"STANDARDISATION OF ORGANIC NUTRIENT SCHEDULE FOR CHILLI (*Capsicum annuum*)"

by

AKSHAY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "**Standardisation of organic nutrient schedule for chilli** (***Capsicum annuum***)" is a bonafied 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 of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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MY FAMILY

and Dr. T Sajitha Rani.

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LIST OF ABBREVIATIONS

@	at the rate of
^{o}C	Degree Celsius
%	Per cent
B:C	Benefit cost ratio
CD	Critical difference
cm	Centimetre
DAT	Days after transplanting
et al.	And others
Evapn.	Evaporation
Fig.	Figure
FYM	Farmyard manure
ha^{-1}	Hectare
g	Gram
i.e.	That is
K	Potassium
K_2O	Potash
kg ha^{-1}	Kilogram per hectare
LAI	Leaf Area Index

l	Litre
m	Metre
mg	Milligram
N	Nitrogen
No.	Number
NS	Not significant
P	Phosphorus
P_2O_5	Phosphate
$Plant^{-1}$	Per plant
POP	Package of practices
$q\ ha^{-1}$	Quintal per hectare
RBD	Randomized block design
RH	Relative humidity
Rs	Rupees
RFD	Recommended fertilizer dose
SE	Standard error
Sl.	Serial
$t\ ha^{-1}$	Tonnes per hectare

INTRODUCTION

INTRODUCTION

Organic agriculture is derived as a production system which largely excludes or completely avoids the use of synthetically compounded pesticides, fertilizers, growth regulators, preservatives and livestock feed additives, organic agriculture practices thus rely upon recycling of crop residues, animal manure, off-farm organic residues and wastes. Organic agriculture is gaining movement in India due to the individual as well as group efforts to conserve environments and avoid contamination of the farm produce from the use of chemical fertilizers and pesticides. The important principle of organic food movement is promotion of ecological soundness and sustainable use of natural resources, and maintenance of crop diversity.

Farmyard manure being a bulky organic material reduces the soil compaction and improves the aeration in addition to the supply of essential plant nutrients and organic matter, thereby increasing the soil microbial establishment along with accumulation of excess humus content. The poultry manure contains 60 per cent organic N. Due to rapid mineralization poultry manure is recognized as a valuable source of plant nutrient for all crops.

In view of higher cost of inorganic fertilizers and its contribution to ill-effects on soil and water, it has become imperative to go for alternative and cheaper sources of organic manures so as to partially reduce the cost and fulfill the crop requirement.

Organic agriculture cannot be adopted uniformly under all farming situations. The technology has a role to play in the cultivation of high value crops, fruits, vegetables, spices, condiments, medicinal and aromatic plants. The organically cultivated food crops have a vast untapped export potential growing at 10-15 per cent per year. The sustainable agricultural practice can effectively prevent entry of pesticides and toxicants in the food chain and prevent soil and water pollution vis-a-vis health hazards. If adopted with a blend of ecologically safe modem technologies, organic agriculture, though not in its orthodox version, has the potential to be accepted by the farmers. Theoretically organic agriculture is the most ideal system of farming.

India is the largest producer, exporter and consumer of spices in the world. Major share of spices (90%) produced in the country is used to meet the domestic need or demand, only 10 per cent is exported. Organic spices fetch 20-50 per cent higher price than inorganic spices. India with its strength in intrinsic quality of spices and low consumption of fertilizers and pesticides can exploit the commercial agriculture sector.

Chilli is an important export oriented crop, suitable for both tropical and sub tropical regions. Though chilli is an introduced crop in India, due to its suitable growing climate, India stands first in chilli cultivation in the world covering 45 per cent of the total acreage (Reddy and Sadashiva, 2001). The area under chillies in India is 792.1 million ha with production of 1223.4 metric tonnes and the productivity is 1.54 tonnes ha^{-1} (NHB, 2011). It is grown throughout the country in almost all the states. Indian chilli is exporting to over 90 countries (81,500 tonnes) in the form of dry chilli, value added products *viz.*, the chilli powder and also the oleoresin with a total revenue of about Rs.355.11 crores annually (Anon., 2004).

Chillies are used both in green and dry form in all culinary preparations equally by rich and poor alike. Chilli is rich in vitamins A, C, and E. Though consumption of chilli is highest in India, maximum export is also from our country. Oleoresin of chilli with low, medium or high pungency is also exported in large quantities. Indian chillies and its products are brought out by a number of countries. The processed and value added products are exported to Sri Lanka, Bangladesh, South Korea, USA, Germany, Japan, United Kingdom and France. We need to expand the organic production of chilli and export with value addition.

Keeping all the above information in view, a field experiment was conducted to study the effect of organic manures on chilli with the following objectives.

1. To standardize the organic nutrient schedule for chilli
2. To assess the economics of the different treatments.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Now-a-days use of excess chemical fertilizers and pesticides has lead to environmental as well as health hazards apart from deteriorating the soil ecosystem. To overcome these problems, organic farming which aims at cooperating rather than confronting with the nature is most appropriate. Chilli is considered as one of the most important commercial spice crops and is one of the important nutritious and highly remunerative vegetable crops grown mainly for its mature green fruits. The literature pertaining to use of organics (farmyard manure, poultry manure and neem cake) on growth, yield and quality of chilli are very scarce, so the effect of organics on chillies as well as on few of the related crops have been reviewed and presented in this chapter.

2.1. CHARACTERISTIC FEATURES OF ORGANIC SOURCES USED

2.1.1 Manurial value of FYM

The nutrient content of FYM varies with the constituents composition. The nutrient content of FYM in a study by Chatterjee *et al.*, (1979) was found to be 0.64 % of N, 0.07 % P and 0.29 % K.

Sharma and Mitra (1989) reported that FYM contained 26.1 % of C, 1.71 % of N, 0.24 % of P and 2.04 % of K on dry weight basis, the C:N ratio was 15:1. The FYM used in the trials of Sriramachadrasekharan *et al.*, (1996) had 1.2 % N, 0.21 % P, 1.96 % K, 26.90 % C with C:N ratio of 22.4:1.0. The FYM seems to act directly by increasing the crop yield either by accelerating the respiratory process through cell permeability or by hormone growth action. It supplies nitrogen, phosphorus and sulphur in available forms to the plants through biological decomposition. Indirectly, it improves the physical properties of soil such as aggregation, aeration, permeability and water holding capacity (Chandramohan, 2002).

2.1.2 Manurial value of poultry manure

Garg *et al*., (1971) reported that the poultry manure can provide annually 0.03, 0.26 and 0.14 million tonnes of N, P_2O_5 and K_2O respectively as they contain 7.5 % N, 6.5 % P_2O_5, 3.5 % K_2O and 60 to 100 ppm Zn, 7 to 15 ppm Cu, 380 to 1450 ppm Fe and 120 to 200 ppm of Mn.

Venkatasubramanian (1988) evaluated the fertilizer value of poultry litter at different stages. The poultry litter up to eight weeks contain higher amounts of nitrogen, phosphorus and potash (3.65, 1.83 and 1.66 % respectively) as compared to farmyard manure (0.9, 0.6 and 1.1 % N, P and K respectively).

Rajput and Goyal (1991) stated that poultry manure was an excellent source of organic matter and it can utilize for growing field crops. Srivastava and Khanna (1994) indicated that the level of nitrogen in fully built up deep litter when it is 12 months old reaches about 3 % N, 2 % P and 2 % K and other trace elements. Sandhyarani and Ramaswamy (1996) reported 2.8 % N, .5 % P, 1.2 % K and 44.5 % organic carbon in the poultry droppings.

Poultry manure contained N (3.4 to 4.3 %), P (1.9 to 2.2 %), K (2.0 to 2.4 %). It was alkaline in nature (pH 7.5 to 8.5) and immediately raised the pH of loams from 6.5 to 7.5 (Sims and Wolf, 1994). Fertilizer value of poultry manure was estimated to be three times than that of FYM. This was attributed to combined presence of urinary faecal excretions in the manure. One tonne poultry litter equals approximately 160 kg ammonium sulphate 150 kg super phosphate, 50 kg of potassium sulphate, 30 kg of calcium, 7 kg of magnesium and 7 kg sodium. One tonne of deep litter manure could meet the recommended nutrients for 0.75 ha of millets or 0.4 ha maize, wheat or rice or 0.2 ha of vegetables or 0.10 ha of sugarcane (Devegowda, 1997).

Poultry waste is a bulky material consisting of waste feed, solid and liquid droppings, litter, diseased and dead birds, egg shells *etc.* On an average it contains 3.2 % N, 2.1 % P_2O_5 and 1.7 % K_2O (Devegowda, 1997). The major portion of the total P of poultry manure was in inorganic form (74 %) with a C:P ratio of 32 and N:P of 3.4 with a dry matter content of 62 % (Shepherd and Withers, 1999).

2.1.3. Manurial value of neemcake

Oil cakes of different kinds are produced in India to the tune of about two million tonnes annually. They contain not only nitrogen but also phosphorus and potash besides large quantity of organic matter. Non edible oil cakes like neem cake, castor cake, mahua cake and pongamia cake can be used as manures. These cakes start decomposing after soil application and liberate nitrogen in the form of ammonia for the use of crops readily and gradually like other organic manures and inhibit soil borne pathogens.

2.2 EFFECT OF ORGANIC MANURES ON GROWTH AND YIELD CHARACTERS OF VEGETABLES

2.2.1 Effect of FYM on growth and yield characters of vegetables

FYM serves as a good source of almost all plant nutrients. The results of the permanent manurial experiment conducted at Coimbatore since 1909 revealed that the effect of FYM on first 36 crops was inferior to that of complete mineral fertilizers (NPK) whereas the yields from the 37^{th} crop onwards indicated a relatively better performance of FYM. The same situation in favor of FYM over NPK existed till the 82^{nd} crop (Krishnamoorthy and Ravikumar, 1973).

Application of FYM resulted in higher plant height of Capsicum (Valsikova and Ivanic, 1982). They also reported that application of chemical fertilizers in the absence of FYM retarded the formation of vegetative organs.

Increase in the growth and yield of chilli, bhindi, tomato and brinjal by organic manure application was reported by Gaur *et al.*, (1984).

Gianquinto and Borin (1990) observed an increase in plant growth of tomato plants by the addition of organic manures.

In a study conducted by Montasser (1991) on bhindi, it was revealed that the average length and fresh weight of shoot and root increased considerably in cattle, pigeon, rabbit and sheep manure amended plots.

In a trial in bhindi, Issac (1995) found the highest root spread of 44.05 cm obtained with the application of 6 t ha^{-1} of FYM along with inorganic fertilizers. The beneficial effect of organic amendments in increasing the growth parameters was reported by Pushpa (1996) in tomato and Anitha (1997) in chilli. Chavan *et al.* (1997) reported that combined application of nitrogen through FYM and urea was more beneficial to fertilizer alone in order to increase yield and quality of chilli. According to Arunkumar (1997) FYM application was found to be superior to vermicompost in inducing better plant height in amaranthus.

Joseph (1998) noted that in snake gourd, growth characters viz., weight of roots $plant^{-1}$ and dry matter production ha^{-1}, and yield attributing characters like length, weight and number of fruits $plant^{-1}$ were highest in FYM treated plants as compared to poultry manure or vermicompost treated plants. Senthilkumar and Sekar (1998) reported that fruit yield $plant^{-1}$ in bhindi was increased markedly by FYM application.

According to Arunkumar (2000), FYM application induced better plant height, root biomass production and leaf area index in amaranthus. Sharma and Sharma (2004) found that application of FYM (10 and 20 t ha^{-1}) in tomato significantly increased the plant height and number of branches $plant^{-1}$ over no application. A comparative study was conducted by Mangila *et al.,* (2007) to determine the effect of organic fertilizer on the yield of watermelon using chicken dung, cow manure, rice straw and ASG 46. The result of study showed that among the organic fertilizers used cow manure produced 30 fruits which was more than the control plants (no fertilizer used)

A field experiment conducted by Akparobi (2009) revealed that when amaranthus was treated with various FYM levels of 0 t ha^{-1}, 15 t ha^{-1}, 25 t ha^{-1} and

35 t ha^{-1}, treatment with the highest manure level of 35 t ha^{-1} attained the highest plant height of 123.27 cm and those that received no manure treatment reached a maximum height of only 80.20 cm.

In a field experiment conducted by Sekhar and Rajasree (2009) at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore to find out the effect of different organic manures on growth, yield and quality attributes of bhindi, it was revealed that among the different organic manure treatments, application of FYM @ 20 t ha^{-1} performed better than the other treatments through improved plant characters viz. Number of fruits $plant^{-1}$ (19.3) and yield (10.39 t ha^{-1}) compared to the FYM manure application at lower doses.

An experiment conducted by Eifediyi *et al.*, (2010) to determine the effects of FYM on the growth and yield of cucumber, it was found that the application of FYM at 10 tha^{-1} produced the highest number of fruits $plant^{-1}$ which was significantly different from the 5 t ha^{-1} and control. Fruit weight and yield increased significantly with increase in the rate of FYM applied. FYM application with the rate of 10 t ha^{-1} out yielded the control plants by 60 %.

2.2.2. Effect of poultry manure on growth and yield characters of vegetables

A study on optimum level of poultry manure requirement for cauliflower by Singh *et al.*, (1970) revealed progressive increase in growth and yield of cauliflower when the dose was increased from 0 to 169.6 q ha^{-1}. Singh *et al.*, (1973) reported that, in potato, poultry manure application exhibited better response over FYM on yield and growth attributes.

Anitha (1997) reported that in chilli various growth attributes like plant height, number of branches, dry matter production and yield, quality and yield attributes were better with poultry manure application as compared to FYM or vermicompost.

In lettuce, poultry manure applied at 0, 20 and 40 kg ha^{-1} either as entire basal dose or in splits increased the yield from 0.66 to 0.81 and 0.90 kg $plant^{-1}$ (Anez and Tavira, 1984). Govindasamy *et al.*, (1994) while studying the optimal combinations of N in the form of urea and poultry manure reported that, use of poultry manure is more economical at high targeted yields than at low targeted yields. The performance of poultry manure was better than FYM. One kg of nitrogen from FYM and poultry manure is able to produce 15 and 28 kg of potato tubers respectively (Srivastava, 1998).

Espiritu *et al.*, (1995) reported that, the crop yield improvement due to addition of poultry manure was attributed to the presence of both readily available and slow release nitrogen.

Chezhiyan *et al.*, (2002) conducted an experiment where in the treatment combinations of poultry manure (3 t ha^{-1}) along with *Azospirillum* (2 kg ha^{-1}) and phosphobacteria (2 kg ha^{-1}) at wider spacing (45 x 10 cm) registered the highest number of branches $plant^{-1}$ (30.23), number of leaves $plant^{-1}$ (328.50), plant spread (55.85 cm^2) and specific leaf area (227.20 cm^2 g^{-1}) in *Phyllanthus amarus*. The increase in plant height was more with the application of composted poultry manure than with FYM. The influence might be due to the improvement in soil physical condition provided for plant growth and due to increased availability of nutrients especially N, P, K even from the early stage of crop growth according to Maskina *et al.* (1988).

Sheshadri and Shetty (2002) recorded significantly higher dry chilli yield (765 kg ha^{-1}) with the application of poultry manure @ 3 t ha^{-1} when compared with 100 % RDF (739 kg ha^{-1}) and FYM @ 10 t ha^{-1} (652 kg ha^{-1}). The higher yield in poultry manure and RDF could be attributed to significantly higher values of yield components like number of fruits $plant^{-1}$, 100 fruit weight, fruit length and yield $plant^{-1}$.

2.2.3. Effect of neem cake on growth and yield characters of vegetables

Som *et al.*, (1992) while studying the influence of organic manures on growth and yield in brinjal it was found that maximum fruit length and diameter were recorded when mahua cake and neem cake were applied @ 50 q ha^{-1} respectively. Neem cake applied @ 50 q ha^{-1} produced the maximum fruit weight of 125.38g, highest yield $plant^{-1}$ of 1.43 kg and highest fruit yield of 22.56 t ha^{-1}.

Raj (1999) reported that in bhindi, growth characters like plant height, LAI, DMP, yield attributes like fruit number $plant^{-1}$, fruit weight, fruit length and fruit yield were higher in neem cake treated plants as compared to that of FYM, poultry manure, green leaf and enriched compost on equivalent N basis.

Arunkumar (2000) reported that in amaranthus, application of neem cake produced higher yield as compared to that of chemical fertilizers on equivalent N basis, but was inferior to that of FYM, vermicompost and poultry manure.

Reddy and Padmodaya (1996) reported that application of panchagavya 3 % along with neem cake @ 250 g $meter^{-2}$ in tomato recorded maximum shoot/root length along with highest fruit yield over control.

Singh (1998) conducted an experiment in brinjal, where in basal application of neem cake @ 20 q ha^{-1} recorded significantly higher yield of 107.70 q ha^{-1}. Further, protection against incidence of borers was also provided by neem cake + neem oils and he concluded that neem products have the potential to increase production without causing environmental problems.

2.3 EFFECT OF ORGANIC MANURES ON QUALITY ASPECTS OF VEGETABLES

2.3.1 Effect of FYM on quality attributes of vegetable

In oriental pickling melon the organic form of manures showed definite advantage over inorganic fertilizers in respect of storability, while the degree of rotting increased in treatment, which received inorganic form of NPK (KAU, 1987).

Abusaleha (1992) recommended equal quantity or more organic form of nitrogen for getting good quality okra fruits. Bhadoria *et al.*, (2002) reported that protein and total mineral content of okra fruit were high, when it was treated with FYM. Omae *et al.,* (2003) reported that cattle compost application increased freshness and vitamin C content in melon.

Meier and Lehri (1989) studied the quality of tomato plants grown with compost from biogenic waste, NPK fertilizers, composted FYM and commercial organic manures used for comparison. They found that storage quality was improved in compost treatments.

Montegu and Gosh (1990) found that fruit colour of tomato was significantly increased as a result of application of organic manures of animal origin.

Nandhakumar and Veeraraghavathatham (2001) recorded significantly higher ascorbic acid content over control due to application of crop residues

Lekshmi (2011) in a study on chilli observed that application of biowastes mixed with cowdung in the ratio of 10:1 on volume basis increased capsaicin content.

2.3.2 Effect of poultry manure on quality attributes of vegetables.

Anitha (1997) observed that chilli plants treated with poultry manure recorded the maximum ascorbic acid content of fruit as compared to vermicompost and control treatments.

Joseph (1998) observed that in snake guard, poultry manure treated plant recorded the highest crude protein content and the lowest crude fibre content as compared to that of FYM and vermicompost treated plants.

According to Sharu (2000) poultry manure application registered maximum keeping quality of fruits compared to vermicompost, neem cake and POP recommendation.

Arunkumar (2000) reported that in amaranthus maximum protein content was obtained with poultry manure application as compared to that of FYM, vermicompost, coir pith compost and POP recommendation.

The application of recommended dose of nitrogen in the form of poultry manure recorded highest pH, total soluble solids, titrable acidity, reducing sugar, non-reducing sugar, crude protein and ascorbic acid content in tomato fruit (Prabhakaran and Pichai, 2002).

Nair (2003) reported that quality attributes like ascorbic acid content and iron content were highest when chemical fertilizer was substituted with poultry manure in 1:1 ratio.

2.3.3 Effect of neem cake on quality attributes of vegetable

Peter *et al.*, (2000) have evaluated different organics with NPK fertilizers on quality of turmeric and ginger. The results indicated that the recovery of curcumin and oleoresin in respect of turmeric and ginger respectively was higher due to incorporation of neem cake.

2.4 EFFECT OF ORGANIC MANURES ON NUTRIENT UPTAKE BY VEGETABLES

2.4.1. Effect FYM on nutrient uptake

Raju *et al.*, (1991) observed FYM application to be more effective in increasing N uptake in chickpea. Minhas and Sood (1994) found that application of FYM was beneficial in enhancing the uptake of phosphorus by potato and maize.

Srivastava (1985) observed that increased use of nitrogenous fertilizers decreased organic matter content and total nitrogen, while FYM increased the above parameters.

Sharma *et al.*, (2001) reported that conjoint use of N along with FYM markedly influenced NPK uptake. FYM application along with different levels of S, Mo, Fe, Zn and Co increased the uptake of major and micro nutrients by cowpea at harvest (Sharma *et al.*, 2002).

2.4.2. Effect poultry manure on nutrient uptake

Abusaleha (1992) observed an increased uptake of N,P,K, Ca and Mg in bhindi when 40 kg N was supplied through poultry manure compared to the application of the same quantity through farm yard manure or ammonium sulphate on equivalent nitrogen basis. In a trial on cabbage, Warneke and Siregar (1992) observed an increased uptake of nutrients due to higher rates of poultry manure application. Anitha (1997) observed the better uptake of N in poultry manure treated chilli plants.

