STANDARDISATION OF ORGANIC AND INORGANIC FERTILISER COMBINATIONS FOR MAXIMISING PRODUCTIVITY IN BITTER GOURD (*Momordica charantia* L.)

BY

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THESIS
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Dedicated to the Loving Memory

of

My Grandmother

DECLARATION

I hereby declare that this thesis entitled **"Standardisation of organic and inorganic fertiliser combinations for maximising productivity in bitter gourd (*Momordica charantia* L.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani,
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CERTIFICATE

Certified that this thesis entitled **"Standardisation of organic and inorganic fertiliser combinations for maximising productivity in bitter gourd (*Momordica charantia* L.)"** is a record of research work done independently by **Ms. Rajasree. G.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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LIST OF ABBREVIATIONS

CEC	-	Cation Exchange Capacity
EC	-	Electrical Conductivity
%	-	Percentage
cm	-	Centimeter
Kg.	-	Kilogram
q	-	Quintal
Rs.	-	Rupees
ha	-	hectare
t	-	tonnes
RBD	-	Randomised Block Design
N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
Fe	-	Iron
MJ	-	Mega Joules
Expt.	-	Experiment
RH	-	Relative Humidity
mm	-	milli meter
DAS	-	Days After Sowing
g	-	Gram
CC	-	Cubic Centimeter
PLW	-	Physiological Loss in Weight
DMP	-	Dry Matter Production
NUE	-	Nitrogen Use Efficiency

INTRODUCTION

INTRODUCTION

The dominance of chemical agriculture in the last 40 years with the intensive use of agrochemicals like fertilisers, herbicides, insecticides, fungicides and growth promoting hormones have adversely affected the soil, water and environment by polluting them. However, chemical fertiliser is unavoidable in the present context where the national priority is to feed the increasing human population. Over 50 per cent increase of crop production attained in developing countries was brought about by the use of fertilisers. Recently these facts have created grave concern among scientists and raised the question whether to risk our environment or to ignore the plight of hungry millions. Thus it becomes imperative to develop a technology or package which would bring about substantial increases in agricultural production with least disturbance to our precious earth and environment.

One of the major practices to achieve sustainability is to substitute chemical fertiliser to the maximum extent possible with organic and biological fertilisers. Unfortunately this practice is riddled by several suspicions like to what extent we can substitute nutrient rich chemical fertilisers with organic materials which carry lesser amount of nutrients, what should be the standard of application of organic sources, what would be the fate of produces such as fruits and vegetables in terms of quality and storage life, what would be the influence of organic nutrition on insects, pests and pathogens etc. Regarding the nutrient content variation in both these sources, it is important to remember that organic manures can no longer be over looked by their low nutrient content as their beneficial effects are mainly due to influence on soil properties, soil buffering capacity, improvement in microbial population in soil and control of soil erosion (Thampan, 1993). Many of the recent research works indicate that residual effects of farm yard manure and other bulky organic manures last many years after their application. Though on equivalent nitrogen basis, farm yard manure or compost is only 40-60 per cent as effective as fertiliser source in increasing crop yields, with long term application the efficiency of nitrogen nutrition through an organic source can reach the same level as that of fertiliser nitrogen as a result of cumulative build up of soil nitrogen. Hence it is obvious to think that substituting the chemical fertilisers especially nitrogen fertiliser with organic manures rather than replacing the chemical fertilisers seems to be ideal to achieve higher productivity without sacrificing the quality of the produce and purity or safety of environment.

Coming to a closer perspective, Kerala is mostly a consumer state with respect to vegetables and more than 75 per cent of daily requirement is fulfilled by vegetables produced in the neighbouring states and this infact has eroded the economy of the state. Intensive efforts are now being undertaken to enhance the vegetable production in the state to achieve self sufficiency through the intensive vegetable cultivation programme. However in a state like Kerala with a population density of 749 per km^2, there is only limited scope in bringing additional area under vegetable cultivation. Therefore the other possible alternative to boost up the vegetable production is to enhance the productivity through better management practices. A literate present day Kerala farmer is aware of the consequences of using synthetic chemicals and fertilisers for enhancing the production keeping his limited land resources at stake. Unfortunately the lack of an alternative technology leaves him in a difficult situation that he is unable to part with the use of chemical inputs. Moreover the standardisation of organic nutrition is still at infancy and there is no solid, viable recommendation of organic nutrition for commercial vegetable production.

The present investigation was undertaken as an attempt to standardise the technique of organic nutrition in combination with chemical fertilisers and to study its impact on yield, quality of produce, pest and disease incidence and soil physical, chemical and biological aspects. Farm yard manure and poultry manure are two major sources of organic nature commonly used by the farmers of Kerala. Between these two sources, poultry manure is preferred by farmers of Southern Kerala for vegetable cultivation. Authentic studies so far conducted to standardise the frequency of application of poultry manure and the added efficiency of its combinations with inorganic fertiliser to maximise the yield are meager. Therefore, it was proposed to investigate the efficiency of different levels of combinations of organic and fertiliser nitrogen and their frequencies of application in bitter gourd (*Momordica charantia* L.) which is one of the most commercially promising vegetable crops in Kerala. As the response of bitter gourd to nitrogen nutrition was found to be linear (Kerala Agricultural University, 1991), higher levels of nitrogen were used for substitution aiming at maximum productivity.

In the light of these facts, the present study was undertaken with the following objectives.

- To study the effect of different levels of nitrogen nutrition, ratios of organic - chemical N substitution or frequencies of application on yield and yield attributes, keeping quality and storage life, soil physical, chemical and biological properties, energy out puts and economics of cultivation.

- To standardise the frequencies of application of farm yard manure and poultry manure for commercial bitter gourd cultivation.

- To investigate the possibilities of enhancing the nutrient N level above the current recommendation of 200 kg ha^{-1} for bitter gourd.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

An investigation was carried out at the Instructional Farm attached to College of Agriculture, Vellayani during 1995-'96 and 1996-'97 to study the effect of different levels of nitrogen nutrition, different ratios of substitution of organic and chemical nitrogen fertiliser and their frequencies of application on the cucurbitaceous vegetable crop, bitter gourd (*Momordica charantia* L.).

The relevant literature available on the subject are reviewed hereunder. Wherever sufficient literature is not available on the crop tried in this experiment, results of similar experiments conducted on cucurbits and other related field crops are also cited.

2.1 Effect of rates of nitrogen nutrition

Nitrogen is an important constituent element of all plant cells and protoplasm. It is intimately associated with the vigour and growth of plants. When the supply of nitrogen is adequate, vigorous growth is noticed with dark green foliage and satisfactory total yield. Liberal supplies of nitrogen tend to prolong the growing period and delay the maturity and ripening of crops. The resistance of the plants to pests and diseases is considerably reduced when nitrogen is supplied in excess. Physical appearance of the fruits, their quality and shelf life are also found to be profoundly influenced by nitrogen nutrition. Further more, when nitrogen is supplied through an organic source on equivalent nitrogen basis, its effects are slightly different from that applied through an inorganic (chemical) source. However, since the literature available on the effects of organic sources of nitrogen are comparatively less than that of chemical nitrogen nutrition, more emphasis has been given to the latter while reviewing the literature on nitrogen nutrition.

2.1.1 Effect of rates of nitrogen nutrition on flowering and sex expression

Rates of application of nitrogen is found to have marked influence on flowering and sex expression of most of the cucurbitaceous crops.

As early in 1928, Tiedjens pointed out that higher nitrogen dressing increased the female flowers in cucumber. Later workers like Saito *et al.* (1963) reported another effect of nitrogen as early flower bud differentiation in tomato. In an experiment conducted on cucurbitaceous vegetable, tinda (Smooth gourd), Singh *et al.* (1982) observed the highest number of female flowers (17.38) produced with the application of 120 kg N ha^{-1}. They further observed a narrowing effect on sex ratio due to higher rates of nitrogen application. Matlop and Basher (1985) noted that when 160 kg N ha^{-1} was applied, number of pistillate flowers $plant^{-1}$ increased in summer squash.

Maurya (1987) observed that nitrogen application decreased the number of male flowers and increased the number of female flowers, resulting in a lower sex ratio in cucumber. In a trial on bitter gourd conducted at Kerala Agricultural University, Ravikrishnan (1989) reported another effect of nitrogen nutrition as, the days taken for the opening of first male and female flowers increased with increase in levels of nitrogen application. However it could not significantly influence sex ratio of the plant. Similar trend was reported by Haris (1989) in snake gourd in the case of flower opening, although application of highest level of nitrogen (90 kg) produced the highest sex ratio of 25.15 male/female. According to Dod *et al.* (1992), days required for flowering increased as the level of nitrogen application was raised from 50 to 125 kg N ha^{-1} in chilli. Recently Ali *et al.* (1995) confirmed the early result that maximum number of female flowers $plant^{-1}$ was produced (36.13) with the highest dose of nitrogen @ 120 kg ha^{-1} in bitter gourd.

As evident from the literature cited, nitrogen nutrition is found to have a favourable influence on sex ratio, flower bud differentiation and female flower production though it tends to prolong days required for flowering.

On contrary to the general observations, Mitra *et al.* (1990) found that abundant supply of nitrogen arrested the female flower production in cucumber, especially under restricted watering.

2.1.2 Effect of rates of nitrogen nutrition on dry matter production

Nitrogen being the most important element for the plant growth markedly influences the dry matter production.

Mccollum and Miller (1971) recorded maximum dry matter production obtained with the application of 91 kg N ha^{-1} in pickling cucumbers. Similar trend was noticed in pumpkin wherein increasing levels of nitrogen application significantly increased the total dry matter at 60 days after sowing and at harvest, (Rajendran, 1981). In another trial conducted on bitter gourd, Thomas (1984) reported an increase in dry matter production with the application of nitrogen upto a level of 60 kg ha^{-1}. When levels of nitrogen supplied through an organic source of poultry manure was raised from 50 to 100 kg ha^{-1}, dry matter yield of corn increased from 7.0 to 10.2 g/pot as observed by Beauchamp (1986). A significant increase in total dry matter production of snake gourd was reported by Haris (1989) when higher doses of nitrogen (50, 70 or 90 kg N ha^{-1}) were applied. When nitrogen was supplied through poultry litter at different rates viz. 0, 13, 26, 53 and 106 g kg^{-1} of soil to the collard plants, dry matter production $plant^{-1}$ increased from 17 to 20.5 g $plant^{-1}$ as the rate of application was raised from 13 to 26 g kg^{-1}, while further increase in the level affected the survival of plants drastically (Lu and Edwards, 1994). Farm yard manure application as an organic amendment increasing the dry matter production of bhindi crop was reported by Senthilkumar and Sekar (1998).

The general influence of nitrogen nutrition either through a chemical fertiliser source or organic source is found to be positive on dry matter production.

2.1.3 Effect of rates of nitrogen nutrition on yield and yield attributes

Nitrogen nutrition has profound influence on yield and yield attributes of crops.

