difference during first crop. Total plant K content was maximum for control during second crop. Uptake of K content was maximum for

sunnhemp 100 kg N ha^{-1} during first crop and was for poultry manure 100 kg N ha^{-1} during second crop.

11. Leaf Ca content was maximum for groundnut cake equivalent to 100 kg N ha^{-1} during first crop and was for FYM equivalent to 75 kg N ha^{-1} during second crop. Fruit Ca content was maximum for groundnut cake equivalent to 50 kg N ha^{-1} and vermicompost equivalent to 75 kg N ha^{-1} during second crop. During first crop treatments did not differ significantly. Total plant Ca content was maximum for FYM equivalent to 100 kg N ha^{-1} during first crop and was for FYM equivalent to 50 kg N ha^{-1} during second crop. The uptake of Ca was maximum for poultry manure 75 kg N ha^{-1} during first crop and was for poultry manure at 100 kg N ha^{-1} during second crop.

12. Leaf Mg content was maximum for vermicompost equivalent to 75 kg N ha^{-1} during both the crops. Fruit Mg was maximum for poultry manure equivalent to 75 kg N ha^{-1} during first crop and was for groundnut cake equivalent to 75 kg N ha^{-1} during second crop. Total plant Mg content was maximum for the groundnut cake equivalent to 100 kg N ha^{-1} and was for poultry manure equivalent to 50 kg N ha^{-1}. The maximum uptake of Mg was for sunnhemp 100 kg N ha^{-1} during first crop and was for poultry manure 50 kg N ha^{-1} during second crop.

13. Leaf S conetnt was maximum for FYM equivalent to 50 kg N ha^{-1} during first crop and was for sunnhemp equivalent to 50 kg N ha^{-1} during second crop. Fruit S content was maximum for sunnhemp equivalent to 50 kg N ha^{-1}. Total plant S content was maximum for groundnut cake equivalent to 50 kg N ha^{-1} during second crop. During first crop treatments did not show significant difference. The maximum uptake of S was for poultry manure at 75 kg N ha^{-1}

during first crop and was for poultry manure at 100 kg N ha^{-1} during second crop.

14. In the early stages of crop there was no significant difference in jassid incidence between treatments. During later stages groundnut cake and poultry manure at different levels showed maximum incidence. Mosaic incidence was increased by increased dose of manures.

15. Economics of application of organic manures revealed that maximum net return will be obtained from plots receiving higher doses of poultry manure

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Appendices

APPENDIX-I

Weather data during the period of experimentation

Period	Maximum temperature (°C)	Minimum temperature (°C)	Rainfall (mm)	Number of raindays	Relative humidity 1 morning (%)	Relative humidity 2 afternoon (%)	Sunshine (h)	Wind speed km/ha
August 95	30.6	23.7	448.7	22	94	78	3.7	2.0
September 95	30.1	23.5	282.5	13	94	70	6.1	2.0
October 95	33.2	23.2	110.4	8	91	65	8.3	1.8
November 95	31.3	22.5	88.4	5	91	69	6.5	1.1
December 95	32.5	21.3	0	0	71	43	10.3	6.7
April 96	34.6	25.0	152.0	7	87	59	8.3	3.0
May 96	32.8	25.2	95.4	4	91	63	7.7	3.0
June 96	30.5	23.8	400.3	16	94	75	4.7	3.0
July 96	28.8	23.1	588.7	25	96	83	2.7	2.7
August 96	29.1	23.6	310.0	20	95	78	3.7	3.0
September 96	29.2	23.7	391.6	17	94	74	4.3	2.7
October 96	30.1	22.9	219.3	12	93	70	6.0	2.0

APPENDIX-II

Percentage of nitrogen in organic manures

Organic manure	N (%)
FYM	0.4
Poultry manure	1.3
Groundnut cake	7.3
Sunnhemp	0.588
Vermi compost	0.8

APPENDIX-III

Analysis of variance of plant height and dry matter

Source	Degree of freedom	Mean square			
		Plant height		Total dry matter	
		Crop I	Crop II	Crop I	Crop II
Replication	1	16.77	5.98	257.24	541.20
Treatment	15	33.79	62.99	80.40	154.21
Error	15	17.99	40.09	69.37	125.96

APPENDIX-IV

Analysis of variance of fruit length, fruit diameter and fruit weight

Source	Degree of freedom	Mean square							
		Index to earliness		Fruit length		Fruit diameter		Fruit weight	
		Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
Replication	1	0.0084	0.0005	9.54	0.53	0.003	0.001	38.65	2.09
Treatment	15	0.0077*	0.0005	2.20	0.99	0.175*	0.009	11.26	2.83**
Error	15	0.0022	0.0164	2.12	0.76	0.005	0.003	6.90	0.62

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX-V

Analysis of variance of yield per plant, yield per plot, number of harvest and crop duration