2.4.3 Effect of neem cake on nutrient uptake

Significant increases in crop yield and N uptake were obtained by using cereal straw and neem cake in the proportion of 3:1 in maize crop (Gaur and Mathur, 1979).

In bhindi, N and P uptake and available N in soil were highest for neem cake application as compared to FYM, poultry manure and compost Raj (1999).

2.5 EFFECT OF ORGANIC MANURES ON NUTRIENT AVAILABILITY

2.5.1 Effect of FYM on soil available nutrients

Havanagi and Mann (1970) in a long term fertilizer experiment under dry farming conditions in Delhi reported that FYM application increased available P_2O_5 content of the soil but not the total nitrogen.

In wheat–maize rotation, available N and P_2O_5 content of the soil increased with continuous use of FYM (Prasad and Singh, 1980). Negi *et al.*, (1981) reported an increase in the available K content of the soil in FYM applied plots compared to fertilizer applied plots. Kanwar and Prihar (1982) reported that continuous application of FYM increased the nitrogen content of soil.

Available K increased slightly with the addition of FYM for a long time (Sharma *et al.*, 1984). Srivastava (1985) observed that increased use of nitrogenous fertilizers decreased total N and available P and K status of soil whereas FYM addition increased all these parameters in the soil.

Sharma and Sharma (1988) compared the effect of FYM and green manure and inferred that there was a built up of available K which was maximum with the use of FYM than green manure. Available phosphorus content of soil was significantly increased with the incorporation of FYM. Dhargawe *et al.*, (1991) observed a significant increase in 'P' availability in soil following the application of FYM.

Dhanokar *et al.*, (1994) found that continuous use of FYM raised the available K content of soil by 1.3 to 5.4 folds over control. Humus by virtue of its chelating properties increases the availability of N, P, S and other nutrients to plants growing in humus rich soil. Bharadwaj (1995) reported the most significant role of organic matter in supplying K. Singh *et al.*, (1995) reported that the application of FYM improved the organic carbon, P and available K contents of the soil.

The results of study on releasing pattern and availability of P from different soil types of Andhra Pradesh showed that increasing levels of FYM and applied P increased the available P in all types of soils (Saravanapandian, 1998).

Hedge *et al.*, (1998) reported that the nutrient content (P, K, Mg and Ca) and organic carbon content of rhizosphere soil almost doubled when it was supplied with FYM or vermicompost for over two seasons. Radhamadhav *et al.*, (1999) observed that incorporation of FYM in field crops improved the phosphorus status of the soil through slow decomposition of FYM. The beneficial effects of FYM on various physic - chemical properties of soil and to sustain higher yield levels was reported by Sudhakar (2000).

Patidar and Mali (2002) found that available N and P in soil after sorghum harvest with 10 tonnes ha^{-1} FYM application was higher by 9 and 16 % respectively over no FYM application. The increase in N and P in soil was due to the release of N and P on decomposition of FYM. Addition of FYM improved the N, P and K status of soil (Bandgopadhyay and Puste, 2002).

2.5.2 Effect of poultry manure on soil available nutrients

Singh *et al.*, (1973) attributed the higher efficiency of poultry manure to its narrow C: N ratio and comparatively higher content of readily mineralisable N.

Bitzer and Sims (1988) reported in a nutrient availability study that when poultry manure is applied to the soil, long term increase in soil levels of P, K, Ca, Mg, Mn, Cu and Zn can be expected though there was a lack of difference in soil nitrogen levels between zero and high nitrogen rates of poultry manure due to complete utilization of N by the plant.

Ningping *et al.*, (1991) observed an increase in potassium and sodium contents of the soil with the application of 17 t ha^{-1} of poultry manure.

In a field experiment conducted to find out the effect of poultry manure on phosphorus availability and uptake, it was observed that soluble phosphorus in soil solution was higher when poultry manure was added (Warncke and Siregar, 1992).

Warncke and Fonteno (1993) reported that the application of poultry manure to loamy sandy soil had increased the available phosphorus status.

Application of poultry manure (15 t ha^{-1}) as source of nitrogen increased the exchangeable K and available K content of soil in a tomato field (Julia *et al.*, 1993).

Sharu (2000) reported that highest level of poultry manure (5 t ha^{-1}) recorded highest level of soil N compared to vermicompost, neem cake and POP recommendation in chilli. Nair (2003) reported that among FYM, poultry manure and vermicompost, poultry manure recorded the highest availability of nutrients NPK.

2.5.3 Effect of neem cake on soil available nutrients

Most of the non-edible oil cakes contain alkaloids, which inhibit the nitrification process of nitrogen transformation in soils. Neem cake contains the alkaloids, nimbin and nimbidin, which effectively inhibit the nitrification (Reddy and Prasad, 1985).

According to Sathianathan (1982) in cassava, neem and mahua cake treatments were efficient in retaining more nitrogen in the ammoniacal form under field condition. These oil cakes reduced leaching losses and extended the period of availability of nitrogen to the crop from applied N. Raj (1999) reported that, in bhindi, available N content in soil was highest for neem cake application as compared to that of FYM, poultry manure and compost.

2.6. EFFECT OF ORGANIC MANURES ON SOIL REACTION

Havanagi and Mann (1970) reported that FYM application increased the organic carbon content of the soil. Srivastava (1985) observed that increased use of nitrogenous fertilizer decreased organic C content and total N, while FYM increased the above parameters. Udayasoorian et al. (1988) reported that carbon content of soil increased from 0.91 to 1.58 % by the continuous application of organic manures and among the organic manures FYM had a significant influence.

Joseph (1998), in a field experiment in snake gourd reported that organic carbon content was highest in FYM applied plots compared to poultry manure and vermicompost treated plots. Lal and Mather (1988) reported that application of N, P and K fertilizers reduced the pH from 5.5 to 3.8 but FYM application maintained or increased the pH of the soil, while the combination of fertilizers and manures decreased the pH. FYM application resulted in lowest acidity due to the decrease in exchangeable and soluble aluminum in soil (Nambiar, 1994). Incorporation of organic waste significantly increased the soil pH and nutrient status of an acid soil (Lal *et al.*, 2000).

Sreekala (2004) reported increased organic carbon content due to FYM application as compared to that of poultry manure and neem cake.

2.7 EFFECT OF ORGANIC MANURES ON ECONOMICS OF CULTIVATION

Arokiaraj and Kannappan (1995) studied the effect of organic waste on yield and economics of sorghum (CO-25) and reported higher straw yield and grain yield resulting in higher net returns and B: C ratio, by the application of FYM 5 tonnes ha^{1}.

Bharadwaj (1995) reported that total returns on organic farming were higher than from other systems due to high premium on standard product prices. A study on the benefit-cost ratio analysis of ginger indicated that application of FYM @ 48 t ha^{-1} recorded the highest return of Rs. 1,20,245 and B:C ratio of 2.32 : 1 (KAU, 1999).

Raj (1999) observed that application of FYM along with neem cake (150 kg ha^{-1}) and azospirillum recorded the highest fruit yield and profit in bhindi. This treatment gave an additional profit of 32.04 % over control (POP recommendation of KAU).

Maximum net return with a benefit: cost ratio of 2.30 was obtained when 100:50:50 kg NPK plus 20 t ha^{-1} FYM were applied to tomato (Raut *et al.*, 2003).

Application of poultry manure / neem cake / FYM to supply 100 kg N ha^{-1} (N equivalent basis) in combination with a seedling dip of azospirillum and foliar application of 2 % pseudomonas combined with cow's urine spray at 5 % concentration was the best economic organic nutrient schedule for increasing the productivity of bhindi (Geethakumari, 2005).

Prabhakaran (2008) observed that application of organic nitrogen in the form of 150 kg N as urea to the soil increased the net returns, gross returns and benefit- cost ratio of tomato cultivation to 5.2. Shekhar and Rajasree (2009) observed that among the treatments, application of FYM at 20 t ha^{-1} resulted in a higher B:C ratio in bhindi (3.56) compared to the lower levels.

2.7.EFFECT OF COMBINED ORGANIC NUTRIENT SOURCES ON GROWTH, YIELD, QUALITY, NUTRIENT UPTAKE, NUTRIENT AVAILABILITY, SOIL REACTION AND ECONOMICS OF VEGETABLES

In a field having low content of available nitrogen (210 kg ha^{-1}) application of four levels of nitrogen (0, 80, 120 and 160 kg) through poultry manure, FYM and their combination with fertilizer recorded significantly increased response to each addition. (Singh *et al.*, 1982).

John (1989) observed that plant height and number of branches increased with increased dose of nitrogen and phosphorus, but potassium had no significant influence on these characters.

Govindasamy *et al.*, (1994) while studying the optimal combinations of N in the form of urea and poultry manure reported that, use of poultry manure is more economical at high targeted yields than at low targeted yields. The performance of poultry manure was better than FYM.

Studies conducted at Kerala Agricultural University revealed that a basal dose of 25t ha^{-1} of FYM and application of poultry manure to supply the recommended dose of 75kgN ha^{-1} was the best economic organic nutrient schedule for bitter gourd, (Meerabai *et al.,* 2006).

Sherly (1996) noted significant increase in plant height and number of branches in chilli at higher levels of N and K.

Organic manure like FYM, compost, oil cake, green leaf, poultry manure etc improve the yield as well as quality of vegetable crops like tomato, onion, gourds, chilli etc. (Rani *et al.*, 1997). Maheswarappa *et al.,* (1997) observed that, organic carbon content was increased to a greater extent at 0.25 m depth with FYM and vermicompost application than the other organic sources.

Increase in ascorbic acid content in tomato, pyruvic acid in onion and minerals in guards were reported by the application of organic manures (Rani *et al.*, 1997). Ascorbic acid of chilli was increased when nitrogen was applied through FYM and urea compared to fertilizer applied alone (Chavan *et al.*, 1997).

Joseph (1998) observed that in snake guard, yield attributing characters like length, weight and number of fruits plant^{-1} were highest in FYM treated plants as compared to poultry manure or vermicompost treated plants. It was also reported that shelf life of snake gourd grown with organic residue was much higher as compared to that grown with fertilizers.

Sathesh (1998) summarized that FYM when applied along with neem cake enhanced the organic carbon content of the soil. In Bhindi (Raj 1999) reported that all organic nitrogen sources (neem cake, green leaf, poultry manure and enriched compost) except FYM showed superior growth characters like plant height and LAI and yield attributes like fruit number plant^{-1}, fruit weight, fruit length and fruit yield.

Raj (1999) reported that in bhindi yield attributes like fruit number plant^{-1}, fruit weight, fruit length and fruit yield were higher in organic manure treated plots. FYM + neem cake recorded maximum number of fruits plant^{-1}, FYM + neem cake and FYM + green leaf recorded comparable and maximum yield of 158 and 153 q ha^{-1} respectively. Raj (1999) also reported that crude protein content and ascorbic acid content were maximum for FYM + poultry manure and FYM + enriched compost respectively. FYM + enriched compost and FYM + neem cake recorded comparable and lowest crude fiber content and highest keeping quality of fruits.

Rao *et al.*, (2001) studied the effect of organic manures like vermicompost, neem cake, *Azospirillum* and *Phosphobacterium* on the growth and yield of brinjal and observed that the highest fruit yield was obtained with the treatment FYM + vermicompost followed by FYM + neem cake.

The application of dairy cattle waste and poultry waste composts released approximately 31.5 and 51.3 % nitrogen respectively and also had decreased nitrate leaching to deeper soil layer in Kyushu area (Yanwang *et al.*, 2002).

Jayasree (2005) found that the combined application organics and inorganics with 100 % RDF significantly increased the growth characters.

According to Shakila and Anburani (2008) combined application of FYM (12.5 t ha^{-1}) + vermicompost (2.5 t ha^{-1}) + panchagavya (3%) foliar spray resulted in improvement of growth characters in tomato. Similar improvement in growth characters was also observed by the application of press mud (6.25 t ha^{-1}) + vermicompost (2.5 t ha^{-1}) + panchagavya (3 %) foliar spray.

Bharadwaj (1995) reported that total returns on organic farming were higher than from other systems due to high premium on standard product prices. Raj (1999) observed that application of FYM along with neem cake (150 kg ha^{-1}) and azospirillum recorded the highest fruit yield and profit in bhindi. This treatment gave an additional profit of 32.04 % over control (POP recommendation of KAU).

In an experiment conducted by Rajeswari and Shakila (2009) at Annamalai University, application of FYM 10 t ha^{-1} + vermicompost 2.5 t ha^{-1} along with panchagavya 3 % as foliar spray significantly enhanced the uptake of nitrogen, phosphorus and potassium in palak.

Increase in available P content of soil due to organic manure application may be due to the solubilization of native P through release of various organic acids (Sharma *et al.*, 2009) which might be the reason for increased uptake. Similar results of increased nutrient uptake due to the application of organic manures were reported by Barani and Anburani (2004) and Raj (1999). Significant increase in nutrient uptake due to increased levels of FYM and vermicompost in bhindi was also reported by Sharma *et al.*, (2009).

Application of poultry manure / neem cake / FYM to supply 100 kg N ha^{-1} (N equivalent basis) in combination with a seedling dip of azospirillum and foliar application of 2% pseudomonas combined with cow's urine spray at 5 % concentration was the best economic organic nutrient schedule for increasing the productivity of bhindi (Geethakumari, 2005). Prabhakaran (2008) observed that application of organic nitrogen in the form of 150 kg ha^{-1} N as urea to the soil increased the net returns, gross returns and benefit- cost ratio of tomato cultivation to 5.2. Shekhar and Rajasree (2009) observed that among the treatments, application of FYM at 20 t ha^{-1} resulted in a higher B:C ratio in bhindi (3.56) compared to the lower levels.

2.9. EFFECT OF INTEGRATED NUTRIENTS ON GROWTH AND YIELD OF VEGETABLES

2.9.1. Effect of integrated nutrients on growth and yield characters of vegetables

Ivanov and Surlekov (1975) showed that cucumber crop receiving a basal dose of 30 t FYM ha^{-1} along with N at 100 and 70 kg ha^{-1} raised the yield by 28.1 and 25.6 % respectively compared with untreated control. For a successful crop of bitter gourd, Katyal (1977) suggested 50 t ha^{-1} FYM and 100 kg ha^{-1} of ammonium sulphate.

Subbaiah *et al.*, (1982) reported that combined application of 25 t FYM ha^{-1} and inorganic fertilizer (80:35:35 kg NPK ha^{-1}) was beneficial in increasing the yield of chilli as compared to fertilizer alone. Thomas (1984) reported an increase in mean length of the bitter gourd fruits by the application of organic and inorganic combination. A combination of 80 kg N through poultry manure and 80 kg N through fertilizer recorded maximum yield of potato (Singh *et al.*, 1982) Effect of varying levels of N with and without FYM was studied at Agricultural College, Tirupati by Narasappa *et al.*, (1985) and their study revealed that, yield of green chillies was maximum at 150 kg N + 10 t FYM ha^{-1}.

A trial conducted by Mesina (1986) in Philippines revealed that application of 10 t cattle dung ha^{-1} along with 120 kg N ha^{-1} as chemical fertilizer increased the number of fruits and yield $plot^{-1}$ of muskmelon by 34% and 84.68% respectively.

Mina (1986) reported that application of poultry manure alone and in combination with 14:14:14 NPK fertilizer mixture irrespective of the rates significantly increased the yield of muskmelon.

Damke *et al.*, (1988) observed an enhanced plant height and highest yield of chilli with application of FYM @ 9 t ha^{-1} along with 50 kg ha^{-1} each of N, P and K. Similarly, Surlekov and Rankov (1989) also reported greater plant height, number of branches and number of leaves $plant^{-1}$ in chilli with the application of FYM @ 20 t ha^{-1} along with 100:80:100 kg N, P_2O_5 and K_2O ha^{-1}.

Natarajan (1990) recorded higher plant height, number of branches $plant^{-1}$, highest fruit number, fruit weight $plant^{-1}$ and yield of chilli ha^{-1} with combined application of 25 t ha^{-1} FYM as a basal dose along with 75:33:35 kg NPK ha^{-1} and observed that only organic or inorganic fertilizer sources will not increase yield of chilli.

Nair and Peter (1990) reported highest yield in chilli with 15 t FYM and 5:40:25 kg NPK ha^{-1} in the three season trial, when compared to FYM alone or inorganic fertilizer alone

Fung *et al.*, (1994) from an experiment conducted on chilli has showed that plant height was significantly higher with organic manures than chemical fertilizers

Thamburaj (1994) found that organically grown tomato plants yielded 28.18 t ha^{-1} which was on par with the recommended dose of FYM and NPK (20 : 100 : 100).

In a trial in bhindi, Issac (1995) found the highest root spread of 44.05 cm obtained with the application of 6 t ha^{-1} of FYM along with inorganic fertilizers.

According to Mallanagouda *et al*., (1995) the application of recommended dose of NPK (100:80:80 kg ha^{-1}) + FYM (10 t ha^{-1}) improved the growth parameters, yield and yield components of chilli.

Chavan *et al*., (1997) found that combined application of nitrogen through FYM and urea was more beneficial compared to fertilizer alone in order to increase the yield and quality of chilli.

An experiment conducted by Dademal and Dongale (1999) on lateritic soils to study the response of bhindi to the application of organic manures and varied levels of chemical fertilizers at Dapoli, revealed that application of FYM @ 7.5 t ha^{-1} along with N P K @ 150, 75 and 75 kg ha^{-1} was most useful for maximization of fruit yield (85.01 q ha^{-1}). Naidu *et al*., (1999) found that application of NPK @ 80:60:50 kg ha^{-1} + 20 t FYM ha^{-1} in bhindi resulted in increased number of fruits $plant^{-1}$, weight of fruits $plant^{-1}$ and maximum fruit yield.

The study conducted by Patil *et al*., (2000) on the effect of organic manures and biofertilizers on yield and quality of bhindi revealed that application of biofertilizers (1 litre slurry) + FYM + 50 kg N ha^{-1} was beneficial for obtaining higher yields of export quality fruits when compared to their individual application.

According to findings from the field experiment conducted at University of Agricultural Sciences, Dharwad by Sutagundi (2000) combined application of RDF + FYM resulted in significant improvement in yield attributes and NPK up take of chilli.

In a long term trial conducted on chilli by Shashidhara (2000) it was reported that, the plant height, number of branches, leaf area and LAI, yield and yield parameters increased significantly at all growth stages due to application of FYM (5 t ha^{-1}) + RDF (100:50:50 kg NPK ha^{-1}). Sharu (2000) reported that integrated use of chemical fertilizer and poultry manure in 3:1 ratio recorded maximum number of branches $plant^{-1}$, shoot-root ratio and LAI in chilli.

Suresh (2000) reported that, combined application of RDF (100:50:50 kg N P K ha^{-1}) + FYM recorded significantly higher dry chilli fruits as compared to RDF alone (11.28 q ha^{-1}).

Sheshadri and Shetty (2002) recorded significantly higher dry chilli yield (765 kg ha^{-1}) with the application of poultry manure @ 3 t ha^{-1} when compared with 100% RDF (739 kg ha^{-1}) and FYM @ 10 t ha^{-1} (652 kg ha^{-1}). The higher yield in poultry manure and RDF could be attributed to significantly higher values of yield components like number of fruits plant $^{-1}$, 100 fruit weight, fruit length and yield plant $^{-1}$

Chezhiyan *et al.*, (2002) conducted an experiment where in the treatment combinations of poultry manure (3t ha^{-1}) along with *Azospirillum* (2 kg ha^{-1}) and phosphobacteria (2 kg ha^{-1}) at wider spacing (45 x 10 cm) registered the highest number of branches per $plant^{-1}$ (30.23), number of leaves $plant^{-1}$ (328.50), plant spread (55.85 cm^2) and specific leaf area (227.20 cm^2g^{-1}) in *Phyllanthus amarus*

According to Malawadi (2003), the plant height, number of branches, leaf area, LAI and total dry matter production in various plant parts of chilli recorded significantly higher values with combined application of NPK + FYM as compared to NPK alone. Patil *et al.,* (2004) reported that application of FYM (50 %) along with half RDF recorded maximum number of fruits $plant^{-1}$ and the highest fruit yield, over 100 % RDF in tomato.

The application of organics *viz.*, FYM, chilli stalks and FYM + chilli stalks with inorganic fertilizers (RDF) significantly influenced growth, yield and nutrient uptake of chilli and the magnitude of combined effect of organic and inorganics was higher than inorganics alone (Kattimani, 2004).

Study conducted by Singh and Mukherjee (2008) on effect of FYM, chemical and biological fertilizers on yield and quality attributes of brinjal revealed that yield increased with the application of FYM and chemical fertilizers at increasing level up to 100 % of recommended dose of N and P + FYM @ 20 t ha^{-1}.