Neubert (1959) reported that tomato yield increased as a result of nitrogen application upto a level of 160kg ha^{-1}, but decreased following further increase in application rates. Proportion of large fruits increased rapidly as the level was raised upto 80 kg N ha^{-1} but less progressively at still higher levels. In another field investigation, application of 169.6 q ha^{-1} poultry manure which supplied 500 kg N ha^{-1} on equivalent nitrogen basis produced the highest marketable yield, maximum size of curd and weight of curd compared to lower rates of poultry manure application (0, 42.4, 84.4 or 127.2 q ha^{-1}) which supplied 0, 125, 250 and 375 kg N ha^{-1} respectively in cauliflower, (Singh *et al.*, 1970). Wilcox (1973) reported that optimum fruit yield was obtained with a preplant application of 80 to 90 kg N ha^{-1} in muskmelon. Later in 1980, Shukla and Gupta observed that increasing levels of nitrogen fertilisation increased the fruit size, fruit number and fruit yield per unit area in squash. Mina (1986) opined that when nutrient nitrogen was supplied through an organic source (poultry manure) alone it significantly increased the diameter of fruits, fruit weight and yield $plot^{-1}$ irrespective of rates in muskmelon. Lingiah *et al.* (1988) reported that application of 80 kg N ha^{-1} recorded highest yield in bitter gourd in coastal regions of Karnataka. Haris (1989) noted a linear increase in the yield of snake gourd from 13.086 t ha^{-1} to 15.124 t ha^{-1} as the nitrogen dose was increased from 50 to 70 kg and then to 90 kg N ha^{-1}!

When different organic sources viz. sheep, horse and cow manure were applied each at 10, 20, 30 or 40 t ha^{-1} to tomato, the highest yield of 2.16 kg $plant^{-1}$ was obtained with the supply of sheep manure at the rate of 30 t ha^{-1}; Hilman and Sawandi (1989). In another experiment, Ravikrishnan (1989) reported that bitter gourd crop responded linearly to increasing levels of nitrogen from 0 to 50, 70 and 90 kg N ha^{-1} in terms of fruit yield. However levels of inorganic nitrogen application could not significantly influence the number of fruits $plant^{-1}$. Recent workers like Julia *et al.* (1993) pointed out the beneficial effect of nitrogen nutrition through poultry manure wherein they noticed an increase in the number of large and medium size fruits by applying 15 t ha^{-1} of poultry manure in tomato. In 1995, Ali *et al.* reported that of various levels of nitrogen application viz. 0, 60, 80 and 120 kg N ha^{-1}, highest yield was obtained with the application of 80 kg N ha^{-1} in bitter gourd. In another trial conducted in Kerala Agricultural University, Issac (1995) noticed that when 12 t of farm yard manure along with 3.6 t of poultry manure or 11 t of vermicompost was applied as organic source of nitrogen in bhindi, weight of mature fruits $plant^{-1}$ and mature fruit yield were inferior to treatments combining with inorganic fertiliser. Recently in 1998. Senthilkumar and Sekar reported that fruit yield $plant^{-1}$ in bhindi was increased markedly by the farm yard manure application.

General observation indicated the positive influence of nitrogen nutrition irrespective of its sources on yield and yield attributes. However, contrary observations on the influence of nitrogen on fruit yield and yield attributes were noticed by some of the workers. Dhesi *et al.* (1966) reported that lower rates of nitrogen fertilisation was more effective for fruit production of bitter gourd.

2.1.4 Effect of rates of nitrogen nutrition on root growth

Drew (1975) reported that exposure of parts of the main seminal roots of barley to zones of nitrate and ammonium concentration caused initiation and prolific development of both first and second order laterals which resulted in considerable modification in root form, but had little influence on the extension of the main seminal roots. Bhadoria (1987) noticed the favourable influence of farm yard manure which increased the depth of root penetration in rice. In a trial on chilli, Goyal *et al.* (1988) opined that when nitrogen was applied at the rate of 15 g $plant^{-1}$ more than 80 per cent of roots were concentrated in 0 to 22 cm soil depth. An increase in the root weight of coastal bermuda grass with the application of nitrogen was reported by Tisdale *et al.* (1990).

In general nitrogen nutrition is found to be favourable for better root penetration and greater root weight.

2.1.5 Effect of rates of nitrogen nutrition on pest and disease incidence

Nitrogen fertiliser application generally causes succulance in plant which inturn makes it susceptible to insect and disease attack. However organic source of nitrogen is found to have a suppressing effect on pest and disease incidence.

2.1.5a Pest incidence

Higher doses of nitrogen fertiliser application increased the jassid population in cotton; (Apparao *et al.*, 1959). In another experiment on cotton, Mistric (1963) observed that as the rate of nitrogen application was increased from 35 to 105 lbs.acre^{-1}, a 30 per cent increase in the number of bolls damaged by cotton boll weevil was noticed. When a comparison was made between experimental plots with 128.3 kg N ha^{-1} and without fertiliser in cotton over five growing seasons, the maximum number of jassids was on an average three times higher in fertiliser plots and for whiteflies the increase was about four fold; Jackson *et al.* (1973). According to the results obtained by Chindo and Khan (1990), when four levels of poultry manure viz. 0, 2, 4 and 8 t ha^{-1} were applied, soil nematode population declined drastically during mid season. Rubeiz *et al.* (1995) noticed higher whitefly population in greenhouse cantaloup when inorganic nitrogen was applied compared to poultry manure application. While evaluating the effects of organic manures on the incidence of stemfly in soybean, Kumar *et al.* (1996) observed least stem tunneling with farm yard manure application alone (6.45 per cent) and highest with inorganic fertiliser alone (14.87 per cent).

However, according to Singh *et al.* (1964) and Jayaraj and Venugopal (1964), application of nitrogen fertiliser had no significant effect on jassid population in cotton. Similar observation was recorded by Singh and Jaglan (1985) in okra. Similarly Porazinska and Coleman (1995) observed that inorganic nitrogen did not differ from poultry manure in its effects on the nematode population throughout the growing season in case of *Cucurbita* spp.

2.1.5b Disease incidence

Seo (1986) opined that the application of poultry manure suppressed the occurrence of *Fusarium* wilt in cucumber (*Cucumis sativus*). In another study, Prezotti *et al.* (1987) pointed out that the nitrogen nutrition in the form of poultry manure decreased the incidence of blossom end rot in tomato. Sharma and Kumar (1995) noticed that out of 11 doses of nitrogen ranging from 0 to 125 kg ha^{-1}, the incidence of *Alternaria* blight increased with increase in nitrogen levels in cucurbits.

In general, organic sources of nitrogen are found to have a suppressing effect on disease incidence while inorganic nitrogen favours it.

2.1.6 Effect of rates of nitrogen nutrition on quality of fruits

Qualitative aspects of fruits are found to be influenced positively or negatively by nitrogen nutrition in vegetable crops.

2.1.6a Ascorbic acid content

Ascorbic acid or vitamin C content is differently influenced by the quantity of nitrogen supplied.

Singh *et al.* (1970) reported high vitamin C content of 90 mg in cauliflower curd with the application of poultry manure (169.6 q ha^{-1}) which supplied 500 kg N ha^{-1} on equivalent nitrogen basis. Ascorbic acid content is promoted by nitrogen nutrition in spinach, kohlrabi, cauliflower and radish; (Fritz and Habben, 1972). Pandita and Bhatnagar (1981) observed high ascorbic acid content in tomato fruits from the plants receiving high rate of nitrogen (120 kg ha^{-1}). In a trial on cucumber, Maurya (1987) noticed an increase in the vitamin C content of fruits with increasing levels of application of nitrogen upto 80 kg ha^{-1}. Dod *et al.* (1992) reported an increase in ascorbic acid content of chilli as nitrogen dose was increased from 50 to 125 kg ha^{-1}. Singh and Singh (1992) also made similar observation in tomato.

Contradicting reports have been made by some of the workers who noticed a general depressing tendency of nitrogen on ascorbic acid content. In this regard, Hester (1951) reported that ascorbic acid content of tomato fruits was reduced at higher nitrogen levels. Similar trend was noticed by Cheng (1982) who noted that when the rate of farm yard manure application was enhanced from 35 to 70 t ha^{-1} as the source of nitrogen, ascorbic acid content of fruit reduced in raspberry. Arora *et al.* (1995) reported a maximum ascorbic acid content of ridge gourd fruits supplied with 60 kg N ha^{-1} and least with comparatively higher dose of nitrogen (90 kg N ha^{-1}).

2.1.6b Protein content

Singh *et al.* (1970) estimated a gradual increase in protein content of cauliflower curd with increasing levels of poultry manure application. Highest protein content of 24.85 per cent was obtained with the application of 169.6 q ha^{-1} of poultry manure, which supplies 500 kg N ha^{-1} on equivalent nitrogen basis. According to Fritz and Habben (1972) crude protein content of spinach increased with the increase in nitrogen fertilisation wherein protein quality remained unchanged upto 120 kg N ha^{-1} and deteriorated only at an increased application of 240 kg N ha^{-1}. Maurya (1987) noticed an increase in protein content of cucumber fruits on increasing the levels of nitrogen application upto 80 kg N ha^{-1}. Snake gourd fruits produced a maximum protein content of 15.14 per cent when 90 kg N ha^{-1} was applied, while the lower levels were on a par (Haris, 1989).

Though the nitrogen nutrition positively influenced the protein content of vegetables, Ravikrishnan (1989) recorded that the protein content of bitter gourd fruits was unaffected by different levels of nitrogen.

2.1.6c Mineral contents

In a trial on nitrogen substitution with poultry manure in cauliflower, Singh *et al.* (1970) observed that when different levels of poultry manure were applied to supply 0, 125, 250, 375 and 500 kg N ha^{-1} on equivalent nitrogen basis, there was a slight increase in phosphorus, potassium, calcium and magnesium contents of curds upon enhancing the rate of poultry manure application from 42.4 q ha^{-1} (equivalent to 125 kg N ha^{-1}) to 169.6 q ha^{-1} (equivalent to 500 kg N ha^{-1}).

However later workers like Haris (1989) reported that levels of nitrogen application did not significantly increase the total P and total K contents of snake gourd fruits. This was further supported by Ravikrishnan (1989) wherein he observed that the different levels of nitrogen application viz. 50, 70 or 90 kg N ha^{-1} had no significant influence on total P and total K contents of bitter gourd fruits.

2.1.7 Effect of rates of nitrogen nutrition on keeping quality and storage life

Effect of nitrogen nutrition on keeping quality, moisture content and shelf life of plant produce is found to differ considerably.

Some workers have remarked the nitrogen nutrition as a factor deteriorating the shelf life.

In an experiment on cauliflower with different levels of poultry manure (0, 42.4 q ha^{-1}, 84.4 q ha^{-1}, 127.2 q ha^{-1} and 169.6 q ha^{-1}) to supply 0, 125, 250, 275 and 500 kg N ha^{-1} respectively, Singh *et al.* (1970) estimated a slight increase in the moisture content of curd with increasing levels of poultry manure and the highest moisture content in the curd was obtained with the application of 169.6 q ha^{-1} of poultry manure supplying 500 kg N ha^{-1}. In another experiment on potato, Basu (1986) reported that the percentage of rotten tubers during storage increased with increasing levels of nitrogen. In another study, Ashcroft and Jones (1993) observed that the number of rotten fruits increased significantly with increasing nitrogen levels in case of processing tomatoes. Kadam *et al.* (1993) opined that the keeping quality of betel leaves after 15 days of harvest was significantly influenced by different levels of nitrogen application. Rotting percentage of leaves was less at lower nitrogen dose and it was maximum (20.81 per cent) with 200 kg N ha^{-1}.