Source	Degrees of freedom	Mean square							
		Yield per plant		Yield per plot		Number of harvest		Crop duration	
		Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
Replication	1	1422.31	2014.53	3014125.28	1107741.74	7.03	0.78	144.5	2.53
Treatment	15	2858.88**	1100.32**	192436.44	657906.60	1.41*	0.99	214.0	9.58
Error	15	301.69	602.4	237580.13	346757.00	0.43	3.04	133.0	21.73

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX-VI

Analysis of variance of protein, vitamin C, pericarp thickness, mucilage, fibre, starch and moisture

Source	Degree of freedom	Mean square										
		Protein		Vitamin C		Pericarp thickness		Muclilage	Fibre	Starch	Moisture	
		Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop II	Crop II	Crop I	Crop I	Crop II
Replication	1	0.04	0.033	5.76	22.70	0.03	0.003	0.025	0.0006	0.005	0.015	0.02
Treatment	15	0.59	0.039	4.94	6.40	0.14	0.004	0.061	0.0215	0.055*	1.200	1.29
Error	15	0.57	0.039	3.59	6.12	0.02	0.003	0.062	0.0271	0.020	0.860	1.38

* Significant at 5 per cent level

APPENDIX-VII

Analysis of variance of seed yield per plant, number of seeds per fruit, weight of seeds per fruit and germination percentage

Source	Degree of freedom	Mean square									
		Seed yield		No. of seeds per fruit		Weight of seeds per fruit		100 seed weight		Germination percentage	
		Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
Replication		10303.30	929.47	19.64	23.65	0.59	0.032	0.75	1.42	64.69	46.32
Treatment		2408.85*	1973.44**	31.15	13.03	0.16	0.066	1.06	0.26	42.18*	20.77**
Error		890.37	370.66	31.68	18.91	0.34	0.068	0.59	0.32	14.97	4.65

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX-VIII

Analysis of variance of pH, total nitrogen and organic carbon

Source	Degrees of freedom	Mean square								
		pH			Total nitrogen			Organic carbon		
		S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Replications	1	0.69	0.001	0.17	0.01	0.0002	0.001	0.02	0.01	0.21
Treatments	15	0.08	0.180	0.18	0.06	0.2400*	0.032	0.06	0.04	0.04
Error	15	0.11	0.310	0.08	0.05	0.0250	0.024	0.04	0.08	0.05

* Significant at 5 per cent level

SOURCE EFFICIENCY RELATIONS OF DIFFERENT ORGANIC MANURES ON QUALITY, PRODUCTIVITY AND SHELF LIFE OF OKRA [*Abelmoschus esculentus* (L.) Moench.]

By

P. K. SMITHA NANDINI

ABSTRACT OF A THESIS

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Kerala Agricultual Univesity

Department of Olericulture
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680654
KERALA, INDIA

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ABSTRACT

Present investigations were conducted at the vegetable research farm, Department of Olericulture, College of Horticulture, Vellanikkara, during September to December 1995 and May to August 1996 to study the source efficiency relations of different organic manures on quality, productivity and shelf life of okra. The experiment comprised of sixteen treatments and were laid out in a randomised block design.

Study revealed that plant height at first harvest was increased by poultry manure at highest dose (100 kg N ha^{-1}). Relative Growth Rate was higher for groundnut cake equivalent to 75 kg N ha^{-1} and 100 kg N ha^{-1} during 30-45 DAS and during 45-60 DAS the maximum RGR was for FYM at 75 kg N ha^{-1}. During 30-45 DAS poultry manure at 75 kg N ha^{-1} recorded maximum Net Assimilation Rate.

Yield per plot was increased with groundnut cake equivalent to 75 kg N ha^{-1} and yield per plant was maximum for poultry manure at 75 kg N ha^{-1}.

Mucilage content of fruit was maximum for poultry manure at 100 kg N ha^{-1}. Starch content was maximum for vermicompost at 75 kg N ha^{-1}, when organoleptic test was conducted the maximum score was obtained for FYM equivalent to 75 kg N ha^{-1}.

Percentage of unmarketable fruits showed difference for different treatments and percentage of unmarketable fruits was maximum for control on fifth day of storage.

Seed yield per plant was maximum for groundnut cake equivalent to 75 kg N ha^{-1} and number of seeds were maximum for poultry manure equivalent to 75 kg N ha^{-1}. Germination percentage was maximum for poultry manure equivalent to ıd 75 kg N ha^{-1}.

Soil properties like organic carbon and total nitrogen and pH did not show significant difference by the addition of organic fertilizers.

Jassid incidence increased by higher dose of groundnut cake and poultry manure. Mosaic incidence increased by higher levels of nitrogen.

Maximum net return was obtained from plots receiving higher dose (100 kg N ha^{-1}) of poultry manure.