2.9.2. Effect of integrated nutrients on quality aspects of vegetables

Shanmugavelu (1989) pointed out that the application of combination of FYM and inorganic mixture was best for firmness, storage life and keeping quality of tomatoes for a long time. Nair and Peter (1990) reported that the number and weight of unmarketable fruits after 10 days of storage from harvest of green chillies increased with increasing rates of NPK along with FYM. Shelf life of fruits under room temperature was more (4 days) when nitrogen nutrition was given through 2:1 ratio of organic chemical nitrogen using poultry manure as organic source in equivalent nitrogen basis (Rajasree, 1999).

Shashidhara (2000) found that the combined application organics and inorganics with 100 % RDF significantly increased the ascorbic acid as compared to 100 % RDF alone. Malawadi (2003) reported that the ascorbic acid content was significantly higher with the application of NPK + Ca + S + Fe (81.67 mg 100^{-1} g of fruits), NPK + Ca + S (79.83 mg 100^{-1} g of fruits), NPK + S (78.73 mg 100^{-1} g of fruits) and NPK + FYM (76.60 mg 100^{-1} g of fruits) as compared to application of NPK alone (59.20 mg 100^{-1} g of fruits). Sreeja (2003) observed that plants treated with 2:1 NK ratio and *Azospirillum* was found to be significantly superior in capsaicin content. Jayasree (2005) also reported higher capsaicin content with POP recommendation of KAU.

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

Prabhakaran (2008) reported that application of 150 kg nitrogen in the form of pressmud recorded higher shelf life period of 8.3 days for tomato fruits. But application of 150 kg nitrogen in the form of urea decreased the shelf life (3.1 days) of fruits. Rodge and Yadlod (2009) found out that the shelf life of fruits was maximum for the treatment with 50% recommended fertilizer dose and 50% vermicompost.

Niranjana and Devi (1990) noted that, the capsaicin content of chilli was very low in plots without P. Favourable effect of P on capsaicin content was shown by several workers (Subbiah *et al.*, 1980, Murugan *et al.*, 2002; Satyaseelan, 2004). Sreeja (2003) observed that plants treated with 2:1 NK ratio and *Azospirillum* was found to be significantly superior in capsaicin content.

2.9.3. Effect of integrated nutrients on nutrient uptake of vegetables

Sharma *et al.*, (1988) noticed higher uptake of nitrogen by rice with the application of organic manure along with increasing doses of inorganic nitrogen. Wei, and Zhan (1988) observed that chemical fertilizer application along with vermicompost increased the nutrient uptake and net production of wheat and sugarcane. The increased uptake of phosphorus is attributed to due to synergistic effect of sulphur in phosphorus uptake as also reported by Sud *et al* (1996). Organic manures applied in conjunction with optimal NPK dose resulted in the highest K uptake by crops (Sarkar *et al.*, 1989 and Singh and Tomar, 1991).

Abhusaleha, (1992) revealed that the uptake of nitrogen and phosphorus was greater in the treatment combination of half inorganic and half organic, particularly from poultry manure. The highest K uptake was observed in plants applied with equal quantities of organic and inorganic nitrogen. Chavan *et al.*, (1997), Shashidhara (2000) and Kattimani (2004) in chilli have also reported the increased uptake of nitrogen due to combined application of organics and inorganics followed by only organics.

Barani and Anburani (2004) opined that application of FYM at 25 t ha^{-1} along with 75 % of the recommended dose of inorganic fertilizer and vermicompost at 5 t ha^{-1} recorded the highest nutrient uptake in bhindi.

2.9.4. Effect of integrated nutrients on nutrient availability of vegetables

Thakur *et al.*, (1998) found that status of nutrients in soil showed an increased availability of N and P, whereas, there was decline in the level of soil K in treatments having organic substitutes over, those without organic substitutes. Singh *et al.* (1998) also reported that net balance of soil available N, P and K increased appreciably with FYM/green manures applied either alone or in combination with inorganic fertilizers.

Raj (2006) had reported that combined application of organic manures showed considerable residual effect in improving available nitrogen content of soil compared to the sole application of manures.

2.9.5. Effect of integrated nutrients on soil reaction

Thakur *et al.*, (1998) found an increased availability of organic carbon in treatments having organic substitutes over those without organic substitutes. Lekshmi (2011) reported lowest pH with the application of POP recommendation of and it was on par with absolute control.

2.9.6. Effect of integrated nutrients on economics of cultivation

Maximum net return with a benefit: cost ratio of 2.30 was obtained when 100:50:50 kg NPK plus 20 t ha^{-1} farmyard manure (FYM) were applied to tomato (Raut *et al.*, 2003).

In a study conducted on tomato Kumar (2011) reported that the POP recommendation of KAU gave the highest combined B:C ratio (at premium price) of 1.79 followed by full organic nitrogen substitution with B:C ratio of 1.38. The B:C ratio was the lowest in 50% organic nitrogen substitution (0.78).

Prabhakaran (2008) observed that application of organic nitrogen in the form of 150 kg N as urea to the soil increased the net returns, gross returns and benefit- cost ratio of tomato cultivation to 5.2.

2.10. EFFECT OF ORGANIC MANURES ON PEST AND DISEASE INCIDENCE

While evaluating the effects of organic manures on the incidence of stem fly in soybean, Kumar *et al.*, (1996) observed least incidence of stem tunnelling with FYM application alone (6.45%) and highest with inorganic fertilizer alone (14.87%).

Various amendments like composted cattle manure, poultry manure, sewage sludge and composted wool waste were found to suppress the club root disease caused by *Plasmodiophora brassicae* in field grown Chinese cabbage (Kinoshita *et al.*, 1984). Mutitu *et al.*, (1988) observed that the Fusarium yellow caused by *Fusarium oxysporum* f. sp. *phaseoli* on bean can be reduced by the application of FYM.

Dayakar *et al.*, (1995) reported that when FYM was applied along with 50: 50 NP fertilizer, the population of pigeon pea pod borer was lower than under the use of straight inorganic fertilizers alone.

Aguilar and Barea (1996) observed that increased levels of soil microbial activity leading to increased competition and antagonism in the rhizosphere, the presence of beneficial root colonizing bacterial and increased levels of vesicular-arbuscular mycorrhizal colonization of roots have all been identified as contributing factors in the control of root diseases in organic farms.

Lotter *et al.*, (1999) reported that organic crops were more tolerant as well as resistant to insect attack. A study on integrated nutrient management in chilli by Sharu (2000) revealed lowest incidence of bacterial wilt when chemical fertilizers and neem cake were applied in the ratio 3:1 whereas highest incidence was noted in plots where package of practices recommendations of Kerala Agricultural University was followed.

Khan *et al.*, (1996) revealed that the application of neem cake, groundnut cake and castor cake increased the fungal population in rhizosphere and suppressed the number of parasitic fungi as well as phytophagus nematodes.

Application of organic manures like neem cake, biocompost and vermicompost harboured more microbes in soil than the control. Bacterial, fungal and actinomycetes counts were maximum under organic treatments (Naidu *et al.*, 1999).

MATERIALS AND METHODS

3. MATERIAL AND METHODS

The field investigation on "Standardisation of organic nutrient schedule for chilli (*Capsicum annuum*)" was taken up at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, during May – October, 2012. The main objectives of the study was to assess the effect of different levels of FYM and levels of organic manure combination on growth, yield, quality of chilli and to assess the economics of the different nutrient sources.

3.1 EXPERIMENTAL SITE

The experiment was conducted at College of Agriculture, Vellayani. (Kerala) situated at 8.5 ^{0} North latitude and 76.9^0 East longitude and at an altitude of 29 m above mean sea level.

3.1.1 Soil

Prior to the experiment, composite soil samples were drawn from 0 - 30 cm layer of the soil and analyzed for its mechanical composition and chemical properties. The data on the mechanical composition and chemical nature of the soil of the experimental site are presented in Tables 1a and 1b respectively.

The soil of the experimental site was sandy clay loam, belonging to the taxonomical order Oxisol. It was acidic in reaction, high in organic carbon content, medium in available nitrogen, high in available phosphorus and low in available potassium status.

Table 1a. Mechanical composition of the soil of the experimental site

Sl.No.	Fractions	Content in soil (%)	Method used
1	Coarse sand	63.09%	Bouyoucos hydrometer method (Bouyoucos ,1962)
2	Silt	10.38%	
3	Clay	26.53%	

Table 1b. Chemical properties of the soil of the experimental site

Sl. No.	Fractions	Content in soil	Method used
1	Available N (kg ha^{-1})	374.60 kg ha^{-1} (med)	Alkaline Permanganate Method (Subbiah and Asija, 1956)
2	Available P_2O_5 (kg ha^{-1})	84.43 kg ha^{-1} (high)	Bray Colorimetric Method (Jackson,1973)
3	Available K_2O (kg ha^{-1})	92.85 kg ha^{-1} (low)	Ammonium Acetate method (Jackson,1973)
4	Organic carbon (%)	1.23% (high)	Walkley and Black Rapid Titration Method (Jackson,1973)
5	Soil reaction (pH)	5.80	1: 2.5 Soil solution ratio using pH meter with glass electrode (Jackson,1973)

3.1.2 Cropping history of the field

The area was under a bulk crop of rice before the experiment.

3.1.3 Season

The experiment was conducted during the *kharif* season from May-October, 2012.

3.1.4 Weather conditions

The weekly averages weather parameters *viz.* maximum and minimum temperature, evaporation, relative humidity and rainfall received during the cropping period was collected from the observatory attached to the College of Agriculture, Vellayani were given in Appendix 1 and illustrated in Fig.1.

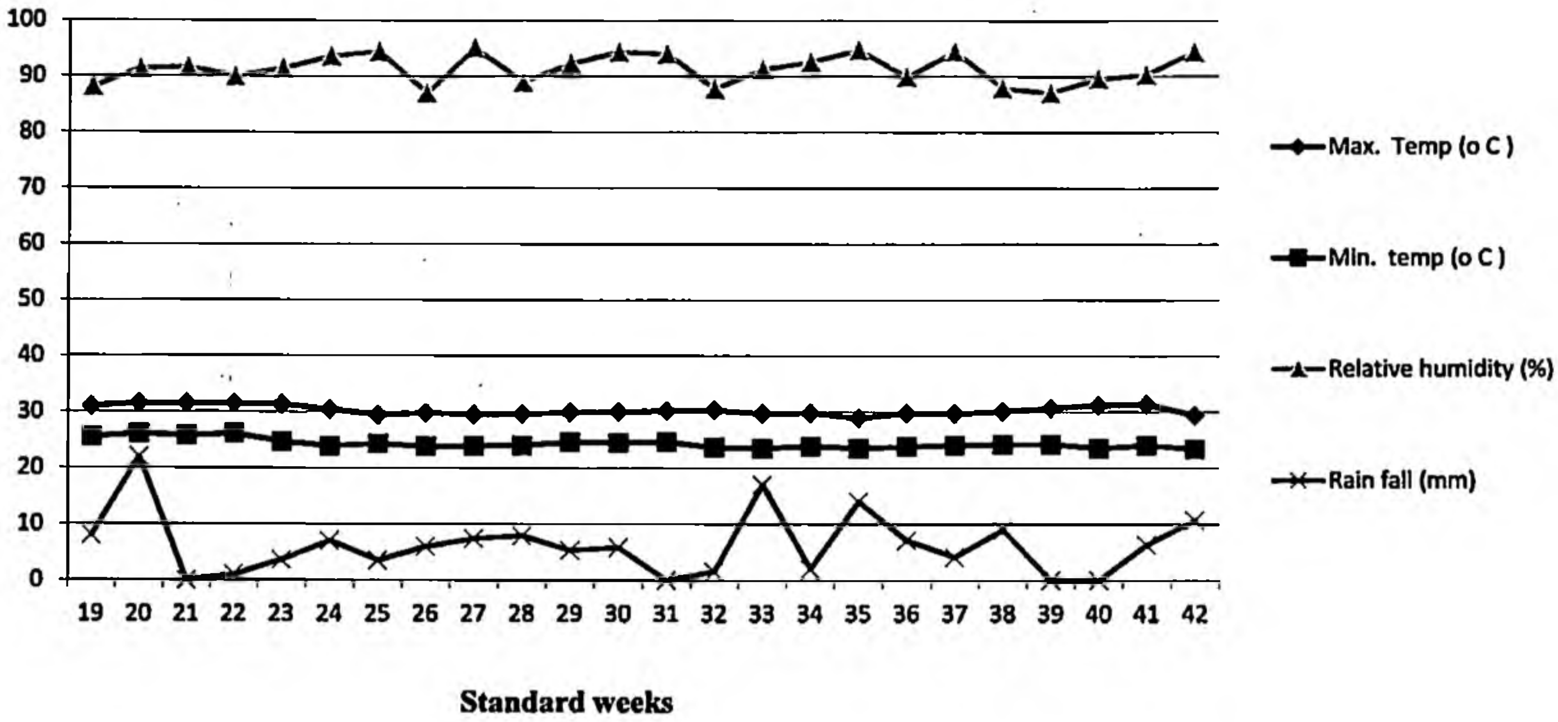

Fig.1. Weather data during the cropping period (May to October 2012)

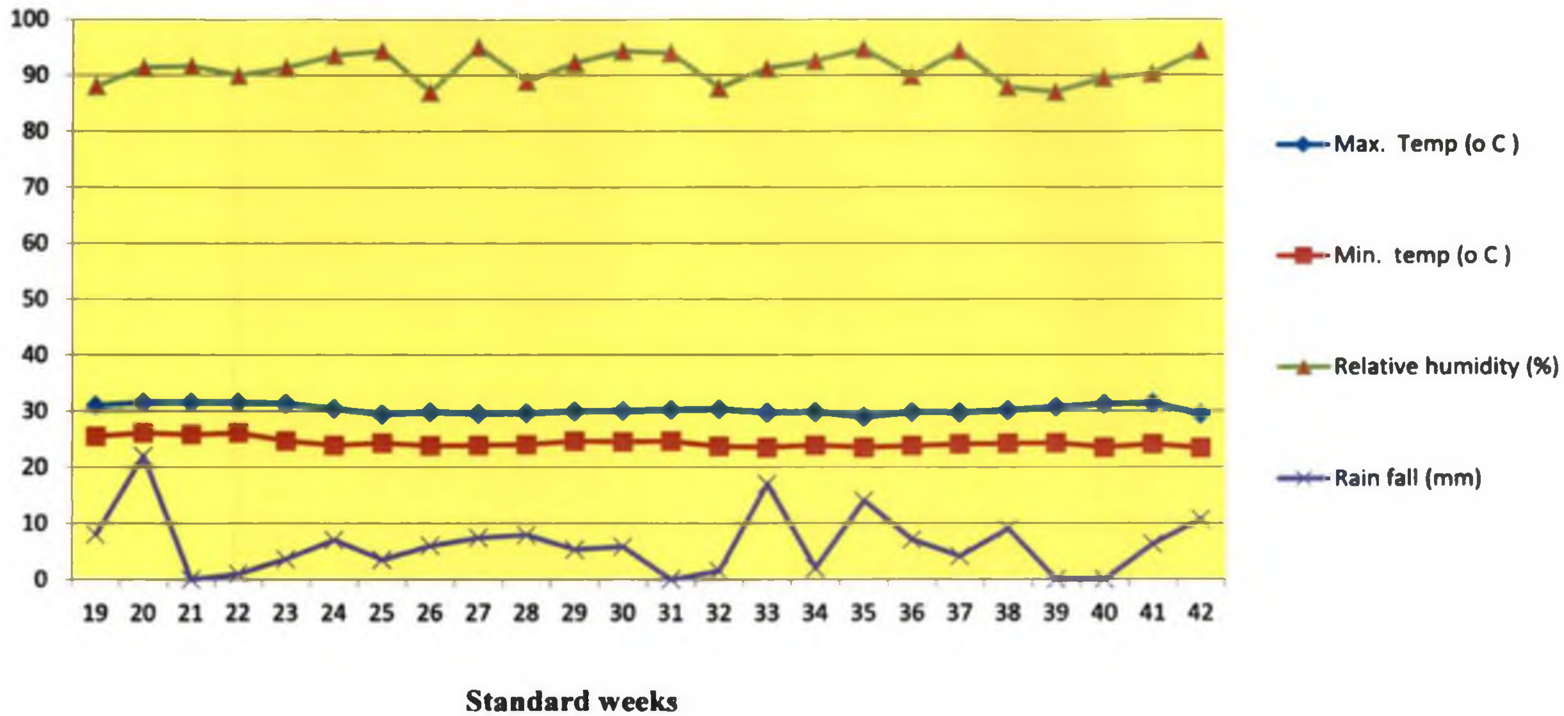

Fig.1. Weather data during the cropping period (May to October 2012)

3.2 MATERIALS

3.2.1 Cultivar used

The chilli variety Vellayani Athulya selected for the experiment had attractive light green colour, long fruit with medium pungency. Plants are short statured with good spread, tolerant to mild shade and was released from College of Agriculture, Vellayani. The variety is a selection from Aryanadu local. The plant grows to a height of 100 cm with canopy spread of approximately one meter, leaves are thick and light green in colour. It is highly branching type. Fruits attain deep blood red colour on maturity and develop wrinkles on the pericarp. Matured fruits are 8-10 cm long but less pungent.

3.2.2 Source of seed material

The seed for the study was obtained from the Department of Olericulture, College of Agriculture, Thiruvananthapuram, Kerala.

3.2.3 Manures and fertilizers

Farm yard manure (0.50 % N, 0.2 % P_2O_5, 0.5 % K_2O) and neem cake (3.0 % N, 0.60 % P_2O_5, 0.5 % K_2O) and poultry manure(2 % N, 1.6 % P_2O_5, 0.9 % K_2O) were used as the organic sources. Urea (46 % N), Rajphos (20 % P_2O_5) and Muriate of potash (60 % K_2O) were used as the inorganic sources for the experiment. The deficiency of phosphorus and potassium computed while substituting the chemical fertilizers on nitrogen equivalent basis was compensated with rajphos and ash (4.2 percent K_2O) respectively.

3.3 METHODS

3.3.1 Design and layout

The investigation was laid out in Randomised Block Design as factorial experiment with 2 factors and three controls and 3 replication.

Layout plan of the experiment is presented in Fig.2

R_1T_2	R_1T_4	R_1T_9	R_1T_7	R_1T_6	R_1T_{10}	R_1T_1	R_1T_{12}	R_1T_3
R_1T_{11}	R_1T_5	R_1T_1	R_2T_1	R_2T_{11}	R_2T_{10}	R_2T_8	R_2T_5	R_2T_9
R_2T_2	R_2T_{12}	R_2T_4	R_2T_3	R_2T_6	R_2T_7	R_3T_2	R_3T_5	R_3T_1
R_3T_9	R_3T_3	R_3T_{12}	R_3T_4	R_3T_7	R_3T_8	R_3T_6	R_3T_{10}	R_3T_6

The details of the layout are given below.

Design	:	Randomised Block Design (RBD)
Treatments	:	(3 x 3) +3 = 12
Replications	:	3
Gross plot size	:	5 x 4m
Net plot size	:	4.5 x 3.6m

3.3.2 Treatments

1 Treatment details

The experiment consisted of 12 treatments.

The treatment details are as follows.

i) FYM (F) - 3 levels

F_1- 100 % (20 t ha^{-1})

F_2- 75 % (15 t ha^{-1})

F_3- 50 % (10 t ha^{-1})

ii) NPK levels (N)–3 levels (Substitution on nitrogen equivalent basis) - FYM + neem cake 1 : 1 ratio is used as organic manure)

N_1- 100 % RFD

N_2- 75 % RFD

N_3- 50 % RFD

Control (C)

C_1 - KAU POP recommendations of KAU

C_2 - Ad hoc organic POP recommendations of KAU

C_3 - Farmers practice (5 tonnes of cow dung slurry at fortnight intervals)

Treatment Combinations – (3 x 3) + 3

f_1n_1 : 100 % FYM + 100 % RFD
f_1n_2 : 100 % FYM + 75 % RFD
f_1n_3 : 100 % FYM + 50 % RFD
f_2n_1 : 75 % FYM) + 100 % RFD
f_2n_2 : 75 % FYM) + 75 % RFD

Plate 1. General view of the field experiment

f_2n_3 : 75 % FYM) + 50 % RFD

f_3n_1 : 50 % FYM) + 100 % RFD

f_3n_2 : 50 % FYM) + 75 % RFD

f_3n_3 : 50 % FYM) + 50 % RFD

C_1 : POP recommendations of KAU

C_2 : Ad hoc organic POP recommendations of KAU

C_3 : Farmers practice

3.5 CULTURAL OPERATIONS

The details of cultural operations carried out during the course of investigation are as follows.