Contrary results were reported by some workers like Fritz and Habben (1972) who observed the canned beans maintaining their good quality even after long storage life when they received 120 kg N ha^{-1}. As against the general observation, Karchi *et al.* (1977) reported that inorganic nitrogen fertilised melon fruits had better colour after 30 days of storage at 18°C.

2.1.8 Effect of rates of nitrogen nutrition on soil properties

Nitrogen nutrition is found to influence various physico-chemical properties of the soil and its microbial activities. When nutrient nitrogen is applied through an organic source, it shows profound influence on soil physical properties and microbial population rather than the application through an inorganic or chemical fertiliser source.

2.1.8a Soil physical properties

Aravind (1987) reported that when farm yard manure was applied as an organic source of nitrogen, bulk density of soil lowered from 1.30 to 1.06 g cc^{-1}, compared to the poultry manure application which lowered the same from 1.30 to 1.10 g cc^{-1}. According to Loganathan (1990) there was an increase in total soil porosity from 42.6 per cent to 44 per cent when rate of application of farm yard manure was raised from 2.5 t ha^{-1} to 5 t ha^{-1}. In the All-India Co-ordinated Long-term Fertiliser experiments, application of inorganic nitrogen continuously for 15 years increased the bulk density and reduced the soil water retention at different locations, (Nambiar, 1994). Darwish *et al.* (1995) reported that when supplied with organic manure (28.9 t ha^{-1}) over 15 years, it produced measurable changes in soil physical properties especially an appreciable increase in the water holding capacity.

Soil physical properties are favourably influenced by nitrogen nutrition by organic source and vice-versa for inorganic fertiliser nitrogen.

2.1.8b Soil chemical properties

Soil chemical composition is markedly affected by nitrogen nutrition either through organic or inorganic source.

Bitzer and Sims (1988) concluded 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 utilisation of nitrogen by the plant. Haris (1989) noted that the available nitrogen content in soil increased as the levels of nitrogen was raised from 50 to 90 kg N ha^{-1}, while nitrogen application could not significantly influence the available phosphorus and potassium contents of the soil in an experiment on snake gourd. In another investigation carried out on bitter gourd, Ravikrishnan (1989) reported that with the increase in levels of nitrogen application, available N and P_2O_5 increased significantly though there was no significant difference between 70 kg and 90 kg N ha^{-1} doses in case of available P_2O_5. However a lower dose of 50 kg N ha^{-1} registered the maximum available K_2O in soil. In another trial, Lavanya and Manickam (1991) reported that when organic sources like coirpith, biogas slurry and compost (0.2, 1.6 and 1.7 per cent N respectively) were applied alone to ragi crop, available N, P, K status in the soil after the harvest were lower than that with the use of inorganic fertilisers alone or in combination with organic sources. 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. Application of poultry manure (15 t ha^{-1}) as source of nitrogen increased the exchangeable K and available K contents of soil in a tomato field; Julia *et al.* (1993). Heathman *et al.* (1995) reported an increase in the total nitrogen, total phosphorus and available phosphorus in the top 5 cm soil with the application of 11 t ha^{-1} of poultry manure. Issac (1995) estimated that available N, P_2O_5 and K_2O contents in the soil after the harvest were highest with the application of 12 tonnes of farm yard manure along with vermicompost as a source of nitrogen in bhindi. In another trial, Selvi and Ramaswami (1995) estimated increased soil available phosphorus in the post harvest stage of black gram when farm yard manure was applied as an organic source of nutrient nitrogen.

Post harvest nutrient status of the soil improved with the application of nitrogen irrespective of the nature of its source.

2.1.8c Soil microbial properties

Rhizosphere microbial activities are profoundly influenced by nitrogen nutrition.

Acea and Carballas (1988) reported the favourable influence of cattle slurry application as an organic source of nitrogen on bacterial population and its inhibitory effect on actinomycetes population. In chilli when biogas slurry (BGS) containing 1.8 per cent N was applied to supply an equivalent nitrogen dose of 100 kg N ha^{-1}, it prolonged the rhizosphere microbial activities especially bacteria and fungi, although actinomycetes population was inhibited by BGS application, (Jagadeesh *et al.*, 1994). In another trial, Nambiar (1994) described the effect of organic or inorganic sources of nitrogen on soil microbial populations. In his observation, when N was supplied through an inorganic source of ammonium sulphate, soil fungal and actinomycetes populations were found to be increased to 10.3 ($1x10^4$ g^{-1}) and 40 ($1x10^4$ g^{-1}) respectively compared to the unmanured control which harboured a lower population of 8.3 ($1x10^4$ g^{-1}) and 21.3 ($1x10^4$ g^{-1}) for fungi and actinomycetes respectively. The bacterial population was slightly reduced from 32.3 (1×10^6 g^{-1}) in control to 31.0 (1×10^6 g^{-1}) for the above treatment. However a different trend was observed when nitrogen was supplied through an organic source of farm yard manure alone, where a hike in bacterial (35.6) and actinomycetes (44.6) populations was observed compared to the control while the fungal population declined to 5.6 from the control population of 8.3 (1×10^4 g^{-1}). In another recent trial, Biedenbeck *et al.* (1996) observed that the soil fungal and bacterial populations increased with increase in nitrogen levels, but the population of actinomycetes decreased at the higher levels of nitrogen application as they were intolerant to acidity. Application of cattle slurry (300 kg total N ha^{-1}) on high and low fertility sites during spring resulted in higher microbial biomass C during the growing season than a control soil or a soil receiving 100 kg N ha^{-1} as urea (Paul and Beauchamp, 1996). In a recent study Singh *et al.* (1998) reported that N application at moderate levels improved the bacterial and fungal population in soil while higher levels of nitrogen application favoured the actinomycetes population in soil.

On the contrary to general observation, Khonje *et al.* (1989) noticed no significant effect on bacteria or actinomycetes or fungi after nine annual applications of anhydrous ammonia at the rates of nitrogen upto 300 kg ha^{-1}.

2.1.9 Uptake of nutrients

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 same quantity through farm yard manure or ammonium sulphate on equivalent nitrogen basis. Hegde (1987) noticed an increased nitrogen uptake in water melon with nitrogen application upto 180 kg N ha^{-1}. In an experiment conducted at Kerala Agricultural University on snake gourd, Haris (1989) observed an increase in N and P uptake as the levels of nitrogen application was increased from 50 to 90 kg N ha^{-1}.. Application of 90 kg N ha^{-1} registered the maximum K uptake, while the two lower levels ie. 70 and 90 kg N ha^{-1} did not differ in their effects. Similar trend was noticed by Ravikrishnan (1989) in bitter gourd who reported that N, P and K uptakes increased with increase in levels of nitrogen application. In a trial on cabbage, Warneke and Siregar (1994) observed an increased uptake of nutrients due to higher rates of poultry manure application.

In general, application of nitrogen through organic or inorganic source promotes the uptake of nutrients.

On contrary in a trial on collard, Lu and Edwards (1994) observed that when poultry litter (total N content 38.5 g kg^{-1}) application rate was increased from 13 to 106 g kg^{-1} of soil, the N uptake by plants decreased linearly from 37 to 6.3 per cent though the total nitrogen added to the soil through poultry litter was linearly related to the application rate. The same trend was noticed with P, K, Ca and Mg uptakes.

2.2 Effect of combined application of organic and chemical sources of nitrogen

The role of nitrogen is well known in the growth of plants. Higher levels of this nutrient promote the growth, yield and yield attributes and qualitative aspects of most of the vegetables. Nevertheless, the higher levels of chemical fertiliser application is costly and may also affect the quality of the plant produce. Hence, substituting a part of the total nitrogen requirement with organic sources of nitrogen on equivalent nitrogen basis is a panacea to this crisis. Farm yard manure is the most commonly used organic manure and poultry manure is the most valued organic nutrient source especially in vegetable cultivation and hence were used as organic sources of nitrogen in the present investigation.

2.2.1 Effect of combined application of organic and chemical sources of nitrogen on flowering and sex expression

When organic manures are supplemented with chemical nutrients, it is found to influence the flowering pattern and sex ratio of many crops.

2.2.1a Farm yard manure as an organic source

Nair (1988) noticed that application of higher rates of nitrogen along with farm yard manure induced earliness in clustered chilli. In another investigation conducted in bhindi, Issac (1995) observed that combined application of either

12 t or 6 t of farm yard manure along with chemical nitrogen fertiliser did not significantly influence the days taken for 50 per cent flowering.

2.2.1b Poultry manure as an organic source

In a trial conducted in bhindi, Abusaleha (1981) noticed early flowering with the application of half the nitrogen through ammonium sulfate and the remaining half through poultry manure. Contradicting the above observation later in 1988, Jose *et al.* reported that brinjal plants supplied with chemical source of nitrogen showed early flowering when compared to the combined application of organic (poultry manure/pig manure) and chemical source of nitrogen (urea).

2.2.2 Effect of combined application of organic and chemical sources of nitrogen on dry matter production

Dry matter accumulation is markedly influenced when organic and chemical sources of nitrogen are used together.

2.2.2a Farm yard manure as an organic source

In an experiment in potato on the combined use of different levels of farm yard manure and chemical nitrogen fertiliser, Singh *et al.* (1973) reported that as the treatment levels increased from 40 kg N through farm yard manure + 40 kg N through fertiliser source to 60 kg N through farm yard manure + 60 kg N through fertiliser source and 80 kg N through farm yard manure + 80 kg N through fertiliser source, the dry matter accumulation in plant top decreased gradually and lowest dry matter per cent of 13.28 was recorded with 80 kg treatment. Subbiah *et al.*

(1982) reported that in chilli, equal split application of 120 kg nitrogen ha^{-1} with 25 t of farm yard manure recorded the highest yield of dry chilli pods and stalks.

Contrary to the above findings, Subbiah *et al.* (1983) reported that the dry matter production of brinjal fruits and stalks were not significantly influenced by the interaction effect of farm yard manure and chemical fertilisers.

2.2.2b Poultry manure as an organic source

Jose *et al.* (1988) observed an enhanced dry matter production in brinjal with the application of 50 kg nitrogen as poultry manure combined with 50 kg nitrogen as urea. In another experiment in okra, Abusaleha (1992) reported the highest uptake of nutrients with the combined application of nitrogen in the form of poultry manure and ammonium sulphate which is attributed to the increased drymatter accumulation in plants.

However Singh *et al.* (1973) recorded the contrary observation that in potato, dry matter per cent in plant tops decreased with increase in the levels of combinations of poultry manure and inorganic nitrogen fertiliser from 40 kg N through poultry manure + 40 kg N through fertiliser source to 80 kg N through poultry manure + 80 kg N through fertiliser source.

2.2.3 Effect of combined application of organic and chemical sources of nitrogen on yield and yield attributes

Application of organic sources of nitrogen along with readily available chemical nitrogen sources profoundly influence the yield and yield determining factors of crops.

2.2.3a Farm yard manure as an organic source

Jagoda *et al.* (1970) noticed higher yields in cucumber with the application of 300 q ha^{-1} farm yard manure along with 66 kg ha^{-1} chemical nitrogen. In a field trial conducted in chilli, Fiegin *et al.* (1978) reported that yields were greatly influenced by nitrogen application and highest yield was obtained in plots manured with 90 t ha^{-1} of farm yard manure along with 90 kg ammonium sulfate. Parducho (1981) noticed that using 50:50 or 25:75 ratio of organic manure and ammonium sulfate produced yields comparable to the use of pure inorganic fertilisers in rice. In a similar experiment on corn, Tilo and San Valentin (1984) noted that the combined use of 50 per cent urea and 50 per cent manure to supply a total 45 kg nitrogen produced corn yield comparable to that using 100 per cent urea. Thomas (1984) reported that bitter gourd crop responded well to nitrogen application at 60 kg N ha^{-1} along with 18 t ha^{-1} farm yard manure producing maximum yield. In another field trial, Mesina (1986) reported that application of cattle dung at the rate of 10 t ha^{-1} with 120 kg inorganic fertiliser nitrogen increased the number of fruits and yield $plot^{-1}$ of muskmelon by 34 per cent and 84.68 per cent respectively. The diameter and weight of the fruits were not however significantly affected by the application of both inorganic and organic fertilisers. Similar result was reported by Nair (1988) in clustered chilli, where an increase in the fruit yield was noticed with the application of higher rates of chemical nitrogen together with farm yard manure. Application of 80 t ha^{-1} of cattle manure in conjunction with 100 kg chemical nitrogen at the time of sowing produced the highest fruit yield of 43 t ha^{-1} in melon as reported by Rivera Segovia (1988). Recent workers like Verma (1996) noticed the favourable influence of combined application of organic and inorganic sources of nitrogen wherein maximum yield was obtained in pearl millet with the application of 5 t ha^{-1} of farm yard manure along with 20 kg chemical nitrogen, compared with the application of either 2.5 or 5.0 t ha^{-1} of farm yard manure alone or 2.5 t farm yard manure + 20 kg N ha^{-1} treatments. A synergetic effect due to the application of fertiliser nitrogen together with farm yard manure was observed as increase in yield characters such as head length, girth, number of non wrapper leaves per head and head weight and was prominent upto 120 kg nitrogen with 20 tonnes of farm yard manure in an investigation made by Dixit (1997) in cabbage.

The general favourable influence of farm yard manure in combination with chemical nitrogen on yield aspects of vegetables are clearly evident from the above findings.

2.2.3b Poultry manure as an organic source

Helkiah *et al.* (1981) reported the maximum grain yield of jowar obtained with the application of combination of 30 t ha^{-1} of poultry manure and half the recommended dose of inorganic nutrients. In an experiment conducted in muskmelon, Mina (1986) found that application of poultry manure alone or in combination with chemical fertiliser, irrespective of rates significantly increased the diameter of fruits, fruit weight and yield $plot^{-1}$. Application of 50 per cent of applied nutrient through chemical source together with remaining 50 per cent through poultry manure significantly increased the total tuber yield in potato (Ifenkwe *et al.*, 1987). In a similar experiment in brinjal, Jose *et al.* (1988) noticed that plants supplied with 50 kg nitrogen as poultry manure and 50 kg nitrogen as urea recorded the highest yield of 51.03 t ha^{-1}. Rivera Segovia (1988) observed the higher yields produced by melons when supplied with 100 kg nitrogen in conjunction with 10 t ha^{-1} poultry manure. In another trial in rice, Rala and Garcia (1992) reported that application of 50 per cent nitrogen from chicken manure + 50 per cent nitrogen from inorganic sources produced the highest yield of upland rice. Dahama (1996) pointed out that substitution of inorganic nitrogen with poultry manure upto 120 kg ha^{-1} increased the potato yield to 108 q ha^{-1} compared to control. Ramesh (1997) concluded that poultry manure can be safely substituted for inorganic nitrogen fertiliser upto 75 per cent level without any reduction in yield.

2.2.4 Combined application of organic and chemical sources of nitrogen on root growth

Root ramification and elongation are often found to be influenced by sources of nitrogen.

2.2.4a Farm yard manure as an organic source

Mosin (1970) observed that application of chemical fertiliser with and without farm yard manure resulted in an increase of productivity coefficient of root system as compared by the increase in yields of tubers and tops in terms of unit length of roots or unit area of root absorbing surface in potato. In a trial in bhindi, Issac (1995) reported the highest root spread of 44.05 cm obtained with the application of 6 t of farm yard manure along with inorganic fertilisers.

2.2.4b Poultry manure as an organic source

Singh *et al.* (1973) pointed out the favourable influence of poultry manure on potato yield on account of resultant better root growth owing to the presence of growth promoting substances, when used in conjunction with chemical nitrogen fertiliser.

2.2.5 Effect of combined application of organic and chemical sources of nitrogen on pest and disease incidence

2.2.5a Farm yard manure as an organic source

Dayakar *et al.* (1995) reported that when farm yard manure was applied along with 50:50 NP fertiliser, the population of pigeon pea pod borers was lower than that under the use of straight inorganic fertilisers alone.

2.2.5b Poultry manure as an organic source

Broadbent and Baker (1975) reported that application of fowl manure along with lime and inorganic nutrients, reduced the losses from *Phytophthora* root rot in avacado.

2.2.6 Effect of combined application of organic and chemical sources of nitrogen on fruit quality

Various quality parameters of fruits are influenced by nitrogen nutrition.

2.2.6a Farm yard manure as an organic source

Singh *et al.* (1970) reported that in cauliflower, application of 80 kg nitrogen through farm yard manure along with 80 kg chemical nitrogen produced a higher crude protein per cent of 2.02 compared with 1.58 per cent obtained with 160 kg ha^{-1} nitrogen through farm yard manure alone. Phosphorus content was also higher (0.282%) with the above treatment when compared with the application of 160 kg nitrogen through farm yard manure alone (0.277%). The highest crude protein content of 6.55 per cent was registered in ragi grains by the combined application of 90 kg nitrogen as farm yard manure and 30 kg nitrogen as ammonium sulfate (Chellamuthu *et al.*, 1987a).

The combined application of farm yard manure and chemical nitrogen positively influence the qualitative aspects.

2.2.6b Poultry manure as an organic source

In a field trial conducted in potato, Singh *et al.* (1973) reported that application of 80 kg ha^{-1} nitrogen through poultry manure along with 80 kg ha^{-1} chemical nitrogen produced higher crude protein content of 2.12 per cent than that obtained with the application of 160 kg nitrogen through poultry manure alone (1.91%). Phosphorus content of tuber was also significantly higher (0.319%) with the above mentioned treatment, when compared to the single application of 160 kg nitrogen through poultry manure (0.246%). Liebhardt (1976) noticed a significantly higher crude protein content in corn grain due to combined application of 22 t ha^{-1} of poultry manure along with chemical fertilisers compared to the check or fertiliser treatment alone.

2.2.7 Effect of combined application of organic and chemical sources of nitrogen on keeping quality and storage life

Keeping quality and shelf life of the produce is influenced by nitrogen nutrition and its sources.

2.2.7a Farm yard manure as an organic source

Shanmugavelu (1989) opined that the application of a combination of farm yard manure and inorganic mixture was the best for firmness, storage life and keeping quality of tomato for a long time.

However, Singh *et al.* (1973) made an observation that the yield of unmarketable potato tubers was highest (17.44 q ha^{-1}) when 80 kg nitrogen was supplied through farm yard manure in combination with 80 kg inorganic nitrogen compared with the application of 60 kg nitrogen through farm yard manure (15.62 q ha^{-1}) + 60 kg nitrogen as inorganic fertiliser, 160 kg nitrogen through farm yard manure alone (14.36 q ha^{-1}) or 120 kg nitrogen through farm yard manure alone. Similar trend was noticed by Nair and Peter (1990) who reported that the application of higher rates of nitrogen along with farm yard manure increased the number and weight of unmarketable fruits in 10 days of storage after the harvest of green chillies.

2.2.7b Poultry manure as an organic source

Singh *et al.* (1973) observed that application of 80 kg nitrogen through poultry manure along with 80 kg nitrogen through inorganic fertiliser produced the highest unmarketable potato tuber yield of 20.72 q ha^{-1} in comparison with the application of 60 kg nitrogen through poultry manure + 60 kg nitrogen through inorganic fertiliser (19.80 q ha^{-1}), 120 kg nitrogen through poultry manure (18.00 q ha^{-1}) or 160 kg nitrogen through poultry manure (16.52 q ha^{-1}) alone.

2.2.8 Effect of combined application of organic and chemical sources of nitrogen on soil properties

Soil physical, chemical and biological properties are either favourably or unfavourably affected by the combined application of organic and chemical sources of nitrogen.

2.2.8a Farm yard manure as an organic source

Manickam and Venkataramanan (1972) reported that a combination of inorganic fertilisers with cattle manure could exert very favourable influence on water holding capacity of soil. In another experiment on soil physical properties, Sinha *et al.* (1980) observed a decrease in bulk density of soil with the application of farm yard manure along with lime and inorganic fertilisers, while the continuous use of chemical fertilisers increased the bulk density. Helkiah *et al.* (1981) recorded the lowest bulk density (1.25 g cc^{-1}) and higher porosity (60.43 per cent) with the application of 30 t ha^{-1} of farm yard manure in conjunction with half of the recommended dose of inorganic fertilisers, when compared with the application of inorganic fertilisers alone or 10 t ha^{-1} farm yard manure + 1/2 recommended NPK in a black soil for jowar crop. Mahimairaja *et al.* (1986) opined that the soil porosity was improved by application of farm yard manure along with chemical fertilisers. According to Nambiar (1994), continuous application of farm yard manure @ 10-15 t ha^{-1} annually for 7-13 years along with inorganic fertilisers brought about a slight lowering of bulk density in almost all soils.

While investigating the effect of manuring on soil chemical properties, early workers like Kanwar and Prihar (1962) observed an increase in nitrogen content of soil due to farm yard manure and ammonium sulfate application. A general increase in total P and K contents of soil in plots receiving inorganic fertilisers along with cattle manure was reported by Krishnamoorthy and Ravikumar (1973). Application of farm yard manure along with inorganic fertiliser increasing the available P content of soil was reported by Bagavathiammal and Muthiah (1995).

Soil microbial activity is found to be influenced by combined application of farm yard manure and inorganic nitrogen fertiliser. In this context, Nambiar (1994) reported that when farm yard manure was applied along with ammonium sulfate, soil bacterial and actinomycete population showed a rapid increase compared to the unmanured control plots. However the soil fungal population was reduced to 5.6 ($1 x 10^4 g^{-1}$) compared to the control plot which had a higher population of 8.3 ($1 \times 10^4 g^{-1}$). Similarly, the cumulative evolution of Co_2 and net release of C, N and P markedly increased with addition of urea and/or farm yard manure and their combined application improved the microbial activity of soil (Indian Council of Agricultural Research, 1995).