3.5.1 Nursery

The soil was brought to fine tilth and raised seed beds of size 6' x 3' x 10" height were prepared and well rotten powdered farmyard manure was applied and incorporated into the soil. Chilli seeds were sown in rows of 10 cm apart and covered with a thin layer of soil. The nursery beds were watered twice daily. The seedlings were sprayed with nimbicidin (2 ml lit^{-1}) two weeks after sowing and spray was repeated after two weeks.

3.5.2. Main field preparation

The main field was ploughed twice to bring the soil to fine tilth. Plots were laid out as per the layout plan before transplanting. One healthy seedling of 30 days old was transplanted at 45 cm x 45 cm spacing in main field

3.5.3. Manure and fertilizer application

As per POP recommendation of KAU, 25 t ha^{-1} of FYM was applied as basal at the time of land preparation along with. 75:40:25 kg $N:P_2O_5:K_20$ ha^{-1} as fertilizer. Half of nitrogen, full phosphorous and half of potash applied as basal dose before transplanting. One fourth of nitrogen and half of potash applied at 30 days after planting. The remaining quantity was applied two months after planting. As per Ad hoc organic POP recommendation of KAU, FYM @25 t ha^{-1} was applied as basal dose along with *Tricoderama* and PGPR mix 1, each @2.5 kg ha^{-1}. *Pseudomonas* and AMF were applied at the time of transplanting. Poultry manure was applied @ 1 t ha^{-1} at fortnight intervals. As per farmers practices five tonnes of cow dung slurry was applied at fortnight intervals.

3.5.4 Gap filling

Gap filling was done 8 days after transplanting to ensure optimum plant population.

3.5.5. Other management practices

Intercultivation was carried out at regular intervals (20, 40 and 60) days after transplanting followed by two hand weeding at 25 and 45 days after transplanting (DAT).

3.5.6 Harvest

The crop was ready for first harvest 45 DAT and subsequent harvests were made at 10 days interval. The fruits were picked when a slight yellowish green colour appeared.

3.6 OBSERVATIONS

For analyzing the growth pattern of the crop, five plants were selected randomly from the net plot area in each treatment and various observations were recorded at 30 days interval from the day of transplanting. The parameters and procedures followed are given below.

3.6.1 Biometric Observations

3.6.1.1 Plant Height (cm)

Height of the plant from the base to the growing tip at 4 stages *viz.* 30, 60, 90 DAT and at harvest were taken from five observational plants. The mean plant heights were worked out and expressed in cm.

3.6.1.2 Number of Primary Branches

Numbers of primary branches at 4 stages viz. 30, 60, 90 DAT and at harvest were taken and the mean worked out.

3.6.1.3 Leaf Area Index (LAI)

The LAI was worked out by linear measurement of leaves suggested by Montgomery (1911). The leaf area was calculated using a general relationship A=b×I×W where b is a coefficient. Such a mathematical equation for estimating leaf area reduces sampling effort and cost, may increase precision where samples are difficult to handle.

The LAI was calculated by the following formula developed by Watson (1947).

$$\text{LAI} = \frac{\text{Leaf area plant}^{-1}\ (\text{cm}^2)}{\text{Land area occupied by the plant}\ (\text{cm}^2)}$$

Length and breadth of two leaves from the bottom, middle and top of the plants from each of the observation plants were taken in case of all treatment plots, leaf area determined and the LAI was worked out using the above formula. The mean LAI obtained in each treatment was taken as the true LAI of the plant plot^{-1}.

3.6.1.4 Length of Tap Root (cm)

Length of tap root was recorded at final harvest and expressed in cm.

3.6.1.5 Lateral Root Spread (cm)

The length of the largest lateral root on both sides of the taproot was measured, the mean worked out and expressed in cm

3.6.1.6 Root Shoot Ratio

The plants were pulled out at harvest and the dry weights of shoots and roots were recorded. From this root-shoot ratio was calculated.

3.6.2 YIELD AND YIELD ATTRIBUTES

3.6.2.1 Number of Fruits Plant^{-1}

Numbers of fruits on five observational plants were recorded and the mean worked out.

3.6.2.2 Length of Fruit (cm)

Lengths of randomly selected fruits from the five observational plants were measured and mean worked out and expressed in cm.

3.6.2.3 Weight of Fruits Plant^{-1} (g)

The weight of green fruits obtained from observational plants was recorded at each harvest. The total weight of fruits plant^{-1} from the vegetable harvests was worked out and the mean calculated.

3.6.2.4 Mature Fruit Yield (kg ha^{-1})

The total weight of mature fruits obtained from the net plot area was recorded and yield in kg ha^{-1} was computed.

3.6.3 Incidence of Pests and Diseases

No major pest and disease were found to infect the crop beyond the economic threshold level demanding control measures. Since the insect and disease attack were below the economic threshold level, scoring was not done.

3.6.4 QUALITY PARAMETERS OF FRUIT

3.6.4.1 Capsaicin (%)

Estimated by colourimetric method (Balasubramanian *et al.*, 1982).

3.6.4. 2 Ascorbic Acid (mg 100g^{-1})

Estimated by titrimetric method (Sadasivam and Manickam, 1992).

3.6.4.3 Shelf Life

Sample fruits were taken treatment wise separately and the number of days taken from the harvest of fruits to the stage at which fruits become shrunken and lost firmness was recorded.

3.6.5 Plant Analysis

The plant samples were subjected to chemical analysis for determining the total N, P, and K content in them. For this purpose, plant samples from each plot were dried in an electric hot air oven to constant weights at a temperature of 70^{0}C, ground and passed through a 0.5 mm sieve. The required quantity of sample was weighed out accurately in an electronic balance, subjected to acid extraction before carrying out the chemical analysis.

3.6.5 .1. Uptake of Nitrogen

The nitrogen content in plants samples was estimated by the modified microkjeldhal method (Jackson, 1973) and the uptake of nitrogen was calculated by multiplying the nitrogen content of plant sample with the total dry weight of plants. The uptake values were expressed in kg ha^{-1}.

3.6.5 .2. Uptake of Phosphorus

The phosphorus content in plants samples was colorimetrically determined by wet digestion of the sample and developing colour by ascorbic acid method and read in a Spectrophotometer (Bray and Kurtz 1964). The uptake of phosphorus was calculated by multiplying the phosphorus content of plant sample with the total dry weight of plants. The uptake values were expressed in kg ha^{-1}.

3.6.5 .3. Uptake of Potassium

The potassium content in plants samples was determined by flame photometer method the uptake of potassium was calculated by multiplying the potassium content of plant sample with the total dry weight of plants. The uptake values were expressed in kg ha^{1}.

3.6.6 Soil analysis

Soil samples were taken from the experimental area before the start of the experiment and after the experiment. The air-dried samples passed through 2 mm sieve were used for the analysis of physico-chemical properties.

3.6.6.1. Organic carbon content

The soil organic carbon content after the experiment was expressed in percentage. It was estimated using Walkley and Black's rapid titration method (Jackson, 1973).

3.6.6.2. Available Nitrogen content

The available N content of soil after the experiment was estimated using alkaline permanganate method (Subbiah and Asija, 1956) and expressed in kg ha^{-1}.

3.6.6.3. Available Phosphorus content

The available P_2O_5 content in soil after the experiment was estimated using Dickman and Brays molybdenum blue method using Bray No.1 reagent for extraction (Jackson, 1973) and expressed in kg ha^{-1}.

3.6.6.4. Available Potassium content

The available K_2O content in soil after the experiment was determined using neutral ammonium acetate extract and estimated using EEL Flame photometer (Jackson, 1973) and expressed in kg ha^{-1}.

3.3.3.4. Economic Analysis

Economics of cultivation was worked out for the field experiment after taking into account the cost of cultivation and prevailing market price of chilli. The net income and BC ratio were calculated as follows.

Net income (Rs ha^{-1}) = Gross income- Total expenditure

$$\text{Benefit: Cost ratio} = \frac{\text{Gross income}}{\text{Total expenditure}}$$

3.3.3.5. Statistical Analysis

Data generated from the experiment were subjected to statistical analysis applying ANOVA technique and significance tested by 'F' test (Snedecor and Cochran, 1975). In the cases where the effects were found to be significant, CD was calculated using standard techniques.

RESULTS

4. RESULTS

The field experiment on "Standardisation of organic nutrient schedule for chilli (*Capsicum annuum*) was taken up at College of Agriculture, Vellayani during May - October 2012. The main objective of the study was to standardise organic nutrient schedule for chilli and to work out the economics. The results of the experiment are presented in this chapter

4.1 GROWTH CHARACTERES

4.1.1 Height of the plant (Table 2)

The perusal of the data revealed that different levels of FYM significantly influenced the plant height at all stages of plant growth. At 30 DAT and 60 DAT higher level of FYM (20 t ha^{-1}) recorded maximum plant height of 38.78 cm and 47.69 cm respectively. At 90 DAT, 15 t ha^{-1} FYM recorded maximum plant height of 67.61 cm where as at harvest again F_1 produced maximum plant height of 82.54 cm which was on par with F_2. The lowest plant height was recorded by F_3 (10 t ha^{-1} FYM).

Levels of substitution also significantly influenced the plant height at all stages of growth. N_1 (100 % RFD) recorded maximum plant height of 37.38 cm at 30 DAT, 46.15 cm at 60 DAT, 67.33 at 90 DAT and 81.56 cm at harvest. At harvest N_1 (100 % RFD) was on par with N_2 (75 % RFD). The lowest plant height was recorded by N_3 (50 % RFD) at all stages except 90 DAT where the lowest plant height was recorded by N_2 (75 % RFD).

The different levels of FYM and its interaction with the different levels of substitution with FYM + neem cake had significant influence on plant height at 30 DAT and 60 DAT. At 30 DAT, f_1n_1 (100 % FYM +100 % RFD) registered maximum plant height of 39.42 cm which was on par with f_1n_2 (100 % FYM +75 % RFD) followed by f_2 n_1 (75 % FYM +100 percent RFD). The lowest plant height was recorded by f_3 n_1 (50 %FYM +100 percent RFD). At 60 DAT f_1n_1

Table.No.2. Height of chilli plant (cm) as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	30 DAT	60 DAT	90 DAT	At harvest
F_1	38.78	47.69	65.38	82.54
F_2	36.40	44.85	67.61	81.21
F_3	33.75	42.13	64.03	76.61
SEm	0.200	0.330	0.62	0.61
CD (0.05)	0.498	0.967	1.870	1.823
Levels of substitution				
N_1	37.38	46.15	67.33	81.56
N_2	36.08	44.69	63.71	80.32
N_3	35.47	43.83	65.97	78.49
SEm	0.200	0.330	0.62	0.61
CD (0.05)	0.498	0.967	1.870	1.823
Interaction effects				
f_1n_1	39.42	49.54	66.67	83.29
f_1n_2	38.58	47.79	62.25	83.21
f_1n_3	38.33	45.75	67.21	81.13
f_2n_1	38.38	46.58	68.58	81.71
f_2n_2	36.29	44.17	66.42	81.21
f_2n_3	34.54	43.79	67.83	80.71
f_3n_1	34.33	42.29	66.75	79.67
f_3n_2	33.38	42.13	62.46	76.54
f_3n_3	33.54	41.96	62.88	73.63
Treatment mean	36.31	44.88	65.67	80.13
SEm	0.350	0.571	1.08	1.05
CD (0.05)	0.862	1.675	NS	NS
Control				
Control 1	39.96	51.87	69.50	81.92
Control 2	39.53	53.08	69.04	82.67
Control 3	30.00	36.12	48.92	62.08
Control mean	36.50	47.02	62.49	75.56
Treatments *Vs* Controls	NS	S	S	S
Between controls	S	S	S	S
Between treatments (including controls)	0.862	1.675	3.239	3.158

(100 % FYM +100 % RFD) recorded maximum plant height of 49.54 cm. The lowest plant height was registered by f_3n_3 (50 % FYM +50 percent RFD).

The comparison of the treatments against the controls revealed that the treatments were significantly superior at all stages of growth except 30 DAT. Between the controls, (C_1) and Adhoc POP (C_2) recommendations of KAU were superior at all stages of growth

In the comparison made between the treatment combinations including controls at 30 DAT, C_2 (Adhoc organic POP recommendation of KAU), f_1n_1 (100 % FYM +100 % RFD) and POP recommendation of KAU (C_1) produced taller plants than other treatment combinations. At 60 DAT, Adhoc organic POP recommendation of KAU (C_1) and POP recommendation of KAU (C_1) produced taller plants than other treatment combinations. The treatment combinations f_1n_2, f_3n_1, f_3n_2, f_3n_3 and C_1 produced shorter plants than other treatment combinations at 90 DAT. At harvest f_3n_1, f_3n_2, f_3n_3 and C_1 produced shorter plants than other treatment combinations.

4.1.2 Number of Branches plant^{-1} (Table 3)

The different levels of FYM significantly influenced the number of branches at all stages of plant growth. F_1 (20 t ha^{-1} FYM) recorded maximum number which is significantly superior to the other two treatments at 30,60 and 90 DAT and at harvest stage F_1 was on par with F_2 (15 t ha^{-1} FYM). F_3 (10 t ha^{-1} FYM) recorded the minimum number of branches at all stages.

Numbers of branches were significantly influenced by the levels of substitution at 60 and 90 DAT. The maximum numbers of branches plant-1 were obtained from N_1 (100 % RFD) at 60 DAT and at 90 DAT it was on par with N_2 (50 % RFD)

The number of branches plant^{-1} was observed to vary significantly among the different treatment combinations only at 60 DAT. f_1n_1 (100 % FYM +100 %

Table. No 3 Number of branches of chilli plant as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	30 DAT	60 DAT	90 DAT	At harvest
F_1	3.33	5.83	8.75	12.00
F_2	2.97	5.53	8.47	11.75
F_3	3.03	4.75	7.67	11.11
SEm	0.082	0.069	0.132	0.129
CD (0.05)	0.248	0.206	0.397	0.388
Levels of substitution				
N_1	3.17	5.36	8.67	11.86
N_2	3.14	5.11	8.31	11.56
N_3	3.03	5.64	7.92	11.44
SEm	0.082	0.069	0.132	0.129
CD (0.05)	NS	0.206	0.397	NS
Interaction effects				
f_1n_1	3.58	6.17	9.25	12.42
f_1n_2	3.25	5.83	8.92	12.17
f_1n_3	3.17	5.50	8.08	11.42
f_2n_1	2.92	5.83	8.75	11.67
f_2n_2	3.08	5.00	8.33	11.58
f_2n_3	2.92	5.75	8.33	12.00
f_3n_1	3.00	4.75	8.00	11.50
f_3n_2	3.08	4.50	7.67	10.92
f_3n_3	3.00	5.00	7.33	10.92
Treatment mean	3.11	5.37	8.29	11.62
SEm	0.142	0.119	0.228	0.223
CD (0.05)	NS	0.357	NS	NS
Control				
Control 1	4.00	7.33	9.33	12.75
Control 2	3.42	6.92	8.92	12.83
Control 3	2.42	4.08	6.00	9.08
Control mean	3.28	6.11	8.08	11.56
Treatments *Vs* Controls	NS	S	NS	S
Between controls	S	S	S	S
Between treatments (including controls)	0.429	0.357	0.687	NS

RFD) recorded maximum number of branches plant^{-1} (6.17) and it was par with f_1n_2, f_1n_3 and f_2n_1.

Significant variation was observed in the comparison of the treatment combinations against the controls except at 30 and 90 DAT. Between controls also significant variation was observed.

The comparison among the treatment combinations including the controls was also proved to be significant at all growth stages except at harvest. The highest number of branches plant^{-1} were recorded in C_1 (POP recommendation of KAU) at 30 DAT. At 60 DAT, C_1 (POP recommendation of KAU) recorded maximum number of branches. At 90 DAT higher number of branches plant^{-1} were obtained from C_1 (POP recommendation of KAU) and it was on par with f_1n_1 (100 % FYM +100 % RFD), C_2 (Adhoc POP recommendation of KAU), f_1 n_2 (100 % FYM + 75 % RFD) and f_2 n_1 (75 % FYM + 100 % RFD).

4.1.3 Leaf Area Index (LAI) (Table 4)

The perusal of the data revealed that different levels of FYM significantly influenced the LAI at all stages of growth. The maximum LAI was recorded by highest level of FYM (20 t ha^{-1} FYM) being 0.36 at 30 DAT, 0.91 at 60 DAT, 2.67 at 90 DAT and 2.21 at harvest.

LAI was significantly influenced by the levels of substitution at all stages of growth with more LAI by N_1 (100 % RFD) 0.35 at 30 DAT, 0.89 at 60 DAT, 2.56 at 90 DAT and 2.09 at harvest.

The different treatment combinations did not significantly influence the LAI.

Significant variation was observed in the comparison of the treatment combinations against the controls except 30 and 90 DAT. Between control at all stages of crop growth, farmers practice (C_3) was proved to be inferior to the other treatments.

Table. No 4. Leaf area index (LAI) of chilli plant as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	30 DAT	60 DAT	90 DAT	At harvest
F_1	0.36	0.91	2.67	2.21
F_2	0.33	0.87	2.47	2.08
F_3	0.31	0.77	2.28	1.74
SEm	0.200	0.200	0.02	0.02
CD (0.05)	0.014	0.024	0.067	0.067
Levels of substitution				
N_1	0.35	0.89	2.56	2.09
N_2	0.33	0.85	2.47	2.01
N_3	0.31	0.82	2.40	1.93
SEm	0.200	0.200	0.02	0.02
CD (0.05)	0.014	0.024	0.067	0.067
Interaction effects				
f_1n_1	0.38	0.95	2.74	2.29
f_1n_2	0.36	0.91	2.68	2.21
f_1n_3	0.33	0.88	2.58	2.12
f_2n_1	0.35	0.92	2.62	2.15
f_2n_2	0.33	0.87	2.44	2.08
f_2n_3	0.32	0.82	2.36	2.02
f_3n_1	0.33	0.72	2.31	1.83
f_3n_2	0.31	0.76	2.29	1.74
f_3n_3	0.29	0.75	2.25	1.64
Treatment mean	0.33	0.849	2.47	2.01
SEm	0.350	0.350	0.04	0.04
CD (0.05)	NS	NS	NS	NS
Control				
Control 1	0.37	0.94	2.71	2.26
Control 2	0.36	0.92	2.69	2.25
Control 3	0.25	0.57	2.05	1.21
Control mean	0.33	0.81	2.48	1.91
Treatments *Vs* Controls	NS	S	NS	S
Between controls	S	S	S	S
Between treatments (including controls)	0.025	0.041	0.115	0.116

The comparison among the treatment combinations including the controls was also proved to be significant at all growth stages. At all stages of plant growth highest LAI were realized from f_1 n_1 (100 % FYM +100 % RFD) and it was on par with C_1(POP recommendation of KAU) , C_2 (Adhoc POP recommendation of KAU) and f_1 n_2 (100 % FYM +75 % RFD).

4.1.4 Length of Tap Root (Table 5)

The perusal of the data revealed that different levels of FYM significantly influenced length of tap root. Highest level of FYM (20 t ha^{-1} FYM) recorded maximum length of tap root (12.67 cm). The lowest length of tap root of (10.44 cm) was recorded by F_3 (10 t ha^{-1} FYM).

The levels of substitution had significant impact on length of tap root. N_1 (100 % RFD) recorded maximum tap root length (12.30 cm) followed by N_2 (75 % RFD) with a tap root length of 11.32 cm. The lowest length of tap root (11.17 cm) was recorded by N_3 (50 % RFD).

The F x N interaction failed to produce any significant effect on length of tap root.

Significant variation was observed in the comparison of the treatment combinations against the controls as well as between controls.

The comparison among the treatment combinations including the controls showed that C_2 (Adhoc POP recommendation of KAU) produced significantly longer tap roots than other treatments (14.70 cm)

4.1.5 Root Spread (Table 5)

Different levels of FYM significantly influenced root spread with maximum spread for (20 t ha^{-1} FYM) 25 cm. The lowest root spread of (21.22 cm) was recorded by F_3 (10 t ha^{-1} FYM).

Root spread was significantly influenced by the levels of substitution. N_1 (100 % RFD) recorded maximum root spread (24.16 cm) followed by N_2 (75 % RFD) with a root spread of 22.66 cm. The lowest root spread of 27.03 cm was recorded by N_3 (50 % RFD).

The root spread was observed to vary significantly among the different treatment combinations, with f_1n_1 (100 % FYM +100 % RFD) recording maximum root spread of (27.03) The lowest root spread (20.13 cm) was recorded by f_3n_2 (50 % FYM +75 percent RFD) which was comparable with f_3n_3 (50 % FYM +50 percent RFD).

Significant variation was observed in the comparison of the treatment combinations against the controls. Between control farmers practice (C_3) was proved to be inferior to the other treatments.

The comparison among the treatment combinations including the controls was also proved to be significant with highest root spread in C_1(POP recommendation of KAU), f_1n_1 (100 % FYM +100 % RFD) and C_2 (Adhoc POP recommendation of KAU) compared to other treatment combinations.

4.1.5. Root Shoot ratio (Table 5)

The different levels of FYM, levels of substitution and their interaction had no significant influence on the root shoot ratio. The comparison of the treatment combinations against the controls, between controls and the comparison among the treatment combinations including the controls were also proved to be not significant.

Table No.5. Root characters of chilli (cm) as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	Length of tap root	Root spread (cm)	Root shoot ratio
F_1	12.67	25.00	0.119
F_2	11.68	23.00	0.115
F_3	10.44	21.22	0.118
SEm	0.200	0.200	0.02
CD (0.05)	0.511	0.024	0.067
Levels of substitution			
N_1	12.30	24.16	0.118
N_2	11.32	22.66	0.116
N_3	11.17	22.41	0.119
SEm	0.200	0.200	0.02
CD (0.05)	0.014	0.024	0.067
Interaction effects			
f_1n_1	13.67	27.03	0.118
f_1n_2	12.43	25.07	0.118
f_1n_3	11.91	22.90	0.121
f_2n_1	12.20	23.40	0.114
f_2n_2	11.40	22.77	0.112
f_2n_3	11.43	22.83	0.119
f_3n_1	11.03	22.03	0.121
f_3n_2	10.13	20.13	0.117
f_3n_3	10.17	21.50	0.116
Treatment mean	11.60	23.07	0.117
SEm	0.350	0.350	0.04
CD (0.05)	NS	NS	NS
Control			
Control 1	13.00	27.10	0.093
Control 2	14.70	27.00	0.089
Control 3	10.10	21.03	0.111
Control mean	12.60	25.04	0.098
Treatments *Vs* Controls	S	S	NS
Between controls	S	S	NS
Between treatments (including controls)	0.885	1.801	NS

4.2 YIELD ATTRIBUTES AND YIELD

4.2.1. Length of Fruit (Table 6)

The results revealed that different levels of FYM significantly influenced the length of fruit. Higher level of FYM (20 t ha^{-1} FYM) recorded maximum fruit length of 13.69 cm, followed by F_2(75 % FYM) with a fruit length of 13.29 cm. The lowest fruit length of 12.62 cm was recorded by F_3 (10 t ha^{-1} FYM).

Levels of substitution also significantly influenced the fruit length. N_1 (100 % RFD) recorded maximum fruit length (13.37 cm) followed by N_2 (75 % RFD) with a fruit length of 13.25 cm. The lowest fruit length of 12.98 cm was recorded by N_3 (50 % RFD).

The length of fruit was observed to be significant among the different treatment combinations f_1n_1 (100 % FYM +100 % RFD) recorded maximum length of fruit (13.84 cm) and it was on par with f_1n_2 (100 % FYM +75 % RFD). The lowest length of fruit (12.39cm) was recorded by f_3 n_3 (50 % FYM +50 percent RFD)

Significant variation was observed in the comparison of the treatment combinations against the controls as well as between controls. The comparison among the treatment combinations including the controls was also proved to be significant with highest fruit length from f_1n_1 (100 % FYM +100 % RFD) which was on par with C_1 (POP recommendation of KAU).

4.2.2 Number of Fruits Plant^{-1} (Table 6)

Number of fruits $plant^{-1}$ showed significant variation due to different levels of FYM. Maximum number of fruits $plant^{-1}$ (43.00) was recorded by (20 t ha^{-1} FYM) which was on par with F_2 (75 % FYM) with 42.33 number of fruits $plant^{-1}$. The lowest number of 40.86 fruits $plant^{-1}$ was recorded by F_3 (10 t ha^{-1} FYM).

Table. No. 6 Yield and yield attributing characters as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	Number of fruits plant^{-1}	Fruit yield plant^{-1}(g)	Length of fruit (cm)	Total fruit yield (t ha $^{-1}$)
F_1	43.00	574.46	13.69	28.57
F_2	42.33	560.52	13.29	27.67
F_3	40.86	539.74	12.62	26.65
SEm	0.29	1.76	0.033	S
CD (0.05)	0.869	5.280	0.100	0.374
Levels of substitution				
N_1	42.83	569.42	13.37	28.32
N_2	42.08	559.52	13.25	27.60
N_3	41.28	545.78	12.98	26.96
SEm	0.29	1.76	0.033	0.12
CD (0.05)	0.869	5.280	0.100	0.374
Interaction effects				
f_1n_1	43.50	588.32	13.84	29.69
f_1n_2	43.17	575.68	13.80	28.40
f_1n_3	42.33	559.37	13.44	27.61
f_2n_1	44.00	567.58	13.37	28.02
f_2n_2	42.17	565.03	13.39	27.85
f_2n_3	40.83	548.93	13.11	27.14
f_3n_1	41.00	552.37	12.89	27.27
f_3n_2	40.92	537.83	12.57	26.55
f_3n_3	40.67	529.03	12.39	26.12
Treatment mean	42.06	558.24	12.20	27.63
SEm	0.50	3.05	0.058	0.22
CD (0.05)	NS	NS	0.174	NS
Control				
Control 1	44.17	586.92	13.73	29.18
Control 2	43.50	585.00	13.55	29.11
Control 3	36.83	487.08	11.80	23.56
Control mean	41.50	553.00	13.03	27.28
Treatments *Vs* Controls	S	S	S	S
Between controls	S	S	S	S
Between treatments (including controls)	1.504	9.146	0.174	0.647

100 % RFD (N_1) recorded maximum number of fruits plant^{-1} (42.83) which was on par with N_2 (75 % RFD) with 42.08 numbers of fruits plant^{-1}. The lowest number of fruits plant^{-1} (41.28) was recorded by N_3 (50 % RFD)

The F x N interaction failed to produce any significant influence on fruit number.

Significant variation was observed in the comparison of the treatment combinations against the controls. The comparison between controls also showed significant variation.

The comparison among the treatment combinations including the controls was also proved to be significant with higher number of fruits plant^{-1} (44.17) by C_1 (POP recommendation of KAU) and it was on par with f_1 n_1 (100 % FYM +100 % RFD), C_2 (Adhoc POP recommendation of KAU), and f_1 n_2 (100 % FYM +75 % RFD)

4.2.3. Fruit Yield Plant^{-1} (Table 6)

The treatment (20 t ha^{-1} FYM) resulted in the highest fruit yield plant^{-1} (574.46 g) followed by F_2 (75 % FYM) with a fruit yield plant^{-1} of (560.52 g). The lowest fruit yield plant^{-1} of 539.74 g was recorded by F_3 (10 t ha^{-1} FYM).

N_1 (100 % RFD) recorded maximum fruit yield plant^{-1} (569.42g) followed by N_2 (75 % RFD) with a fruit yield plant^{-1} of 559.52 g. The lowest fruit yield plant^{-1} of 545.78 g was recorded by N_3 (50 % RFD).

The interaction between the levels of FYM and levels of substitution was not significant.

Significant variation was observed in the comparison of the treatment combinations against the controls as well as between controls. The farmers practice (C_3) was significantly inferior to the other control treatments. The comparison among the treatment combinations including the controls was also proved to be significant with highest fruit yield plant^{-1} from f_1n_1 (100 % FYM

+100 % RFD) and it was on par with C_1 (POP recommendation of KAU) and C_2 (Adhoc POP recommendation of KAU).

4.2.4 Total Fruit Yield (Table 6)

Highest level of FYM, (20 t ha^{-1}FYM) recorded maximum fruit yield (28.57 t ha^{-1}) followed by F_2 (15 t ha^{-1}). The lowest fruit yield of 26.65 t ha^{-1} was recorded by F_3 (10 t ha^{-1} FYM).

100 % RFD (N_1) recorded maximum fruit yield (28.32 t ha^{-1}) followed by N_2 (75 % RFD) with a fruit yield of 27.60 t ha^{-1}. The lowest fruit yield of 26.96 t ha^{-1} was recorded by N_3 (50 % RFD).

The F x N interaction was not significant. However f_1 n_1 (100 % FYM +100 % RFD) recorded maximum fruit yield of 28.57 t ha^{-1} and lowest fruit yield of 26.65 t ha^{-1} by f_3n_3 (50 % FYM +50 % RFD).

Significant variation was observed in the comparison of the treatment combinations against the controls. Between control treatments the farmers practice (C_3) recorded the lowest total fruit yield of 23.56t ha^{-1}.

The comparison among the treatment combinations including the controls was also proved to be significant with highest yield (29.69) t ha^{-1} from f_1n_1 (100 % FYM +100 % RFD) and it was on par with C_1 (POP recommendation of KAU- 29.18 t ha^{-1}) and C_2 (Adhoc POP recommendation of KAU- 29.11 t ha^{-1}).

4.3 QUALITY ASPECTS OF CHILLI

4.3.1 Shelf Life (Table 7)

Highest level of FYM (20 t ha^{-1} FYM) recorded maximum shelf life (8.11 days) and it was on par with F_2, which recorded a shelf life of (8.44 days) and the lowest shelf life (7.88 days) was recorded by F_3 (10 t ha^{-1} FYM).

N_1 (100 % RFD) recorded maximum shelf life of 8.89 days and it was comparable with N_2 (75% N RFD). The lowest shelf life (7.94 days) was recorded by N_3 (50% RFD).

The interaction between F x N combination, the comparison of the treatment combinations against the controls, comparison between controls and comparison of the treatment combinations against the controls were not found significant.

4.3.2 Ascorbic Acid Content (Table 7)

Application of different levels of FYM significantly influenced the ascorbic acid content of fruit. Higher levels of FYM (20 t ha^{-1} FYM) recorded maximum ascorbic acid content (94.24 $mg100g^{-1}$) followed by F_2 (89.63 $mg100g^{1}$) and the lowest (85.99 $mg100g^{-1}$) was recorded by F_3 (10 t ha^{-1} FYM).

The ascorbic acid content was observed to differ significantly among the various levels of substitution. N_1 (100 % RFD) recorded maximum the ascorbic acid content of (93.56 $mg100g^{-1}$) followed by N_2 (75 % RFD). The lowest the ascorbic acid content (86.47 $mg100g^{-1}$) was recorded by N_3 (50 % RFD).

The ascorbic acid content was observed to vary significantly among the different treatment combinations. 100 % FYM +100 % RFD (f_1n_1) recorded maximum ascorbic acid content of (102.73 $mg100g^{-1}$) followed by f_1n_2 (92.22 $mg100g^{-1}$). The lowest ascorbic acid content was recorded by f_3n_2 (50 % FYM +75 percent RFD) which was comparable with f_3n_3 (50 % FYM +50 % RFD). Significant variation was observed in the comparison of the treatment combinations against the controls as well as between controls.

The comparison among the treatment combinations including the controls was also proved to be significant with highest ascorbic acid content from C_2 (Adhoc POP recommendation of KAU).

Table. No 7. Fruit quality aspects of chilli as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	Shelf life (days)	Ascorbic acid ($mg100g^{-1}$)	Capsaicin content (%)
F_1	9.11	94.24	0.76
F_2	8.44	89.63	0.75
F_3	7.88	85.99	0.72
SEm	0.18	0.736	0.00
CD (0.05)	0.530	2.160	0.011
Levels of substitution			
N_1	8.89	93.56	0.75
N_2	8.50	89.83	0.74
N_3	7.94	86.47	0.74
SEm	0.18	0.736	0.00
CD (0.05)	0.530	2.160	0.011
Interaction effects			
f_1n_1	9.83	102.73	0.78
f_1n_2	9.17	92.22	0.77
f_1n_3	8.33	87.76	0.75
f_2n_1	8.83	91.11	0.76
f_2n_2	8.5	91.11	0.74
f_2n_3	8	86.66	0.74
f_3n_1	8	86.83	0.72
f_3n_2	7.83	86.16	0.72
f_3n_3	8.06	84.99	0.72
Treatment mean	8.44	89.85	0.74
SEm	0.30	1.276	0.011
CD (0.05)	NS	3.741	NS
Control			
Control 1	7.67	86.66	0.78
Control 2	8.67	113.11	0.77
Control 3	7.83	97.69	0.74
Control mean	8.06	99.15	0.76
Treatments *Vs* Controls	NS	S	S
Between controls	NS	S	S
Between treatments (including controls)	NS	3.741	0.019

4.3.3 Capsaicin Content (Table 7)

Levels of FYM significantly influenced the capsaicin content. Higher levels of FYM (20 t ha^{-1} FYM) recorded maximum capsaicin content (0.76 %) followed by F_2 (0.75 %) The lowest the capsaicin content (0.72 %) was recorded by F_3 (10 t ha^{-1} FYM).

N_1 (100 % RFD) recorded maximum capsaicin content of 0.75 followed by N_2 (75 % RFD). The lowest the capsaicin content (0.74 %) was recorded by N_3 (50 % RFD).

The capsaicin content was observed to be non significant among the different treatment combinations

Significant variation was observed in the comparison of the treatment combinations against the controls as well as between controls.

The comparison among the treatment combinations including the controls was also proved to be significant with highest capsaicin content from f_1n_1 (100 % FYM +100 % RFD) and it was on par with C_1, C_2, f_1n_2 and f_2 n_1.

4.4 NUTRIENT UPTAKE

4.4.1 Nitrogen Uptake (Table 8)

Highest dose of FYM (20 t ha^{-1} FYM) recorded maximum nitrogen uptake of (43.76 kg ha^{-1}) which was on par with F_2 (42.21 kg ha^{-1}). Lowest nitrogen uptake of 39 kg ha^{-1} was recorded by F_3 (10 t ha^{-1} FYM).

The nitrogen uptake was observed to be non significant among different levels of substitution and F x N interaction.

Significant variation was observed in the comparison of the treatment combinations against the controls as well as between controls.

Table. No 8. Nutrient uptake of chilli at harvest as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
F_1	43.76	10.43	30.96
F_2	42.21	10.36	29.64
F_3	39.00	9.26	28.41
SEm	1.148	0.200	0.200
CD (0.05)	3.336	0.617	1.071
Levels of substitution			
N_1	42.79	10.46	30.52
N_2	41.85	9.94	29.47
N_3	40.33	9.64	29.01
SEm	1.148	0.200	0.200
CD (0.05)	NS	NS	1.701
Interaction effects			
f_1n_1	44.85	10.70	31.58
f_1n_2	43.91	10.37	30.98
f_1n_3	42.53	10.20	30.30
f_2n_1	43.41	11.21	30.86
f_2n_2	43.21	10.16	29.19
f_2n_3	40.01	9.69	28.86
f_3n_1	40.12	9.46	29.13
f_3n_2	38.44	9.29	28.24
f_3n_3	38.44	9.03	27.87
Treatment mean	41.66	10.01	29.67
SEm	1.988	0.350	0.350
CD (0.05)	NS	NS	NS
Control			
Control 1	53.69	13.46	33.51
Control 2	47.27	13.20	31.38
Control 3	36.09	8.63	24.18
Control mean	45.69	10.56	28.92
Treatments *Vs* Controls	S	S	NS
Between controls	S	S	S
Between treatments (including controls)	5.831	1.069	1.856

The comparison among the treatment combinations including the controls was also proved to be significant with highest nitrogen uptake (53.69 kg ha^{-1}) from C_1 (POP recommendation of KAU).

4.4.2 Phosphorus Uptake (Table 8)

Higher phosphorus uptake (10.43 kg ha^{-1}) was recorded by (20 t ha^{-1} FYM) which was on par with F_2 (75 % FYM) with an phosphorus uptake of 10.13 kg ha^{-1}. The lowest phosphorus uptake of 9.26 kg ha^{-1} was recorded by F_3 (10 t ha^{-1} FYM).

The different levels of substitution as well as the F x N interaction failed to exhibit any significant influence on this parameter. The treatments when compared against controls showed significant difference. Significant variation was observed in the comparison of the treatment combinations against the controls as well as between controls. Between control treatments the farmers practice (C_3) recorded the lowest phosphorus uptake of 8.63 kg ha^{-1}.

The comparison among the treatment combinations including the controls was also proved to be significant with highest phosphorus uptake (13.47 kg ha^{-1}) from C_1 (POP recommendation of KAU) and it was on par with C_2 (Adhoc POP recommendation of KAU).

4.4.3 Potassium Uptake (Table 8)

Highest potassium uptake of 30.96 $plant^{-1}$ was recorded by 20 t ha^{-1} FYM and the lowest potassium uptake of 28.41 kg ha^{-1} was recorded by 10 t ha^{-1} FYM

100 % RFD (N_1) recorded maximum potassium uptake (30.52 kg ha^{-1}) and it was comparable with N2 (75 % RFD). The lowest potassium uptake (29.01 kg ha^{-1}) was recorded by N_3 (50 % RFD).

The potassium uptake was observed to be non significant among the different treatment combinations. And in the comparison of the treatment combinations against the controls. Among the control treatments the lowest potassium uptake (24.18 kg ha^{-1}) was recorded by C_3.

The comparison among the treatment combinations including the controls was also proved to be significant with highest potassium uptake from C_1 (POP recommendation of KAU).

4.5 SOIL REACTION

4.5.1 Organic Carbon Content (Table 9)

Different levels of FYM significantly influenced the organic carbon content with highest value 1.51 % from 20 t ha^{-1} FYM. The lowest organic carbon content (1.40 %) was recorded by F_3 (10 t ha^{-1} FYM).

N_1 (100 % RFD) recorded maximum the organic carbon content of 1.49 % The lowest the organic carbon content (1.41) was recorded by N_3 (50 % RFD).

The organic carbon content was observed to be non significant among the different treatment combinations. No Significant variation was also observed in the comparison of the treatment combinations against the controls.

Between control treatments C_2 recorded maximum organic carbon content and it was on par with C_3. The comparison among the treatment combinations including the controls was also proved to be significant with highest organic carbon content from C_2 (Adhoc · POP recommendation of KAU) followed by f_1 n_1 and f_1 n_2.

Table. No.9. Available nutrient status of soil of chilli plant as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	Organic carbon (%)	pH
F_1	1.51	5.98
F_2	1.42	5.86
F_3	1.40	5.80
SEm	0.01	0.02
CD (0.05)	0.042	0.045
Levels of substitution		
N_1	1.49	5.94
N_2	1.44	5.86
N_3	1.41	5.83
SEm	0.01	0.02
CD (0.05)	0.042	0.079
Interaction effects		
f_1n_1	1.54	6.13
f_1n_2	1.52	6.02
f_1n_3	1.46	5.80
f_2n_1	1.47	5.88
f_2n_2	1.44	5.83
f_2n_3	1.35	5.85
f_3n_1	1.45	5.82
f_3n_2	1.35	5.73
f_3n_3	1.41	5.85
Treatment mean	1.44	5.88
SEm	0.02	0.03
CD (0.05)	NS	0.079
Control		
Control 1	1.34	5.75
Control 2	1.55	6.23
Control 3	1.48	5.92
Control mean	1.46	5.97
Treatments *Vs* Controls	NS	S
Between controls	S	S
Between treatments (including controls)	0.073	0.079

4.5.2 pH

Among the different levels of FYM, 20 t ha^{-1} FYM recorded significantly higher soil pH (5.98) and the lowest pH (5.80) was observed in plots treated with F_3 (10 t ha^{-1} FYM).

N_1 (100 % RFD) recorded highest soil pH (5.94) and the lowest pH was recorded by N_3 (5.83) and it was on par with N_2.

The soil pH was observed to be significant among the different treatment combinations and significantly lower pH was recorded by f_3n_2, f_2n_3 and f_3n_1.

Significant variation was observed in the comparison of the treatment combinations against the controls as well as between controls.

The comparison among the treatment combinations including the controls was also proved to be significant with highest pH content from C_2 (Adhoc POP recommendation of KAU).

4.6 AVAILABLE NUTRIENT STATUS OF SOIL

4.6.1 Available Nitrogen (Table 10)

Highest dose of FYM 20 t ha^{-1} FYM recorded maximum available nitrogen content of 270.39 kg ha^{-1}. Available nitrogen content of 252.88 kg ha^{-1} and the lowest available nitrogen content of 251.49 kg ha^{-1} was recorded by F_3 (10 t ha^{-1} FYM).

The available nitrogen content was observed to differ significantly among the various levels of substitution. N_1 (100 % RFD) recorded maximum available nitrogen content of (264.24 kg ha^{-1}) and was on par with N_2 (75 % RFD). The lowest available nitrogen content (250.49 kg ha^{-1}) was recorded by N_3 (50 % RFD).