However contrary to the general observations, Mathen *et al.* (1978) reported that combined application of farm yard manure and inorganic fertilisers had little influence on available nitrogen content of soil. A similar observation was reported by Nair (1988) that the application of farm yard manure along with nitrogen fertiliser did neither influence the soil physical properties, nor it had any effect on soil chemical properties such as available nitrogen, available P_2O_5 and available K_2O contents of soil after the harvest. Natural incidence of vesicular arbuscular mycorrhizae was also unaffected by the treatments.

2.2.8b Poultry manure as an organic source

Liebhardt (1976) reported that though there was significant decrease in the soil potassium on plots receiving high rates of poultry manure, this reduction was less apparent when poultry manure was applied along with inorganic fertilisers. In another field experiment, Helkiah *et al.* (1981) noticed that when poultry manure was applied at the rate of 30 t ha^{-1} in combination with half the recommended dose of inorganic fertilisers, the lowest bulk density (1.17 g cc^{-1}) and highest porosity (61.00%) were obtained when compared with the application of full recommended dose of chemical fertilisers or 10 or 20 t ha^{-1} poultry manure plus half the dose of recommended inorganic treatments. In a field trial with poultry manure, Budhar *et al.* (1991) obtained increased post harvest nutrient status of soil to an extent of 217, 28 and 412 kg ha^{-1} NPK with the application of 5 t ha^{-1} of poultry manure along with 100 per cent recommended fertilisers.

2.2.9 Effect of combined application of organic and chemical source of nitrogen on uptake of nutrients

When organic and inorganic sources of nitrogen are applied in combinations, nutrient uptake by crops are greatly influenced.

2.2.9a Farm yard manure as an organic source

Chellamuthu *et al.* (1987b) reported that increased levels of application of nitrogen through farm yard manure (60 kg N ha^{-1}) and ammonium sulfate (30 kg N ha^{-1}) resulted in a higher uptake of phoshphorus (12.33 kg ha^{-1}) in ragi. Higher nutrient uptakes of 52.53 kg ha^{-1} N, 13.09 kg ha^{-1} P and 55.89 kg ha^{-1} K were recorded by Abusaleha (1992) in okra at 90 days after sowing, when 40 kg nitrogen was applied as 20 kg in the form of ammonium sulfate and remaining 20 kg in the form of farm yard manure compared with the application of 40 kg nitrogen through farm yard manure alone. In long term fertilser trials, addition of farm yard manure along with inorganic fertiliser increased the uptake of N, P and K in most of the crops when compared with the application of inorganic fertiliser alone (Nambiar, 1994).

2.2.9b Poultry manure as an organic source

Jose *et al.* (1988) noted that application of half (50 kg) nitrogen as poultry manure along with remaining half (50 kg) as urea increased the uptake of nitrogen, phosphorus, potassium, calcium and magnesium in brinjal. Abusaleha (1992) recorded the highest N, P and K uptakes in okra at 90 days after sowing (76.92 kg ha^{-1}, 20.04 kg ha^{-} and 71.91 kg ha^{-1} respectively) when 40 kg nutrient nitrogen was applied equally through ammonium sulfate and poultry manure in comparison with other treatments including application of 40 kg N through poultry manure alone.

2.3 Effect of frequency of application of nitrogen

Nutrient nitrogen has a tendency to leach out of the soil very quickly compared with the other nutrients and hence its application in several splits is advisable to obtain better crop growth and higher yields.

2.3.1 Effect of frequency of application of nitrogen on flowering and sex expression

Singh *et al.* (1982) observed that when 120 kg nitrogen was applied half as basal before seeding and remaining half dose in two equal split doses after 25 and 50 days of seeding in tinda, highest number of days (40.21) were taken for the first female flower opening. Sex ratio was also narrowed under this treatment. When nitrogen was applied at bolting stage compared to flowering stage in cabbage, number of flowers showed an increase as reported by Mitra *et al.* (1990). According to Dod *et al.* (1992), application of nitrogen in four splits (at the time of transplanting + 30 + 51 + 72 days after transplanting) required the maximum days for flowering (54.50) compared to 2, 3 or 5 splits in chilli. In an experiment with tomato, Singh and Singh (1992) observed that application of 120 kg nitrogen 1/3 as basal prior to transplanting and remaining 2/3 nitrogen in two equal splits at 30 and 45 days after transplanting delayed the flowering. Mitra *et al.* (1994) recorded a highest percentage of flowering (76.4%) in pineapple with the two split applications of inorganic nutrients including nitrogen at 6 and 10 months after planting compared with single dose or three splits. In another experiment on pumpkin (*Cucurbita moschata* Poir), Swiader *et al.* (1994) noticed that the number of male and female flowers that reached anthesis by 72 days after seeding was highest with application of 112 kg nitrogen applied as five fertigation doses together with an equal quantity of potash.

Split application of nutrient N is found to influence the flowering and sex expression of vegetable crops.

2.3.2 Effect of frequency of application of nitrogen on dry matter production

According to Subbiah *et al.* (1982), equal split application of 120 kg nitrogen along with 25 t of farm yard manure resulted in highest yield of dry chilli pods and chilli stalks. The fruit dry weight was significantly higher (44.60 g) when nitrogen was applied in 4 splits (at the time of transplanting + 30 + 51 + 72 days after transplanting) compared to 2, 3 or 5 splits in chilli (Dod *et al.*, 1992).

On contrary, Mitra *et al.* (1990) reported that in cabbage application of 250 kg nitrogen in 5 splits as top dressing at an interval of 3 weeks resulted in a lower dry matter yield compared to a single application. In another study, Gora *et al.*, (1996) observed that drymatter accumulation in cumin plants was not under the influence of time of nitrogen application.

2.3.3 Effect of frequency of application of nitrogen on yield and yield attributes

Application of split doses of nitrogen influence the yield and yield attributes of vegetable crops in general.

Dhesi *et al.* (1966) observed that when 56 kg nitrogen was applied in two splits, one half after planting and the other half about one month later, maximum fruit yield of 14.15 q ha^{-1} was obtained in bitter gourd. According to Katyal (1977), application of 50 tonnes ha^{-1} of farm yard manure as basal dose and top dressing of ammonium sulfate @ 100 kg ha^{-1} soon after flowering was sufficient for a successful crop of bitter gourd. In another experiment Longbrake *et al.* (1977) reported that for muskmelon, split fertiliser applications beginning at the 2 to 4 leaf stage is ideal for profitable yield. Sharma *et al.* (1978) noticed a highest yield in tomato when 60 kg nitrogen ha^{-1} was applied in two split doses; half before and half after transplanting. Srinivas and Prabhakar (1982) opined that fruit yield of capsicum was highest with the application of 150 kg nitrogen ha^{-1} in three equal splits at planting, 30 days after planting and 60 days after planting. In a field trial in lettuce, when poultry manure was applied at the rate of 0, 20 or 40 m^3 ha^{-1} either all at transplanting, half at transplanting, and half 20 days after transplanting, 1/3 at transplanting, 1/3 at 20 days after transplanting and remaining 1/3 at 40 days after transplanting, yields were found to increase from 0.66 to 0.88 and 0.90 kg $plant^{-1}$ respectively (Anez and Tavira, 1984). In an experiment on pointed gourd, Das *et al.* (1987) reported that maximum fruit yield was obtained when 90 kg nitrogen was applied in the form of urea in two equal splits, first at planting and the rest half of nitrogen as top dressing two months after planting. In an experiment with tomato cv. Campbell 28, when plants were fertilised with nitrogen @ 120 kg ha^{-1} applied either at sowing or in various split applications, yields were lowest (14.37 kg ha^{-1}) when 1/3 of nitrogen was applied at sowing and 2/3 applied between 30 and 40 days after sowing (Fonseca *et al.*, 1988). Singh *et al.* (1988) reported the favourable influence of split application of nitrogen in chilli, where maximum yield was obtained with two split doses. Mitra *et al.* (1990) concluded that when nitrogen was applied during flowering in cabbage, it enhanced the fruit set. In another trial in chilli, Dod *et al.* (1992) observed that maximum fruit length (9.09 cm) and fresh fruit yield (54.66 q ha^{-1}) were obtained when nitrogen was applied in four split doses as at the time of transplanting + 30 + 51 + 72 days after transplanting compared to two, three or five splits. According to Batal *et al.* (1994), when nitrogen fertiliser was applied in different rates and frequencies, less frequent applications of the lowest dose (84 kg N ha^{-1}) reduced the marketable weight of bulbs in onion. Split application providing 33 per cent of total nitrogen in the first 12 weeks of the growth period and 3 applications each providing 22 per cent nitrogen in the second 12 week period increased the bulb size and maximised the yield of premium marketable grades. Swiader *et al.*

(1994) reported the favourable influence of 112 kg N ha^{-1} applied as five split fertigations along with an equal amount of potash during the growing season in pumpkin (*Cucubita moschata* Poir) which resulted in high yields without compromising early fruit maturity.

On contrary to the above observations, Wiedenfeld (1986) opined that timing of nitrogen fertiliser application did not affect the yield of either musk melon or peppers (*Capsicum annum*).

2.3.4 Effect of frequency of application of nitrogen on pest and disease incidence

Influence of frequency of nitrogen nutrition on pest population was studied by some workers.

Dayakar *et al.* (1995) observed that when organic (farm yard manure) and inorganic sources of nitrogen were applied in full quantity as basal dressing, population build up of pigeon pea borers was minimum in plots where full farm yard manure was applied as basal.

Effect of split application of nitrogen on disease incidence in crops was investigated by many workers.

Salt (1952) opined that when higher nitrogen doses were applied at different times in split doses, it increased the attack of *Cercosporella* fungus causing eye spot disease, mainly due to the increased tiller production in wheat. According to Kruger and Stammfaul (1970), there was a slight increase of root rot of fully grown maize plants, when they were top dressed with 25 to 50 kg N ha^{-1}. In an experiment on the effect of time of nitrogen application on fungal disease incidence of barley, Widdowson *et al.* (1976) observed that late nitrogen application favoured the rust infestation than did the early nitrogen application, when nitrogen fertiliser was applied either fully at seed bed stage or as two splits. According to Batal *et al.* (1994), split method of applying nitrogen during early and late growth periods influenced the incidence of onion rot.

Though the split method of nitrogen application is found to have a promoting effect on disease incidence there are some contrary results reported in this regard. Mitra *et al.* (1990) pointed out that ammonium sulphate application before and after sowing reduced the infestation of wilt and damping off in water melons. Similar result was reported by Davis *et al.* (1994) who observed significantly lower wilt incidence in potato with the split application of 300 kg N ha^{-1} compared to the pre plant application or unfertilised control.

2.3.5 Effect of frequency of application of nitrogen on fruit quality

Higher protein (11.94%) and Vitamin C (11.87 mg 100 g^{-1}) contents were obtained in cucumber when 80 kg nitrogen was applied at six leaf stage and at the time of flower bud initiation (Maurya, 1987). Dod *et al.* (1992) found that maximum ascorbic acid content of fruit (119.28 mg 100 g^{-1}) was obtained when nitrogen was applied in four splits as at the time of transplanting + 30 + 51 + 72 days after transplanting in chilli. Singh and Singh (1992) noticed a higher ascorbic acid content in tomato fruits when 125 kg nitrogen was applied through urea as one-third as basal dose prior to transplanting and remaining 2/3 of nitrogen in two equal splits at 33 and 45 days after transplanting.