Table. No.10. Available nutrient status of soil of chilli plant as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
F_1	270.39	60.05	59.73
F_2	252.88	54.53	57.48
F_3	251.49	53.97	57.70
SEm	2.73	1.18	0.39
CD (0.05)	8.207	3.530	1.162
Levels of substitution			
N_1	264.24	57.35	58.81
N_2	260.04	56.21	58.40
N_3	250.49	54.99	57.70
SEm	2.73	1.18	0.39
CD (0.05)	8.207	NS	NS
Interaction effects			
f_1n_1	280.14	60.82	60.84
f_1n_2	271.78	59.82	59.99
f_1n_3	259.24	59.52	58.36
f_2n_1	263.42	57.97	57.76
f_2n_2	254.94	53.06	57.59
f_2n_3	240.29	52.56	57.10
f_3n_1	249.15	53.27	57.84
f_3n_2	253.39	55.76	57.62
f_3n_3	251.93	52.89	57.65
Treatment mean	258.25	56.19	58.31
SEm	4.73	2.04	0.67
CD (0.05)	NS	NS	NS
Control			
Control 1	284.32	63.54	61.82
Control 2	301.67	64.26	62.31
Control 3	240.29	47.82	53.28
Control mean	275.43	58.54	59.14
Treatments *Vs* Controls	S	NS	NS
Between controls	S	S	S
Between treatments (including controls)	14.215	6.113	2.013

The available nitrogen content was observed to be non significant among the different treatment combination.

Significant variation was observed in the comparison of the treatment combinations against the controls as well as between controls.

The comparison among the treatment combinations including the controls was also proved to be significant with highest available nitrogen content from C_2 (Adhoc POP recommendation of KAU).

4.6.2 Available Phosphorus (Table 10)

Available phosphorus was significantly influenced by different levels of FYM. Highest dose of FYM (20 t ha^{-1} FYM) recorded maximum content of (60.5 kg ha^{-1}). Lowest available phosphorus content of 53.97 kg ha^{-1} was recorded by F_3 (10 t ha^{-1} FYM).

The available phosphorus content was observed to be non significant among the various levels of substitution and its interaction with levels of FYM. Treatments against control was significant. Between control treatments C_3 recorded the lowest available phosphorus content.

The comparison among the treatment combinations including the controls was also proved to be significant with highest available phosphorus content from C_2 (Adhoc POP recommendation of KAU) it was on par with C_1(POP recommendation of KAU) and $f_1 n_1$ (100 % FYM +100 % RFD) $f_1 n_2$ (100 % FYM +75 % RFD) and f_1n_3 (100 % FYM +50 % RFD).

4.6.3 Available Potassium (Table 10)

Available potassium content in soil varied significantly with different levels of FYM. 20 t ha^{-1} FYM recorded maximum available potassium content in soil (59.73 kg ha^{-1}). The lowest potassium content of 57.70 kg ha^{-1} was recorded by F_3 (10 t ha^{-1} FYM).

The available potassium content of was observed to be non significant among the various levels of substitution, F x N interaction and treatment against control.

Between control treatments C_3 recorded the lowest available potassium content. The comparison among the treatment combinations including the controls was also proved to be significant with highest available potassium content from C_2 (62.31 kg ha^{1}) and it was on par with C_1 (61.82 kg ha^{-1}) and f_1n_1 (60.84 kg ha^{-1}).

4.7 ECONOMIC ANALYSIS

4.7.1 Net Income (Table 11)

Different levels of FYM significantly influenced the net income. The highest levels of FYM (20 t ha^{-1}) recorded highest net income (Rs 224866.78) and the lowest net income of Rs 190502.33 was recorded by F_3 (10 t ha^{-1} FYM).

The net income was observed to differ significantly among the various levels of substitution. N_1 (100 % RFD) recorded maximum net income of (Rs 215096.11) followed by N_2 (75 % RFD). The lowest net income Rs (201838.33) was recorded by N_3 (50 % RFD).

Different treatment combinations also showed significant influence on net income with highest value of Rs 240358.33 by f_1 n_1 (100 % FYM +100 % RFD). The lowest the net income was recorded by f_3n_3 (50 % FYM +50 % RFD).

Significant variation was observed in the comparison of the treatment combinations against the controls. Between control treatments also significant variation was observed with highest net income of Rs 283644.00 from C_1 (POP recommendation of KAU)

The comparison among the treatment combinations including the controls was also proved to be significant with highest net income from C_1 (POP

Table. No.11. Net income (Rs) and benefit-cost ratio as influenced by different levels of FYM, levels of substitution and their interaction.

FYM levels	Net income (Rs)	B: C ratio
F_1	224866.78	1.65
F_2	208929.00	1.61
F_3	190502.33	1.56
SEm	2489.52	0.007
CD (0.05)	7476.03	0.021
Levels of substitution		
N_1	215096.11	1.61
N_2	207363.67	1.60
N_3	201838.33	1.60
SEm	2489.52	0.007
CD (0.05)	7476.03	NS
Interaction effects		
f_1n_1	240358.33	1.68
f_1n_2	221337.00	1.64
f_1n_3	212905.00	1.63
f_2n_1	208985.00	1.59
f_2n_2	212297.00	1.62
f_2n_3	205505.00	1.61
f_3n_1	195945.00	1.56
f_3n_2	188457.00	1.55
f_3n_3	187105.00	1.56
Treatment mean	208099.37	1.60
SEm	4311.97	0.012
CD (0.05)	12948.87	0.037
Control		
Control 1	283644.00	1.95
Control 2	244838.33	1.73
Control 3	145785.00	1.45
Control mean	224755.78	1.71
Treatments *Vs* Controls	S	S
Between controls	S	S
Between treatments (including controls)	12948.87	0.037

Cost of chilli Rs = 20 Kg^{-1}

recommendation of KAU) followed by C_2 (Adhoc POP recommendation of KAU) which was on par with f_1 n_1 (100 % FYM +100 % RFD).

4.7.2 Benefit-Cost Ratio (B: C ratio) (Table 11)

Different doses of FYM significantly influenced the B:C ratio. F_1 (20 t ha^{-1}) FYM recorded maximum B:C ratio (1.65) and the lowest B:C ratio of 1.56 was recorded by F_3 (10 t ha^{-1} FYM).

There was no significant difference with respect to B:C ratio by the various levels of substitution.

Different treatment combinations also showed significant influence on B:C ratio with f_1n_1(100 % FYM +100 % RFD) recording maximum value of 1.68 and the lowest B:C ratio by f_3 n_2 (50 % FYM +50 % RFD) which was comparable with f_3 n_3,f_3 n_1.

Significant variation was observed in the comparison of the treatment combinations against the controls. Between control treatments also significant variation was observed and C_1 (POP recommendation of KAU) recorded highest B:C ratio of 1.95 and lowest by C3.

The comparison among the treatment combinations including the controls was also proved to be significant with highest B:C ratio from C_1 (POP recommendation of KAU) followed by C_2 (Adhoc POP recommendation of KAU) and f_1n_1 (100%FYM+100%RFD).

DISCUSSION

5. DISCUSSION

The experimental findings detailed in the previous chapter have been briefly discussed here in the light of published information and fundamental theoretical knowledge.

5.1. GROWTH CHARACTER

The critical evaluation of the data (Table 2) revealed that application of 20 t ha^{-1} FYM was significantly superior to all other treatments with respect to plant height (Fig.3), number of branches (Fig.4) and leaf area index (Fig.5) at all stages of plant growth. The length and spread of root (Fig.6) were also significantly superior with the application of 20 t ha^{-1} FYM. Plant height, number of branches, LAI, root length and spread were observed to differ significantly among the various levels of substitution. N_1 (100 % RFD- applied as combination of FYM + neem cake in 1: 1 ratio) recorded higher growth characters followed by N_2 (75% RFD). The lowest plant height, number of branches and LAI were recorded by N_3 (50% RFD) at all growth stages.

Plant height, number of branches, LAI and root spread were observed to vary significantly among the different treatment combinations. The application of 20 t ha^{-1} FYM (100 % FYM) combined with 100 % RFD (f_1n_1) recorded maximum plant height, number of branches, LAI and root spread. The increase in plant height, number of leaves, number of branches $plant^{-1}$ and length and spread of root might be due to organic manures with narrow C: N ratio which resulted in the production of more humic acid and humic substances in the form of chelates with phosphorous. The chelated phosphorous has been reported to be more soluble in water which could make it available to crop. This is mainly due to FYM supplies plant nutrients through its own decomposition, forming an additional source of ammonical nitrogen (NH_4-N) that might have resulted in increased growth parameters. The beneficial effect of organic amendments in increasing the growth parameters was reported by Pushpa (1996) in tomato, Anitha (1997)

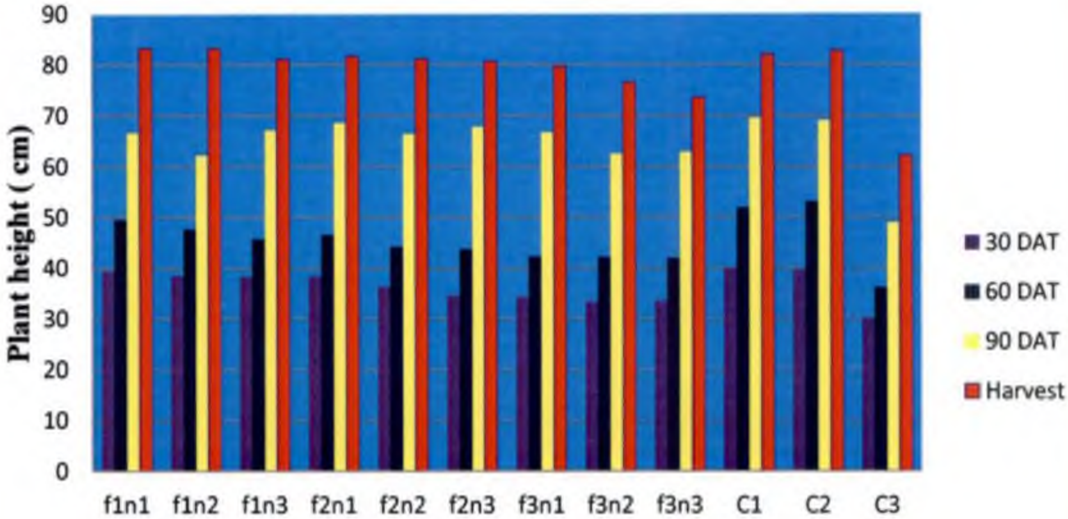

Fig.3. Effect of levels of FYM , levels of substitution and their interaction on plant height (cm)

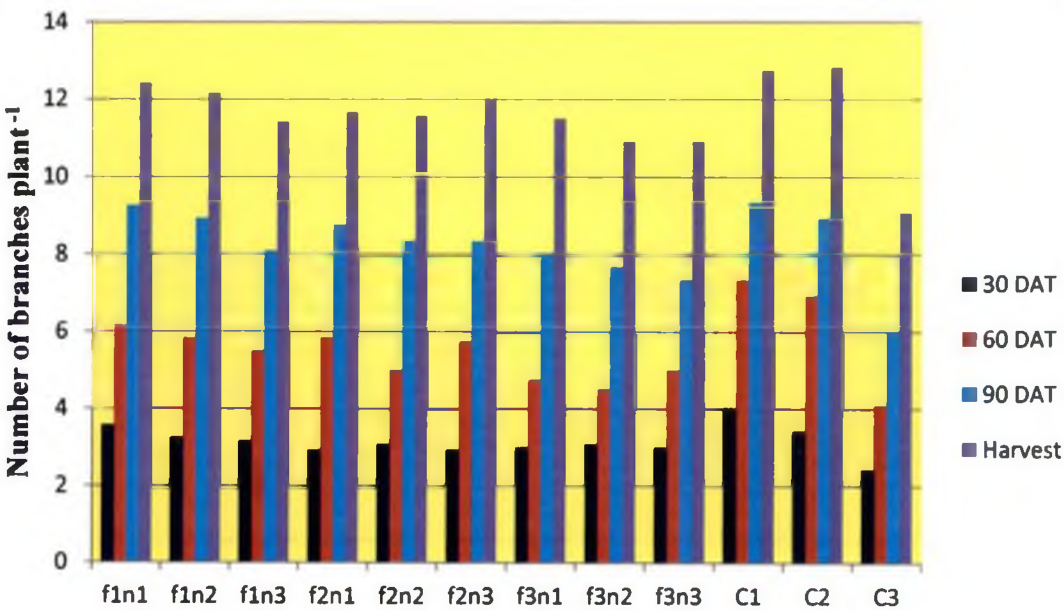

Fig.4. Effect of levels of FYM , levels of substitution and their interaction on number of branches plant $^{-1}$

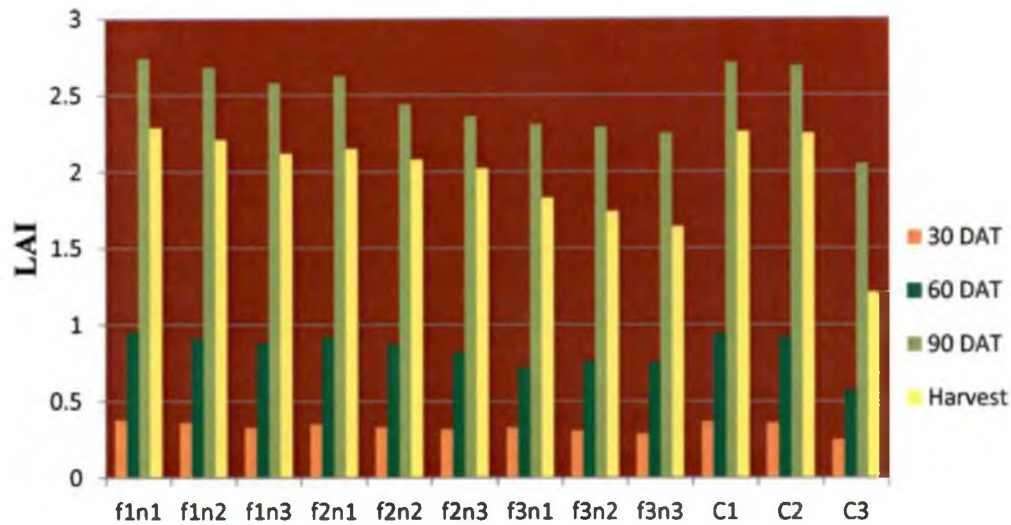

Fig.5. Effect of levels of FYM , levels of substitution and their interaction on LAI

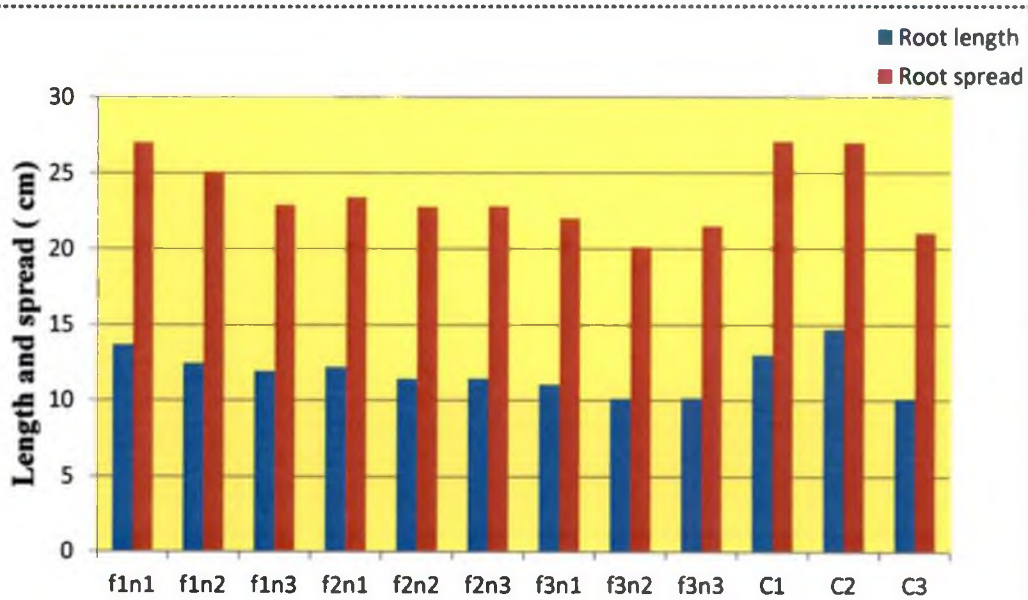

Fig.6. Effect levels of FYM, levels of substitution and their interaction on root characters

and Chavan *et al.*, (1997) in chilli. The increased availability of nutrients through higher dose of FYM and neem cake might have increased the nutrient uptake. The increased uptake of nitrogen might have contributed to rapid meristematic activity and the higher rate of metabolic activity coupled with rapid cell division brought about by phosphorus and the increased growth of meristematic tissue might have led to the increase in plant height, branches plant^{-1} and LAI. So the combined application of FYM and neem cake might have increased the growth attributes in chilli. Similar findings of increased plant height by the application of FYM in capsicum was reported by Valsikova and Ivanic (1982), Gaur *et al.* (1989) and in tomato by Gianquinto and Borin (1990) and Sharma and Sharma (2004). Sharu (2000) also reported the increased growth characters viz. plant height, number of branches, LAI and dry matter accumulation as a result of neem cake application in chilli and in bhindi by Raj(1999).

Among the control treatments the POP recommendation for integrated nutrients as well as the Adhoc organic farming POP recommendations of KAU recorded more or less similar plant height, number of branches and LAI and were significantly superior to the farmers practice of applying 5 tonnes of cow dung slurry at fortnight intervals. In POP recommendation there was readily available nutrients from chemical fertilizers and FYM which might have resulted in increased photosynthetic surface area leading to more production and assimilation of photosynthates. This in turn increased the plant height and number of branches. This is in conformity with the findings of John (1989), Sherly (1996) and Jayasree (2005).

The Ad hoc organic POP recommendation comprising of 25 t of FYM ha^{-1} along with 5 t ha^{-1} of poultry manure also recorded higher plant height, number of branches and LAI. Nutrient value of poultry manure was higher due to combined presence of urinary fécal excretions in the manure. The higher availability of nutrients might also have contributed to the higher growth parameters. Similar better growth attributes like plant height, number of branches, and dry matter production with poultry manure application in chilli were reported by Anitha (1997).

5.2 YIELD ATTRIBUTES AND YIELD

Highest number of fruits plant^{-1} (43) (Fig.7), fruit length (13.69 cm) (Fig.8), fruits yield plant^{-1} (574.46 g) (Fig.9), and total fruit yield (28.57 t ha^{-1}) (Fig.10) were realized in the present investigation with the application of highest dose of FYM 20 t ha^{-1} and these yield attributing characters were significantly superior to 10 t FYM ha^{-1}. FYM seems to act directly by increasing the crop yield either by accelerating the respiratory process through cell permeability or by hormone growth action. It supplies nitrogen, phosphorus and sulphur in available forms to the plants through biological decomposition. Senthilkumar and Sekar (1998) and Joseph (1998) also found significant increase in yield and yield attributing characters with FYM application.

Application of 100 % RFD (N_1) in the form of nitrogen substitution with FYM and neem cake (1:1 ratio) recorded higher number of fruits plant^{-1} (42.83), fruit length (13.37 cm) and it was on par with 75 % RFD. The weight of fruits plant $^{-1}$and mature fruit yield were highest from the plot treated with 100 % RFD. The lowest number of fruits plant^{-1} (41.28), fruit length (12.98 cm) and weight of fruits plant^{-1} (545.78 g), mature fruit yield (26.96 t ha^{-1}) were recorded by N_3 (50 % N substitution with FYM and neem cake).