But in an experiment on lettuce when poultry manure was applied at the rates of 0, 20 or 40 m^3 ha^{-1} either all at transplanting, half at transplanting and half 20 days after transplanting or one-third at transplanting, one-third 20 days after transplanting and one-third 40 days after transplan-ting, quality of the produce was not affected by the split application (Anez and Tavira, 1984).

2.3.6 Effect of frequency of application of nitrogen on keeping quality and storage life

In an experiment conducted in clustered chilli, Nair and Peter (1990) reported that when organic source of nitrogen was applied as farm yard manure (full as basal) and inorganic nitrogen 1/2 as basal dressing, 1/4 at 20 to 25 days after transplanting and remaining quantity of nitrogen one month after second application, number and weight of chilli fruits after 10 days of storage from harvest increased with higher levels of farm yard manure and inorganic nitrogen.

2.3.7 Effect of frequency of application of nitrogen on soil properties

Frequency of application of nutrients is found to influence various soil properties viz. physical, chemical and biological.

Haris (1989) reported that available nitrogen content of the soil after the experiment was maximum when 90 kg nitrogen was applied 1/2 as basal one day prior to sowing and the remaining quantity in two equal splits at 30 and 60 days after sowing in snake gourd where as available P_2O_5 and K_2O contents were unaffected by nitrogen application. Ravikrishnan (1989) also reported similar results in bitter gourd. Influence of frequency of nitrogen application on soil microbial activity was studied by some workers.

Davis *et al.* (1994) observed that split application of 300 kg N ha^{-1} resulted in significantly lower colonisation of wilt fungus (*Verticillium dahlias*) in soil compared with pre plant application of N or unfertilised control. In another study, Campbell *et al.* (1995) opined that microbial biomass C which is a measurement of soil microbial activity was slightly increased by the higher frequency of split application at 144 kg N ha^{-1}.

2.3.8 Effect of frequency of application of nitrogen on nutrient uptake

Haris (1989) observed highest phosphorus and potassium uptake in snake gourd, when 90 kg nitrogen was applied half at planting and remaining half in two equal doses at 30 and 60 DAS. Similar observations were made by Ravikrishnan (1989) in bitter gourd. In another study, Mitra *et al.* (1990) reported that in cabbage, application of 250 kg N in 5 split doses as top dressing at an interval of 3 weeks increased the nitrogen and phosphorus uptake. According to Gora *et al.* (1996) nitrogen uptake by cumin plants was higher when 30 kg nitrogen was applied in two equal splits (half as basal + half 30 DAS) when compared to its full basal application.

The general influence of split application of nitrogen on nutrient uptake was found to be positive.

MATERIALS AND METHODS

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The present investigation was undertaken through two experiments done simultaneously during January-May 1996 in the first year and January-May 1997 in the subsequent year.

3.1 Experimental site

The field experiments were laid out at the Instructional Farm attached to College of Agriculture, Vellayani. Both the experiments were laid out in the same area situated at 8°5' N latitude and 76°9' E longitude and at an altitude of 29 m above the mean sea level.

3.1.1 Soil

The soils of the experimental sites belonged to the order oxisol and family of loamy skeletal Kaolinitic Isohyperthermic Rhodic Haplustox, and were non saline, moderately acidic in reaction, low in CEC, low in organic carbon, low in available nitrogen, medium in available phosphorus and low in available potassium. Soil samples were collected from 0-30 cm depth and composite samples were used for determining the chemical properties of both the sites.

The physico-chemical properties of the soil are presented in Table 1.

Table 1. Physico-chemical properties of soil at the experimental sites

Table 1.a. Physical composition

Parameters	Content in soil (%)		Method used
	Experiment I	Experiment II	
Coarse sand	13.25	12.00	Bouyoucas
Fine sand	33.65	33.59	Hydrometer method
Silt	28.10	30.10	(Bouyoucas, 1962)
Clay	25.00	24.31	
Textural class	Loam	Loam	

Table 1.b. Chemical and Biological composition

Constituent		Content in Soil and Rating				Method
		Experiment I		Experiment II		
1. Soil reaction (pH)	1995-96	5.4	(Acidic)	5.5	(Acidic)	pH meter with glass
	1996-97	5.5	(Acidic)	5.4	(Acidic)	electrodes (Jackson, 1973)
2. EC (d SM^{-1})	1995-96	0.02	(Safe)	0.018	(Safe)	Conductivity bridge
	1996-97	0.022	(Safe)	0.020	(Safe)	
3. CEC ($CmolP^+$) kg^{-1}	1995-96	4.5		4.5		Buchner funnel
	1996-97	4.58		4.7		method (Jackson, 1973)
4. Organic carbon (%)	1995-96	0.29		0.31	(low)	Walkley and Black's
	1996-97	0.40		0.44	(medium)	rapid titration method (Jackson, 1973)
5. Available nitrogen	1995-96	185.02	(low)	134.85	(low)	Alkaline potassium
(kg ha^{-1})	1996-97	200.74	(low)	206.98	(low)	permanganate method (Subbiah and Asija, 1956)
6. Available P_2O_5	1995-96	22.57	(medium)	27.29	(medium)	Bray colourimetric
(kg ha^{-1})	1996-97	23.09	(medium)	20.52	(medium)	(Jackson, 1973)

Constituent		Content in Soil and Rating		Method
		Experiment I	Experiment II	
7. Available K_2O (kg ha^{-1})	1995-96	107.52 (low)	105.83 (low)	Ammonium acetate method (Jackson, 1973)
	1996-97	134.40 (medium)	147.84 (medium)	
8. Soil bacterial population ($1x10^8$ g^{-1})	1995-96	$11.9x10^8$	$13.1 x 10^8$	Dilution plate technique (Timonin, 1940)
	1996-97	$14.9x10^8$	$11.5 x 10^8$	
9. Soil fungal population ($1x10^4$ g^{-1})	1995-96	$76.7x10^4$	$78.2x10^4$	-do-
	1996-97	$65.5x10^4$	$78.9x10^4$	
10. Soil actinomycetes population ($1x10^6$ g^{-1})	1995-96	$1.0x10^6$	$1.25x10^6$	-do-
	1996-97	$2.0x10^6$	$1.00x10^6$	

Table 1.c. Physical properties

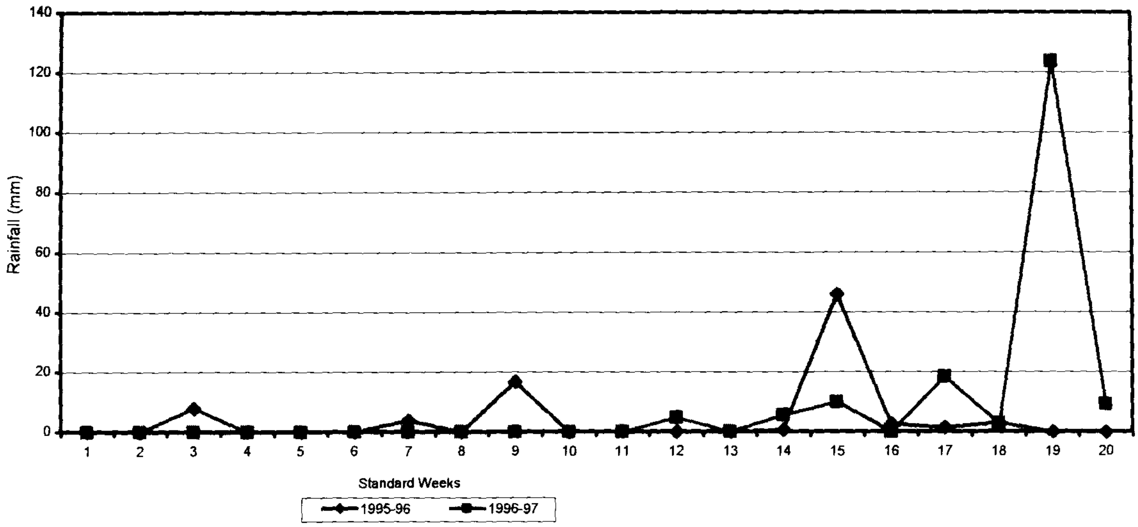
Constituent		Content in Soil and Rating		Method
		Experiment I	Experiment II	
1. Bulk density (g cc^{-1})	1995-96	1.41	1.43	Core method (Gupta and Dakshina moorthi, 1980)
	1996-97	1.29	1.28	
2. Water holding capacity (%)	1995-96	30.25	28.83	-do-
	1996-97	32.35	35.91	
3. Particle density (g cc^{-1})	1995-96	3.25	2.98	-do-
	1996-97	2.95	2.60	
4. Porosity (%)	1995-96	42.95	37.19	-do-
	1996-97	45.33	40.92	

3.2 Season

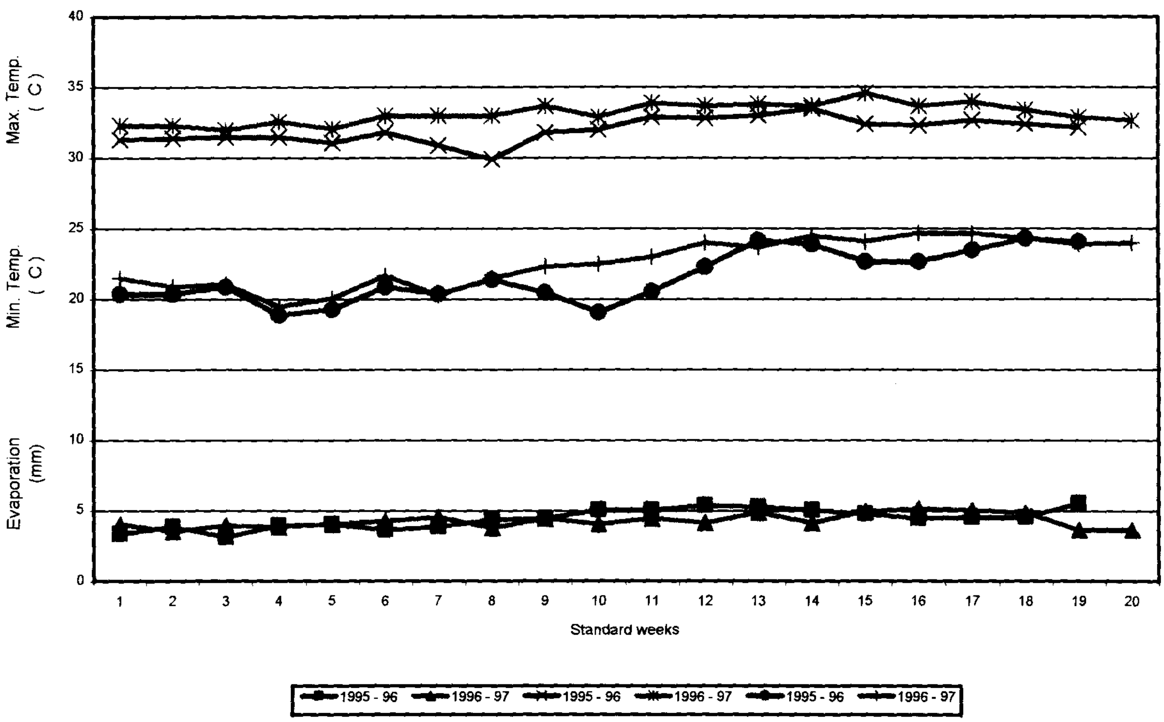
The field experiments were first laid out during January-May 1996 and were repeated during January-May 1997 retaining the same layout in the next year. The bitter gourd variety MC-84 (Preethi) was raised during 4th January to 12th May 1996 in two simultaneous experiments and in the next year, the crop was raised during 6th January to 15th May 1997 in the same manner.

Fig1 WEATHER PARAMETERS DURING THE CROPPING PERIOD

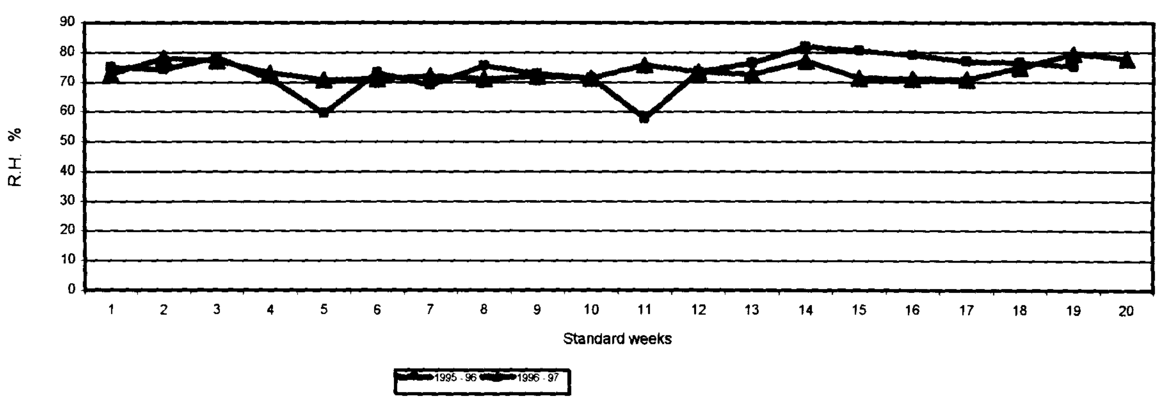
1 a. Rainfall



1b. Maximum temperature, Minimum temperature & Evaporation



1c. Relative Humidity



3.3 Weather conditions

Data on weather conditions such as temperature, rainfall and relative humidity were obtained from the meteorological observatory, College of Agriculture, Vellayani. Weather condition was satisfactory for proper growth and establishment of the crop in both the years. The average values of climatic parameters for the cropping period are in Appendix I. Mean maximum temperature ranged from 29.9°C to 33.5°C in the first year and 32.0°C to 34.6°C in the second year. Minimum temperature ranged from 19.1°C to 24.3°C in the first year and 19.5°C to 24.7°C in the second year. The mean relative humidity ranged from 57.9 to 82.1 per cent in the first year and 71.0 to 79.6 per cent in the second year. Total rainfall received during the cropping period was 82.2 mm in 13 days in the first year and 174.5 mm in 16 days in the second year.

3.4 Cropping history of the field

A bulk crop of vegetable snake gourd was raised prior to the commencement of the experiment in both the years.

3.5 Materials

3.5.1 Seeds

Seeds of bitter gourd variety MC-84 (Preethi) were obtained from the R&D unit of Kerala Horticulture Development Programme, Thrissur. The variety MC-84 has an average vine length of 6.86 m with about 36.13 side branches plant^{-1}. Fruits are white, medium long, broad with spines present and ridges absent on fruit body (Vahab, 1989).

3.5.2 Manures

Farm yard manure and poultry manure were used as organic sources in experiment I and II respectively. The nutrient contents of manures used for the experiments were analysed in each year and are given in Table 2. Doses of farm yard manure and poultry manure were fixed on equivalent nitrogen basis and applied at fixed frequencies as per the treatments given in Appendix IIa and IIb.

Table 2. Estimated nutrient values of manures (%)

	1995-96			1996-97		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Farm yard manure	0.50	0.30	0.50	0.52	0.33	0.50
Poultry manure	2.56	2.10	1.50	2.62	2.17	1.35

3.5.3 Fertilisers

Urea containing 45.6% N was used as a source of chemical nitrogen in both experiment I and II and was applied in fixed quantities and intervals as per the treatments as given in Appendix II. Mussoriephos (20% P_2O_5) and muriate of potash (59.81% K_2O) were used as sources of phosphorus and potassium respectively.

3.6 Methods

The trial consisted of two experiments conducted simultaneously viz. experiment I using farm yard manure and experiment II using poultry manure as organic sources of nitrogen. Three levels of nutrient nitrogen applied as three combinations of organic and chemical nitrogen at three different frequencies consisted the treatments in general.

3.6.1 Treatments

I Levels of nitrogen

l_1 - 200 kg N ha^{-1}

l_2 - 250 kg N ha^{-1}

l_3 - 300 kg N ha^{-1}

II Ratios of organic and chemical nitrogen

r_1 - 1 : 1

r_2 - 1 : 2

r_3 - 2 : 1

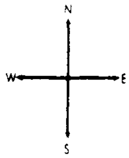
III Frequency of application

f_1 - Full quantity of farm yard manure/poultry manure as basal + chemical N source in equal splits as basal and at fortnightly intervals upto one month before final harvest.

f_2 - Farm yard manure/poultry manure applied in three equal splits as basal and at 40th and 70th days after planting + chemical N source in equal splits as basal and at fortnightly intervals upto one month before final harvest.

f_3 - Farm yard manure/poultry manure and chemical N source in equal splits as basal and at fortnightly intervals upto one month before final harvest.

Fig 2 **LAYOUT PLAN**



RI B1	RI B2	RI B3	RII B1	RII B2	RII B3
$(l_2r_2f_1)$ **221**	$(l_1r_1f_2)$ **112**	$(l_2r_1f_2)$ **212**	$(l_2r_1f_2)$ **212**	$(l_1r_3f_1)$ **131**	$(l_3r_3f_1)$ **331**
$(l_3r_3f_1)$ **331**	$(l_3r_2f_1)$ **321**	$(l_3r_1f_1)$ **311**	$(l_3r_2f_1)$ **321**	$(l_3r_2f_2)$ **322**	$(l_2r_3f_3)$ **233**
$(l_1r_2f_2)$ **122**	$(l_2r_2f_2)$ **222**	$(l_1r_1f_3)$ **113**	$(l_3r_3f_2)$ **332**	$(l_2r_3f_2)$ **232**	$(l_2r_1f_1)$ **211**
$(l_3r_2f_3)$ **323**	$(l_3r_3f_2)$ **332**	$(l_1r_3f_2)$ **132**	$(l_1r_1f_1)$ **111**	$(l_2r_2f_1)$ **221**	$(l_3r_1f_2)$ **312**
$(l_1r_1f_1)$ **111**	$(l_1r_3f_1)$ **131**	$(l_2r_3f_1)$ **231**	$(l_2r_2f_3)$ **223**	$(l_3r_3f_3)$ **333**	$(l_1r_2f_1)$ **121**
$(l_1r_3f_3)$ **133**	$(l_1r_2f_3)$ **123**	$(l_3r_3f_3)$ **333**	$(l_1r_2f_2)$ **122**	$(l_1r_1f_2)$ **112**	$(l_2r_2f_2)$ **222**
$(l_2r_3f_2)$ **232**	$(l_2r_3f_3)$ **233**	$(l_3r_2f_2)$ **322**	$(l_2r_3f_1)$ **231**	$(l_1r_2f_3)$ **123**	$(l_1r_1f_3)$ **113**
$(l_3r_1f_2)$ **312**	$(l_2r_1f_1)$ **211**	$(l_2r_2f_3)$ **223**	$(l_3r_1f_3)$ **313**	$(l_2r_1f_3)$ **213**	$(l_1r_3f_2)$ **132**
$(l_2r_1f_3)$ **213**	$(l_3r_1f_3)$ **313**	$(l_1r_2f_1)$ **121**	$(l_1r_3f_3)$ **133**	$(l_3r_1f_1)$ **311**	$(l_3r_2f_3)$ **323**

TREATMENTS :

I. Levels of nitrogen

- l_1 - 200 Kg. N ha^{-1}
- l_2 - 250 Kg. N ha^{-1}
- l_3 - 300 Kg. N ha^{-1}

II. Ratios of N substitution

- r_1 - 1:1
- r_2 - 1:2
- r_3 - 2:1

III. Frequencies of N application

- f_1 - Full quantity of farm yard manure / poultry manure as basal + chemical N source in equal splits as basal and at fortnightly intervals upto 1 month before final harvest.
- f_2 - Farm yard manure / poultry manure in 3 equal splits as basal and at 40th and 70th days after planting + chemical N source in equal splits as basal and at fortnightly intervals upto 1 month before final harvest.
- f_3 - Farm yard manure / poultry manure and chemical N source in equal splits as basal and at fortnightly intervals upto 1 month before final harvest.

Design - Confounded factorial experiment with 9 plot blocks (confounding LR^2F in RI and LRF^2 in RII)

Number of replications - 2

Total number of treatments - 27

3.6.2 Treatment combinations

$l_1r_1f_1$	$l_2r_1f_1$	$l_3r_1f_1$
$l_1r_1f_2$	$l_2r_1f_2$	$l_3r_1f_2$
$l_1r_1f_3$	$l_2r_1f_3$	$l_3r_1f_3$
$l_1r_2f_1$	$l_2r_2f_1$	$l_3r_2f_1$
$l_1r_2f_2$	$l_2r_2f_2$	$l_3r_2f_2$
$l_1r_2f_3$	$l_2r_2f_3$	$l_3r_2f_3$
$l_1r_3f_1$	$l_2r_3f_1$	$l_3r_3f_1$
$l_1r_3f_2$	$l_2r_3f_2$	$l_3r_3f_2$
$l_1r_3f_3$	$l_2r_3f_3$	$l_3r_3f_3$

3.6.3 Design of experiments

Experiment I and II were laid out separately and simultaneously as a confounded 3^3 factorial design in 9 plot blocks in two replications, confounding LR^2F in RI and LRF^2 in RII.

Treatment combinations	-	27
Replications	-	2
Total number of plots	-	54 in each experiment

3.6.4 Spacing and plot size

A spacing of 2x2 m was adopted. Each plot consisted of 6 pits/treatment/ replication, for both experiment I and II.

3.7 Details of cultivation

3.7.1 Sowing

Pits of 60 cm diameter and 30 to 45 cm depth were dug at 2x2 m spacing and were refilled with basal dose of manure ie. with farm yard manure in experiment I and with poultry manure in experiment II. Seeds were soaked in water for overnight, 3 seeds were sown in each pit and 2 seedlings were retained in each pit. Gap filling was done wherever required. During the first year (1995-96) crop sowing was done on 6.1.1996 and during the second year, sowing was done on 10.1.1997.

3.7.2 Application of manures

Farm yard manure and poultry manure were applied as basal and in split doses in required quantities as per the levels of nutrient nitrogen on equivalent nitrogen basis and their rates of substitution with chemical fertiliser and also according to different frequencies of application, as per the treatments. These prefixed quantities of farm yard manure/ poultry manure on equivalent nitrogen basis according to treatments are given in Appendix IIa and IIb.