Interaction effect of different doses of FYM and levels of substitution also proved to be significant. The highest dose of FYM (20 t ha^{-1}) along with 100 % RFD in the form of FYM and neem cake recorded maximum number of fruits plant^{-1}, fruit length, weight of fruits plant^{-1} and mature fruit yield. The higher availability and uptake of nutrients might have enabled the plant to produce more number of flowers buds which in turn increased the number of fruits. The positive direct effect of growth and yield attributing character's due to increased dose of organic manure have resulted in significantly higher number of fruits plant^{-1}, fruit

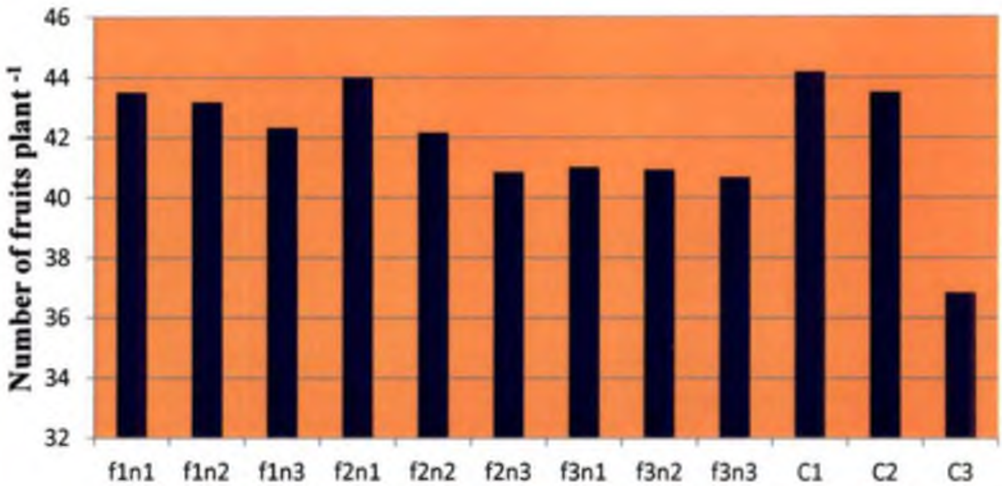

Fig.7. Effect levels of FYM, levels of substitution and their interaction on Number of fruits plant $^{-1}$

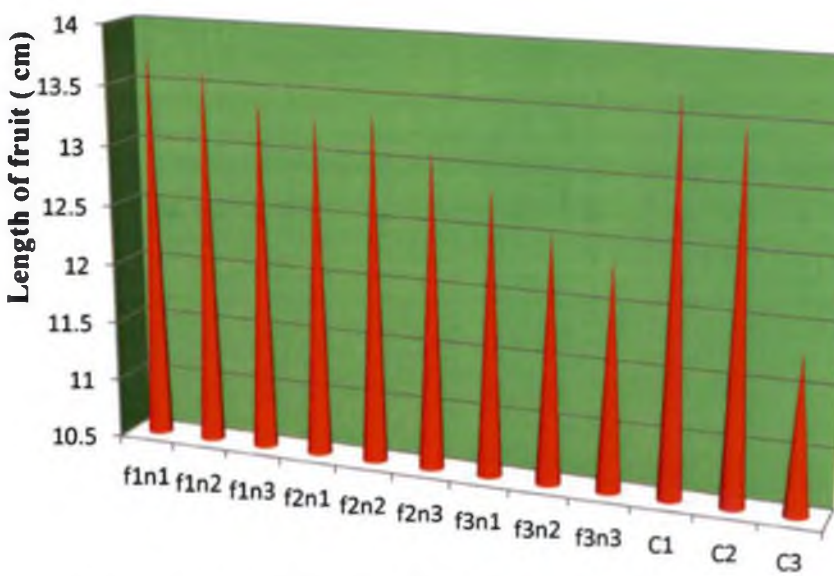

Fig.8. Effect levels of FYM, levels of substitution and their interaction on Length of fruit (cm)

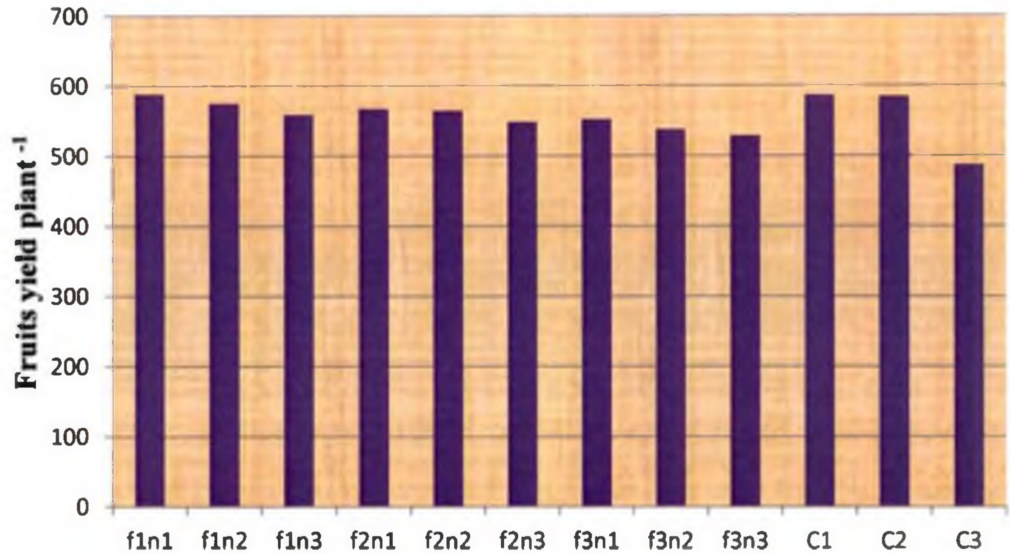

Fig.9. Effect levels of FYM, levels of substitution and their interaction on fruits yield g plant $^{-1}$

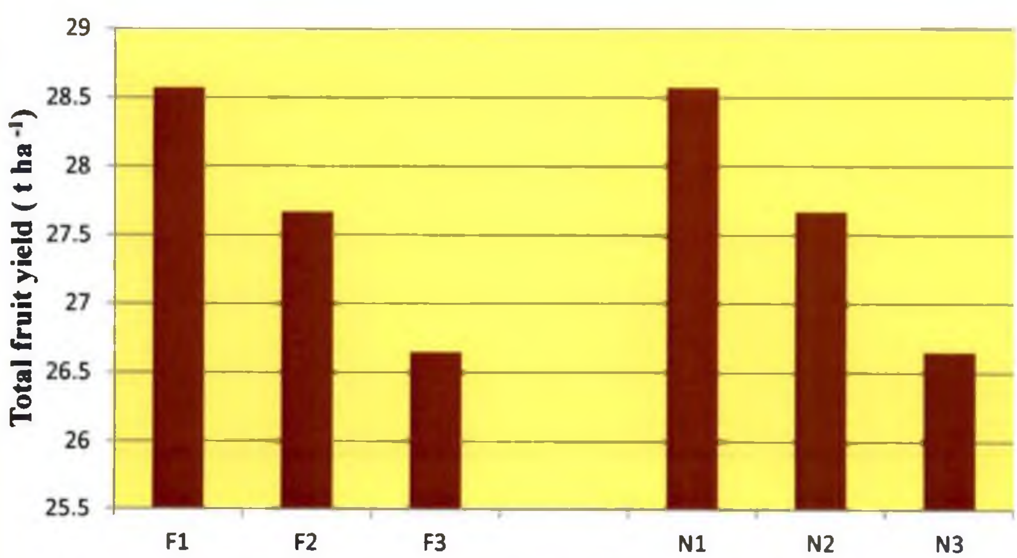

Fig.10. Effect levels of FYM and levels of substitution on Total fruit yield (t ha^{-1})

length ,weight of fruits plant^{-1}and mature fruit yield. Similar results of increased fruit yield due to increased nutrient levels have been reported by Gaur *et al.* (1984) and Raj (1999). The lowest yield attributing characters were obtained from the treatment combination consisting of 10 t ha^{-1} FYM along with 50 % RFD in the form of FYM and neem cake (f_3n_3). The lower availability of nutrients due to the application of lower quantity of nutrients might have led to the lower growth and yield attributing characters and yield.

POP recommendation of KAU as well as Adhoc organic recommendation consisting of FYM and poultry manure recorded higher number of fruits plant^{-1}, fruit length and weight of fruits plant^{-1} and mature fruit yield. The increased yield and yield attributes obtained in this study might be due to the interaction of organic and inorganic nutrients resulting in better translocation of nutrients under optimum moisture condition of the soil leading to ready availability of nutrients, increased photosynthetic activity, increased leaf area of the crop, inducing better growth. Positive response of increase in 100 fruit weight of chilli, fruit length and number of fruits plant^{-1} due to application of FYM + RFD and organics in combination were reported by Shashidhara (2000) Malawadi (2003) and Kattimani (2004).

The Ad hoc POP recommendation comprising of 25 t of FYM ha^{-1} along with 5 t ha^{-1} of poultry manure also recorded higher plant height, number of branches and LAI. Fertilizer value of poultry manure was estimated to be higher due to combined presence of urinary faecal excretions in the manure. The higher availability of nutrients might also have contributed to the higher growth parameters and inturn yield and yield attributing characters. Similar better growth attributes, yield and yield attributing characters with poultry manure application in chilli were reported by Anitha (1997).

5.3 QUALITY PARAMETERS OF FRUIT

Highest keeping quality (shelf life) (Fig 11) was realized in the present investigation with the application of highest levels of FYM (20 t ha^{-1}), 100 % RFD (N1) and 75 % RFD F (N_2) recorded more or less same shelf life. Maximum ascorbic acid content (Fig 12) of fruits was recorded by the highest dose of FYM (20 t ha^{-1}), 100 % RFD (N1) and f_1n_1. Combined application of FYM and poultry manure (Adhoc organic POP recommendation of KAU) recorded the highest ascorbic acid content. Keeping quality and ascorbic acid content were maximum in the treatments which were treated with organic manures because of the more balanced availability of macro as well as micro nutrients from organic sources which might have increased the vitamin C content of fruits. The biological function of ascorbic acid is based on its ability to donate electrons, which provides intra and extra cellular reducing power for a variety of biological reaction. Substantially high cellular levels of ascorbic acid provide antioxidant protection against photo synthetically generated free radicals (Singh *et al.*, 2004) and this might have increased the shelf life of chilli fruits. Similar results of increase in ascorbic acid content and shelf life with the application of organic manures were reported by Sharu (2000), Rani *et al.*, (1997), Omae *et al.*, (2003) Chavan *et al.*,(1997) and Anitha (1997).

Highest capsaicin content of fruits (Fig.11) were recorded with the application of 20 t ha^{-1} FYM and 15 t ha^{-1}. 100 % RFD (N1) and 75 % RFD (N_2) also recorded maximum capsaicin content. C_1 (POP recommendation of KAU) as well as f_1n_1 recorded higher capsaicin content and these were comparable with C_2 (Adhoc POP recommendation of KAU) and f_1n_2. Pungency is considered as one of the most important quality trait in chilli. Capsaicin is the condensation product of 3-hydroxy, 4-methoxy benzylamine and undecylenic aid. Optimum nitrogen content is considered to be essential for the production of these chemicals. The higher availability of nutrients in increasing the capsaicin content might be due its beneficial role in increasing amino acids synthesis and thereby protein synthesis

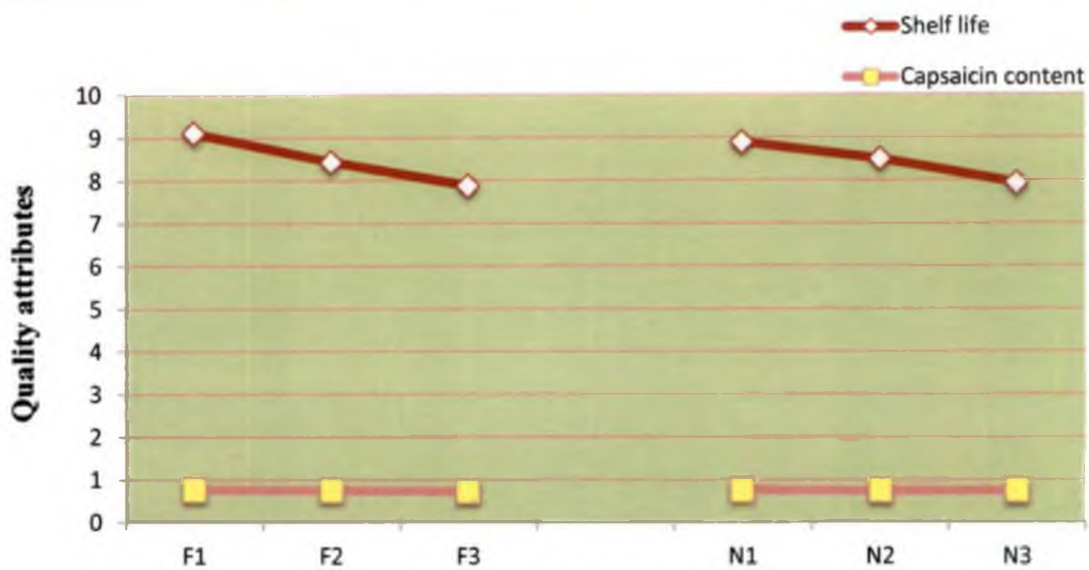

Fig.11. Effect of levels of FYM , levels of substitution on quality aspects of fruits

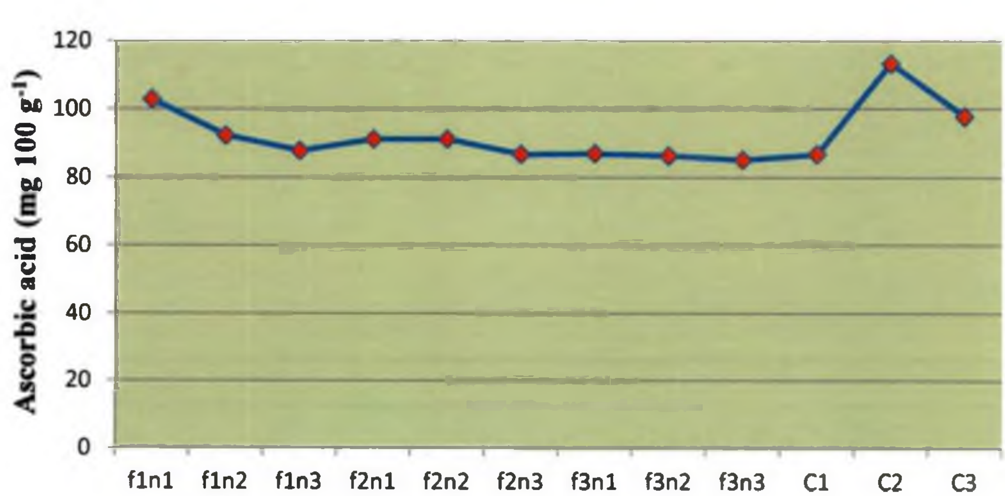

Fig12. Effect of levels of FYM , levels of substitution and their interaction on Ascorbic acid (mg 100 g^{-1})

favoured by the increased availability of N and P. Moreover, adequate availability of high energy compounds in the plant system under assured P nutrition with higher dose of manure application might have enhanced the activity of enzymes involved in capsaicin synthesis. The highest value for the growth and yield characters might have increased the capsaicin content and similar results of increased capsaicin content with higher yield and growth characters were reported earlier by Lekshmi (2011). Similarly Jayasree (2005) also reported higher capsaicin content with POP recommendation of KAU.

5.4 PLANT UPTAKE

The uptake of nitrogen phosphorus potassium (Fig. 13) by the crop differed with different levels of FYM. Levels of substitution significantly influenced the potassium uptake only. 20 t FYM ha^{-1}, recorded maximum nitrogen uptake (43.76 kg ha^{-1}) phosphorus uptake (10.43 kg ha^{-1}) potassium uptake (30.96 kg ha^{-1}) and these were on par with F_2 with nitrogen uptake (42.21 kg ha^{-1}), phosphorus uptake (10.36 kg ha^{-1}) potassium uptake (29.64 kg ha^{-1}). The higher levels nutrients N_1 (100% RFD) and N_2 (75 % RFD) recorded higher potassium uptake of 30.52 kg ha^{-1} and 29.47 kg ha^{-1} respectively. The increase in nutrient uptake due to the application of organic manures might be due to fact that organic manure like FYM when applied to soil results in the breakdown of complex nitrogenous compounds by the action of micro organisms (slow mineralization) and its availability to the soil in the form of nitrite nitrogen. Increase in available phosphorus content of soil (10.43 kg ha^{-1}) due to organic manures application may be due to the solubilization of native phosphorus through release of various organic acids which might be the reason for increased uptake. Similar results of increased nutrient uptake were reported by Raju *et al.*, 1991(N uptake) and Minhas and Sood, 1994 (phosphorus uptake). Similar results of increased nutrient uptake due to the application of organic manures were reported by Barani and Anburani (2004) and Raj (1999).

POP recommendation of KAU (C_1) recorded maximum nitrogen phosphorus potassium uptake of 53.69 kg ha^{-1}, 13.47 kg ha^{-1} and 33.51 kg ha^{-1}

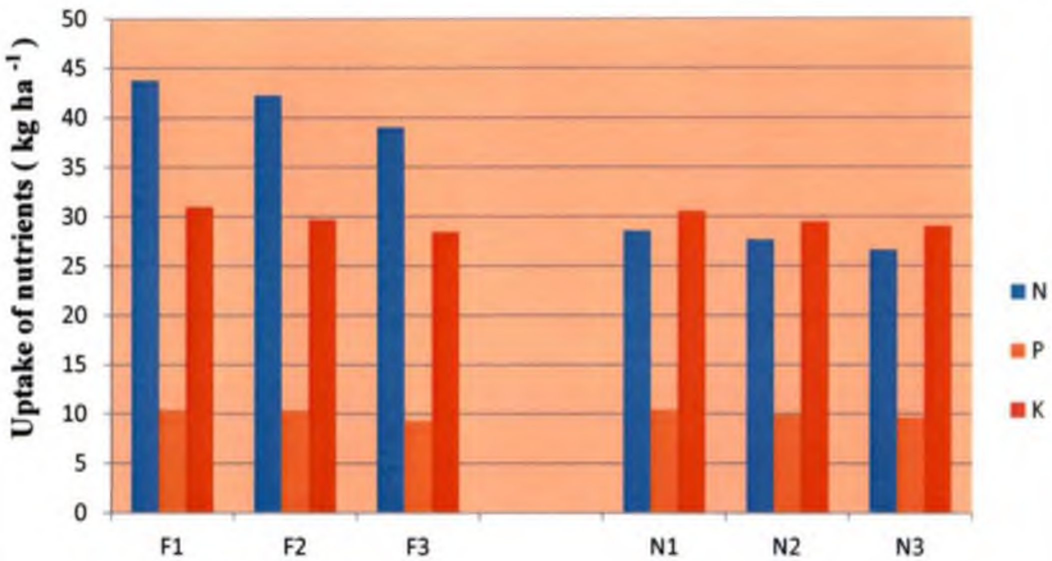

Fig.13. Effect of levels of FYM and levels of substitution on uptake of nutrients

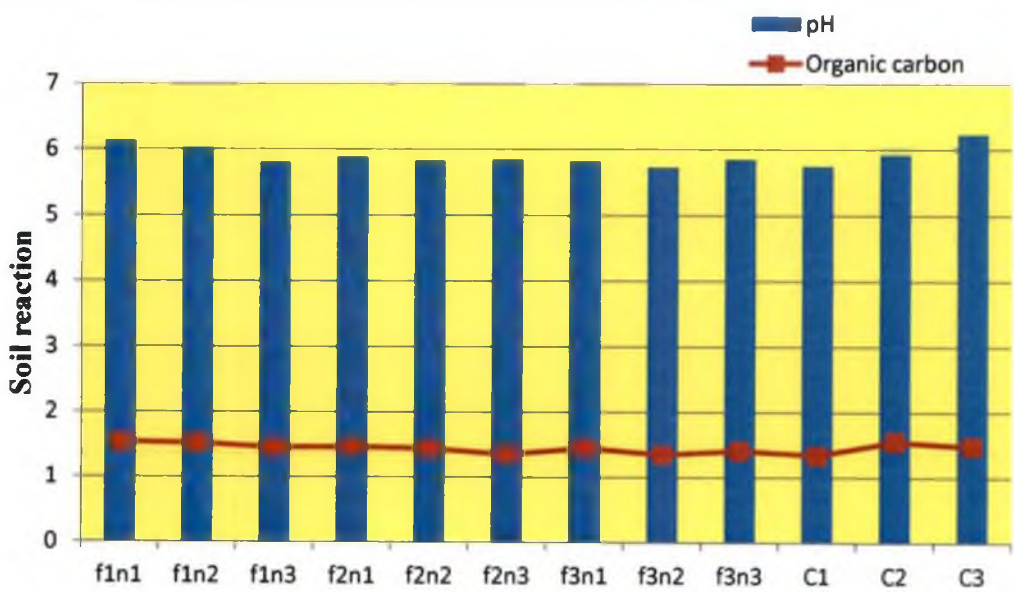

Fig.14. Effect of levels of FYM, levels of substitution and their interaction on soil reaction

respectively. The additional nutrient supply by the application of organics coupled with inorganics as compared to other organic combinations might have resulted in increased nitrogen uptake. Chavan *et al.*, (1997), Shashidhara (2000) and Kattimani (2004) in chilli have also reported the increased uptake of nitrogen due to combined application of organics and inorganics in chilli followed by only organics. The synergistic effect of sulphur in phosphorus uptake might have contributed the increase of uptake of phosphorus as reported by Sud *et al.*, (1996). Similarly, the increased uptake of potassium observed in above said treatments might be the result of increased availability of potassium in soils due to the application of organics and inorganics.

5.5 SOIL REACTION

Maximum soil pH (Fig.14) was noticed with the application of the F_1 (20 t ha^{-1} FYM), 100 % RFD (N_1) and (f_1n_1). The significant increase in pH due to FYM might be due to the buffering action associated with organic matter wherein decreased activity of iron and aluminium ions in the soil solution due to chelation by organic molecules. Further a sudden release of bases by the active degradation of organic matter also contributes to the observed increase in pH. Nambiar (1994) also reported that FYM application resulted in lowest acidity due to the decrease in exchangeable and soluble aluminium in soil. Lal and Mather (1988) reported that FYM application maintained or increased the pH of the soil, while the combination of fertilizers and manures decreased the pH. POP recommendation of KAU recorded lowest pH. The low acidity in POP may be due to the acidity generated by the $NH4^+$ ions formed by the hydrolysis of urea. Similar findings of lowest pH with the KAU POP recommendations were reported by Lekshmi (2011).

Highest organic carbon content (Fig 14) was realized in the present investigation with 20 t ha^{-1} (F_1). 100% RFD and 75 % RFD recorded higher organic carbon content. The lowest organic carbon content was recorded by KAU

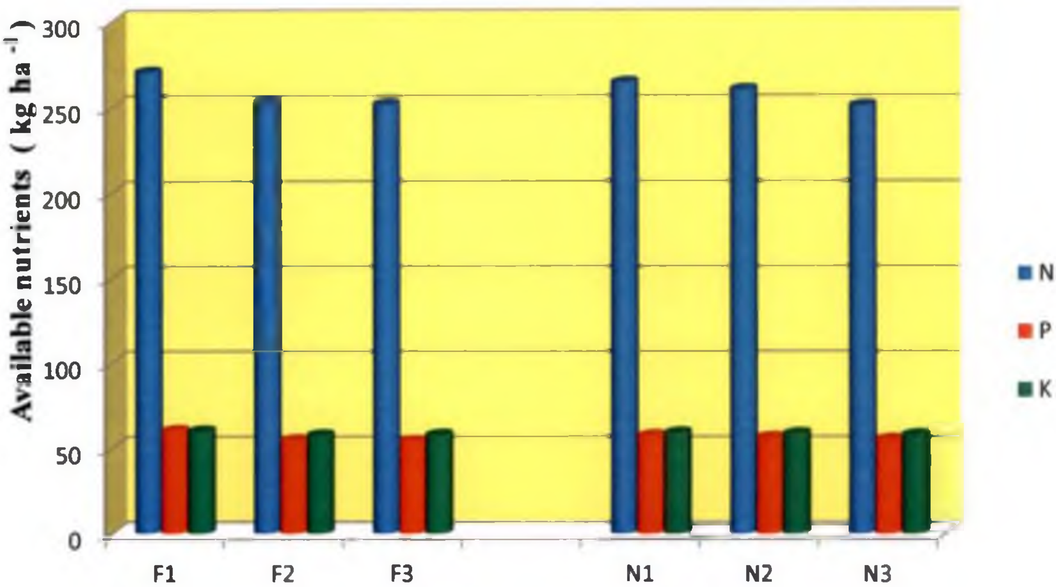

Fig.15 Effect of levels of FYM and levels of substitution on available nutrient status of soil

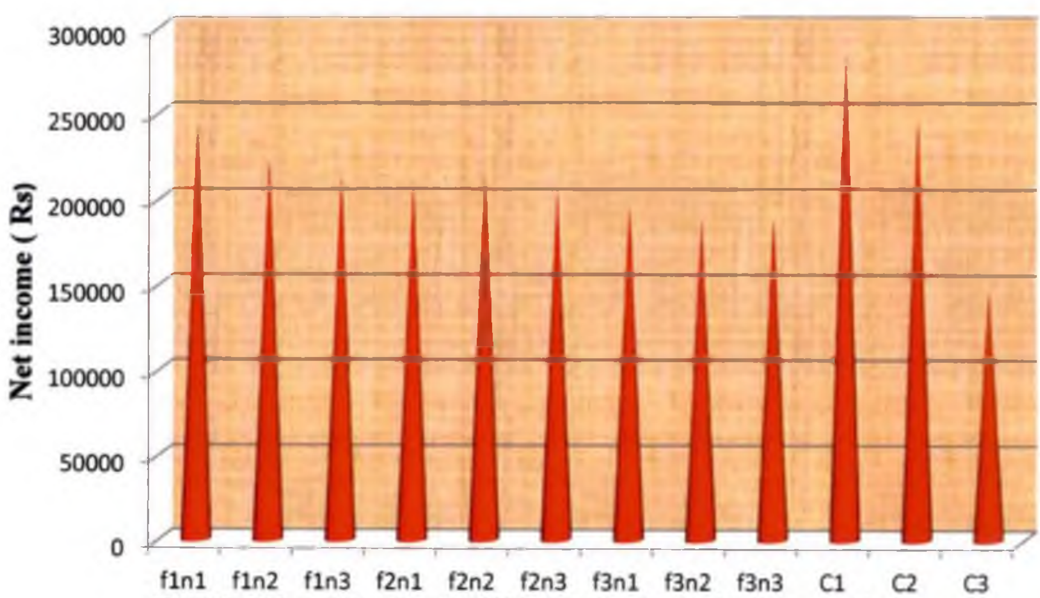

Fig.16. Effect of levels of FYM , levels of substitution and their interaction on net income (Rs)

POP recommendations. An Adhoc POP recommendation recorded the maximum organic carbon content and was comparable with (f_1n_1) and (f_1n_2). The highest organic carbon content with highest FYM may be due to the higher carbon content in FYM and its slower decomposition as compared to all other manures. Similarly Udayasoorian *et al.*, (1988) and Havanagi and Mann (1970) also reported that organic carbon content of soil increased by the continuous application of FYM.

5.6 AVAILABLE NUTRIENT STATUS OF SOIL

The available NPK status of the soil (Fig. 15) differed significantly with application of different level of FYM. F_1 (20 t ha^{-1} FYM) recorded maximum available nitrogen (280.14 kg ha^{-1}) available phosphorus (60.82 kg ha^{-1}) and available potassium (59.73 kg ha^{-1}). Levels of substitution significantly influenced the available nitrogen content of soil. 100 % RFD recorded maximum available nitrogen and it was on par with 75 % RFD (260.04 kg ha^{-1}). Similar increased available nitrogen content with continuous use of organic manures have already been reported by Prasad and Singh (1980) and Kanwar and Prihar (1982). Srivastava (1985) and Bandgopadhyay and Pustae (2002) also observed that FYM addition increased the total nitrogen, available phosphorus and potassium status of soil.

Among the treatments Adhoc organic POP recommendation of KAU recorded maximum available nitrogen phosphorus potassium content of 301 kg ha^{-1}, 64.26 kg ha^{-1} and 62.31 kg ha^{-1} respectively. The higher phosphorus and potassium in poultry manure might be reason for this improvement in available nitrogen, phosphorus and potassium content of soil by poultry manure application was reported by Sharu (2000), Ningping *et al.* (1991) and Nair (2003).

5.7 ECONOMIC ANALYSIS

The highest level of organic nutrition and levels of substution resulted in higher net income (Fig 16) and B: C ratio (Fig 17) of chilli. The continuous supply of nutrients for a prolonged period due to organic manures might have resulted in higher yield, and the higher yield along with higher price for the organically produced vegetables have resulted in high net income and B:C ratio. A similar result of increased profit with FYM and neem cake was reported by Raj (1999) and Shekhar and Rajasree (2009).

POP recommendation of KAU registered maximum net returns and B:C ratio. This increase in net returns and B:C ratio may be due to higher yield along with reduced cost of cultivation due to the low cost incurred for nutrition with inorganic nutrients. Raut *et al.*, (2003) reported the maximum net return with benefit: cost ratio of 2.30 with the application of inorganic fertilizers and FYM.

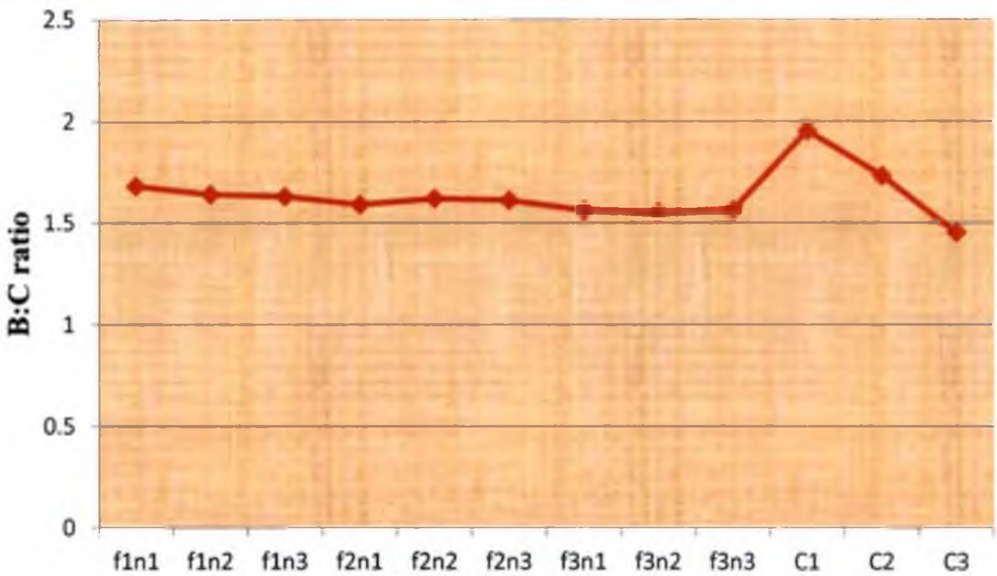

Fig.17 Effect of levels of FYM , levels of substitution and their interaction on B:C ratio

SUMMARY

6. Summary

The research project entitled 'Standardization of organic nutrient schedule for chilli (*Capsicum annuum*)' was conducted at Instructional Farm attached to the College of Agriculture, Vellayani during the kharif season of 2012 to standardize the organic nutrient schedule for chilli and to work out the economics. The investigation was laid out as factorial experiment in Randomized Block Design (RBD) with three replications. The treatments consisted of three levels of FYM - F_1 (20 t ha^{-1}), F_2 (15 t ha^{-1}) and F_3 (10 t ha^{-1}) and three levels of substitution of the recommended dose of nitrogen. The levels of substitution are N_1 (100 % recommended dose of N- 75 kg ha^{-1}), N_2 (75 % recommended dose of N -56.25 kg ha^{-1}) and N_3 (50 % recommended dose of N - 37.5 kg ha^{-1}). FYM along with neem cake in 1: 1 ratio is used as organic manure for N substitution. Three controls were also tested in this study. These controls are C_1 (KAU POP recommendation .FYM@ 25 t ha^{-1} along with75:40:25 kg $N:P_2O_5:K_20$ ha^{-1} as inorganic fertilizer), C_2 (KAU Adhoc organic POP recommendation -FYM @25 t ha^{-1} + Poultry manure at 5 t ha^{-1} + Pseudomonas + Trichoderma and PGPR mix 1, each @2.5 kg ha^{-1}) and C_3 (Farmers practice - Cow dung slurry @ 20 t ha^{-1}).

From the results it was found F_1 with 20 t ha^{-1} FYM (100 % FYM) was significantly superior to all other treatments with respect to plant height at all growth stages except 90 DAT. F_1 recorded highest number of branches and leaf area index at all stages of plant growth. The length and spread of root was also significantly superior with the application of 100 % FYM. Plant height, number of branches, LAI, root length and spread were observed to differ significantly among the various levels of substitution. N_1 (100 % RFD) recorded higher growth characters followed by N_2 (75% RFD). The application of 20 t ha^{-1} FYM combined with 100 % RDF recorded maximum plant height, number of branches, LAI and root spread. Plant height, number of branches, LAI and root spread were observed to vary significantly among the different treatment combinations. The application of 20 t ha^{-1} FYM (100 % FYM) combined with 100 % RDF (f_1 n_1) recorded maximum plant height, number of branches, LAI and root spread.

Highest number of fruits plant $^{-1}$, fruit length, weight of fruits plant $^{-1}$, and mature fruit yield were realized in the present investigation with the application of highest dose of FYM 20 t ha^{-1}. Application of 100 % RFD (N_1) in the form of nitrogen substitution with FYM and neem cake also recorded higher number of fruits plant^{-1}, fruit length and it was comparable with 75 % RFD. The weight of fruits plant^{-1} and mature fruit yield were highest from the plot treated with 100 % RFD. The highest dose of FYM (20 t ha^{-1}) along with 100 % RFD recorded maximum number of fruits plant^{-1}, fruit length and fruit yield plant^{-1} and mature fruit yield.

Highest shelf life was realized in with the application of highest dose of FYM (F_1). 100 % RFD (N_1) and 75 % RFD (N_2) recorded more or less same shelf life. Maximum ascorbic acid content of fruits was recorded by the highest dose of FYM (F_1), 100 % RFD (N_1) and (f_1n_1). Highest capsaicin content of fruits were recorded with the application of 20 t ha^{-1} (F_1) and 15 t ha^{-1} (F_2). 100 % RFD (N_1) and 75 % RFD (N_2) also recorded maximum capsaicin content.

Maximum soil pH was noticed with the application of the 20 t ha^{-1} FYM, 100 % RDF (N_1) and (f_1n_1). Highest organic carbon content was realized in the present investigation with 20 t ha^{-1} (F_1). 100% RDF and 75 % RDF recorded higher organic carbon content.

F_1 recorded maximum N uptake, P uptake and K uptake and these were comparable with F_2. The higher levels nutrients N_1 and N_2 recorded higher K uptake.

F_1 recorded maximum available N, available P and available K. 100 % RDF recorded maximum available N and it was comparable with 75 %.

Different levels of FYM significantly influenced the net income. The highest levels of FYM (20 t ha^{-1}) recorded highest net income and the lowest net was recorded by F_3 (10 t ha^{-1} FYM). The net income was observed to differ significantly among the various levels of substitution. N_1 (100 % RFD) recorded maximum net income followed by N_2 (75 % RFD). The lowest net income was recorded by N_3 (50 % RFD). Different treatment combinations also showed significant influence on net income with highest value recorded by f_1 n_1 (100 % FYM +100 % RFD). The lowest the net income was recorded by f_3n_3 (50 % FYM +50 % RFD) the comparison among the treatment combinations including the controls was also proved to be significant with highest net income from C_1 (POP recommendation of KAU) followed by C_2 (Adhoc POP recommendation of KAU) which was on par with f_1 n_1 (100 % FYM +100 % RFD).

Different doses of FYM significantly influenced the B:C ratio.F_1 recorded maximum B:C ratio and the lowest B:C ratio by F_3. There was no significant difference with respect to B:C ratio by the various levels of substitution. Different treatment combinations also showed significant influence on B:C ratio with highest value from f_1n_1 (100 % FYM +100 % RFD) the lowest by f_3 n_2 (50 % FYM +50 % RFD) which was comparable with f_3 n_3,f_3 n_1.

The comparison among the treatment combinations including the controls was also proved to be significant with highest B:C ratio from C_1 (POP recommendation of KAU) followed by C_2(Adhoc POP recommendation of KAU) and f_1n_1(100%FYM+100%RFD)

Future Line of Work:

- More studies to be conducted for fixing the organic nutrient scheduling for other vegetable crops
- Other organic sources also should be evaluated.
- Organic plant protection measures to be studied in a scientific way.
- Population effect on pests and diseases incidence should also be studied.

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"STANDARDISATION OF ORGANIC NUTRIENT SCHEDULE FOR CHILLI (*Capsicum annuum*)"

by

AKSHAY

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ABSTRACT

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ABSTRACT

The research project entitled 'Standardization of organic nutrient schedule for chilli (*Capsicum annuum*)' was conducted at Instructional Farm attached to the College of Agriculture, Vellayani during the kharif season of 2012 to standardize the organic nutrient schedule for chilli and to work out the economics. The investigation was laid out as factorial experiment in Randomized Block Design (RBD) with three replications. The treatments consisted of three levels of FYM - F_1 (20 t ha^{-1}), F_2 (15 t ha^{-1}) and F_3 (10 t ha^{-1}) and three levels of substitution of the recommended dose of nitrogen. The levels of substitution are N_1 (100 % recommended dose of N- 75 kg ha^{-1}), N_2 (75 % recommended dose of N -56.25 kg ha^{-1}) and N_3 (50 % recommended dose of N - 37.5 kg ha^{-1}). FYM along with neem cake in 1: 1 ratio is used as organic manure for N substitution. Three controls were also tested in this study. These controls are C_1 (KAU POP recommendation -FYM@ 25 t ha^{-1} along with75:40:25 kg $N:P_2O_5:K_20$ ha^{-1} as inorganic fertilizer), C_2 (KAU Adhoc organic POP recommendation -FYM @25 t ha^{-1} + Poultry manure at 5 t ha^{-1} + Pseudomonas + Trichoderma and PGPR mix 1, each @2.5 kg ha^{-1}) and C_3 (Farmers practice - Cow dung slurry @ 20 t ha^{-1})

Result of the study revealed that FYM @ 20 t ha^{-1} recorded significantly higher plant height, no of branches & LAI. The maximum value for all growth parameters were observed at 100% level of N substitution .Combined application of FYM @ 20 t ha^{-1} along with 100% substitution of recommended dose of N (75 kg ha^{-1}) in organic form registered maximum plant height, branches, LAI, and root spread .This treatment was on par with KAU POP and Adhoc organic POP

Maximum yield was recorede at the highest level of FYM (20 t ha^{-1}). Yield contributing characters were also significantly higher at this level. Among the levels of substitution 100% substitution recorded maximum productivity. Application of FYM @ 20 t ha^{-1} along with 100 % recommended dose of N

(75 kg ha^{-1}) as organic form gave maximum productivity which was on par with the yield realized from KAU Adhoc organic POP and KAU POP.

Highest level of FYM @ 20 t ha^{-1} and 100 % substitution of recommended dose of N recorded maximum ascorbic acid, capsaicin content and shelf life. FYM @ 20 t ha^{-1} along with 100% of substitution of N as organic recorded maximum capsaicin content which was on par with KAU POP recommendation. Ad hoc organic POP recommendation of KAU recorded maximum ascorbic acid content.

KAU POP recommendation registered significantly higher N and K uptake than other treatments. Adhoc organic POP recommendations of KAU recorded highest soil pH and organic carbon content. Available nitrogen status of soil was significantly higher in Adhoc organic POP recommendations of KAU but P and K status were on par to KAU POP. Highest B:C ratio and net income were realized in KAU POP.

Best nutrient schedules for realising maximum yield from organic chilli is 1) FYM @20 t ha^{-1} along with 75kg N ha^{-1} applied through a combination of FYM and neem cake in 1 : 1 ratio + Pseudomonas + Trichoderma and PGPR mix 1, each @2.5 kg ha^{-1} and 2) Adhoc POP recommendation of KAU -FYM @ 25 t ha^{-1} along with poultry manure @ 5 t ha^{-1} + Pseudomonas+Trichoderma and PGPR mix 1, each @2.5 kg ha^{-1}.

Economic nutrient schedule for organic chilli is application of FYM @ 25 t ha^{-1} along with poultry manure @ 5 t ha^{-1} + Pseudomonas + Trichoderma and PGPR mix 1, each @2.5 kg.

Appendix 1

Weather data for the cropping period

(15th May – 15th October, 2012) – Weekly averages

Standard Week	Temperature (° C)		Relative humidity (%)	Rain fall (mm)
	Max. temp	Min. temp		
19	31.0	25.5	88.1	8.0
20	31.5	26.1	91.4	22.0
21	31.5	25.8	91.7	00.0
22	31.5	26.1	90.0	1.0
23	31.3	24.7	91.4	3.6
24	30.4	23.9	93.6	7
25	29.4	24.3	94.4	3.5
26	29.8	23.8	87.0	6.0
27	29.5	23.9	95.1	7.4
28	29.6	24.0	88.9	7.9
29	29.9	24.6	92.3	5.3
30	30.0	24.5	94.4	5.8
31	30.2	24.6	94.0	0
32	30.3	23.7	87.7	1.5
33	29.7	23.5	91.3	17.0
34	29.8	23.9	92.6	2.0
35	28.9	23.5	94.7	14.0
36	29.8	23.8	89.9	7.1
37	29.7	24.1	94.4	4.1
38	30.1	24.2	87.9	9
39	30.7	24.3	87.1	0.0
40	31.2	23.5	89.6	0.0
41	31.4	24.1	90.3	6.3
42	29.4	23.4	94.4	10.7