3.7.2a Application of basal dose of manures

Farm yard manure or poultry manure was applied in different quantities according to the doses fixed as per treatments. Farm yard manure was mixed thoroughly with the soil while making the pit and used for refilling. In the case of poultry manure, it was mixed thoroughly with the soil in the pit and then the pit

Plate 1. An overall view of the experimental plot

Plate 2. A close view of the experimental plot

was watered. Seeds were sown 3 days after watering the pit to avoid the germination impediment if any, associated with basal application of poultry manure.

3.7.2b Application of manures in split doses

Farm yard manure or poultry manure was applied in different split doses according to the frequencies of application as per the treatment. Two splits were required according to f_2 treatment and five splits were required according to f_3 treatment besides basal dose.

3.7.3 Application of fertilisers

Urea was applied as a source of chemical fertiliser nitrogen in different quantities as basal and in split doses according to the treatments. Different doses of urea fixed as per the treatments are given in Appendix IIa and IIb. Mussoriephos and muriate of potash were applied in uniform basal doses to supply phosphorus and potassium respectively.

3.7.3a Basal application of fertilisers

Basal doses of urea were applied at the two leaf stage of the crop. Mussoriephos and muriate of potash were also applied at the same stage in uniform doses as per KAU package of practices recommendations.

3.7.3b Application of split dose of fertilisers

Urea was applied as side dressing in different split doses to supply fertiliser nitrogen in the required level, ratio and frequency as per the treatments as shown in Appendix IIa and IIb. Five split applications were required for the application at fortnightly intervals, besides the basal dose.

3.7.4 After cultivation

3.7.4a Trailing of vines

Vines were trailed and tied carefully on thin bamboo splits from time to time since one week after germination till they reached the pandal height.

3.7.4b Pandal making

A strong pandal was erected immediately after sowing using hardy casurina poles and coir rope and was firmly secured by metal wires from all the four sides of the pandal.

3.7.4c Nipping off of lateral buds

Lateral buds were nipped off from time to time to avoid lateral branching till the central vine reached the pandal height.

3.7.4d Irrigation

Alternate day irrigation was given during the vegetative phase and daily irrigation was given on flowering and fruiting phase excluding rainy days wherein the water was applied carefully to the pits.

3.7.4e Plant protection

Plant protection measures were taken as per the KAU package of practices recommendation (Kerala Agricultural University, 1996). The acaricide Kelthane 18.5 per cent EC was applied as a prophylatic measure against mite attack. Furadan traps were set up for catching the fruit flies immediately after flowering. Dithane M-45 and Malathion were sprayed to check the fungal leaf spot disease and insects respectively.

3.7.5 General condition of the crop

General condition of the crop was satisfactory in experiment I and II in both the years. Pest and disease incidence were not much apparent as indicated by the scoring of pests and diseases in the forthcoming chapter.

3.8 Harvesting of fruits

Mature fruits were hand picked and weighed from each plot separately.

3.9 Sampling of plants and fruits

Four plants were tagged for the purpose of recording biometric observations from each plot in both experiment I and II. After the final harvest, these plants were carefully dug out to determine root length, root dry weight and plant dry weight. Fruit samples were taken from each plot from the middle harvest, dried, powdered and used for the analytical purpose. Fresh fruit samples were also collected from each plot and were immediately subjected to quality studies.

3.10 Observations taken and studies conducted during the cropping period

3.10.1 Days taken to flower

Days taken for the appearance of first flower was noted for each observation plant.

3.10.2 Sex ratio

Number of female and male flowers on each plant was noted at 40 DAS, at peak flowering stage (60 DAS) and at later growth stage (90 DAS) and their ratio (number of male flowers/female flowers) was expressed as the sex ratio.

3.10.3 Total dry matter production (g plant^{-1})

Observation plants from each plot were uprooted at the final harvest stage, first dried in shade and then dried in an hot air oven at 70°C. Dry weight of each plant was recorded and average value was taken as dry matter yield plant^{-1}. In a similar manner oven dry weight of fruit yield was found out from a representative sample of 1 kg from the observation plants and total dry matter production plant^{-1} was calculated by adding the plant dry matter yield to the fruit dry matter yield.

3.10.4 Scoring of pests

Scoring of important pests were done at three different growth stages viz. 30 DAS, 60 DAS and 90 DAS to assess their population.

3.10.4a Jassid - *Hishimonas phycitis* (Dist.) (Homoptera : Cicadellidae)

Five leaves were selected at random, starting from the tender tip downwards from each plant and number of insects present was counted and recorded.

3.10.4b Epilachna beetle - *Henosepilachna septima* (Sab.) (Coleoptera : Coccinellidae)

Five leaves were selected at random from the tip downwards from each plant and total number of beetles in all stages was noted.

3.10.4c Aphid - *Aphis malvae* (Koch) (Homoptera : Aphididae)

Five leaves were selected at random from the tender tip downwards from each plant and number of aphids present was counted and recorded.

3.10.4d Red pumpkin beetle - *Aulocophora foveicollis* (Lucas) (Coleoptera : Galerucidae)

Five leaves were selected at random from the tender tip downwards from each plant and number of red pumpkin beetles present was noted.

3.10.4e Fruit fly - *Bactrocera cucurbitae* (Coq.) (Diptera : Tephritidae)

Number of fruits infested by fruit fly was noted and expressed as percentage of total number of fruits harvested.

3.10.5 Scoring of diseases

Scoring was done for fungal leaf spot disease and viral mosaic at three different growth stages viz. 30 DAS, 60 DAS and 90 DAS.

3.10.5a Leaf spot (C.O. *Pseudoperonospora cubensis*)

Five different scores were fixed based on visual observation of infestation intensity viz. 0, 1, 3, 5 and 7 as shown in Plate 3 (Gokulapalan, 1996) and each observation plant was scored according to this score chart at 30, 60 and 90 DAS. At 30 DAS, infestation if any was generally noticed only upto 0.5 m from the ground level and hence each leaf was observed to allot a suitable score upto 0.5 m height and average of the scores of these leaves were taken as the score representing the observation plant. For scoring at 60 and 90 DAS, same procedure was followed where the scores were allotted to each leaf and average of the score of all the leaves was taken.

Percentage infestation was calculated by the simple formula given below

$$\text{Infestation (\%)} = \frac{\text{Score x 100}}{\text{Maximum score}}$$

3.10.5b Viral mosaic

All the observation plants in each plot were scored for viral mosaic. Standard mosaic symptoms appeared on a single leaf was taken as 100 per cent infestation and average score of all the observation plants was taken to represent the treatment.

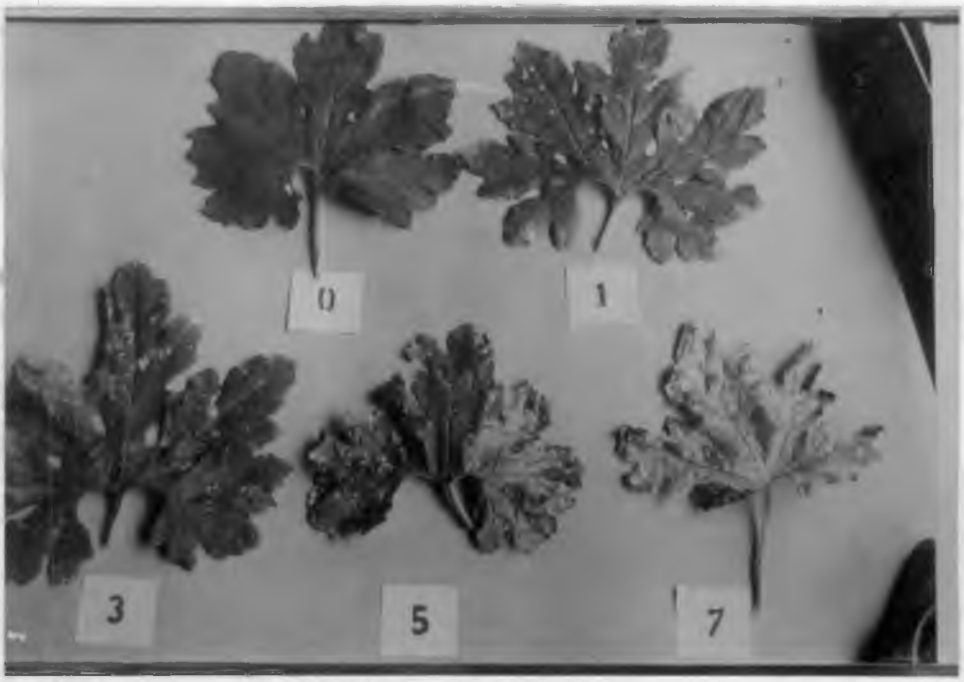


Plate 3. Score diagram of leaf spot disease

3.11 Yield and harvest studies

3.11.1 Number of fruits plant^{-1}

Number of fruits harvested from each observation plant was noted separately for each harvest and the average number of fruits plant^{-1} was calculated for each treatment.

3.11.2 Yield plant^{-1}

Fruit yield from each observation plant was noted separately for each harvest and the average fruit yield plant^{-1} was calculated for each treatment.

3.11.3 Yield plot^{-1}

Fruit yield plot^{-1} from each harvest was added and expressed in tonnes per hectare to represent the fruit yield plot^{-1}.

3.11.4 Days to first harvest

Days taken for the first harvest was noted in each plot.

3.11.5 Days to 50 per cent harvest

Number of days taken for harvest of fifty per cent of total fruit yield was noted for each plot.

3.11.6 Days to final harvest

Days taken for the last harvest was noted for each plot.

3.11.7 Number of harvests

Number of harvests taken from each plot was noted.

3.12 Root studies

Each observation plant was uprooted after the harvest to conduct root studies such as depth of root penetration and root dry weight.

3.12.1 Depth of root penetration (cm)

After uprooting the observation plants, root system was separated and cleaned. The entire length of the tap root was measured by using a thread and scale and the mean for each plot was worked out and expressed in cm.

3.12.2 Root dry weight (g)

Roots of observation plants were dried in an hot air oven at 70°C to a constant weight and root dry weight $plant^{-1}$ was worked for each plot and expressed in grams.

3.13 Keeping quality and shelf life studies

Keeping quality and shelf life were tested under two conditions viz. at room temperature and under refrigeration as these are the prevailing common storage conditions.

3.13.1 Shelf life at room temperature (days)

One kg of fruit sample with fruits having uniform maturity representing each plot was kept at room temperature to determine the extent to which it could be stored without damage for culinary purpose. Shelf life of each lot was assessed by visual observations like change in colour, drying, decay etc.

3.13.2 Shelf life under refrigeration (days)

From each plot, one kg of fruit sample containing fruits having uniform maturity was kept under refrigeration (6-7°C) to determine the extent of period it could be stored without damage for culinary purpose.

3.13.3 Physiological loss in weight (PLW) at room temperature storage (%)

Weight of sample lot was taken on the last possible day of storage and physiological loss in weight in percentage was calculated as

$$\frac{\text{Initial weight of lot - Final weight of lot}}{\text{Initial weight of lot}} \times 100$$

(Srivastava and Tandon, 1968)

3.13.4 Physiological loss in weight under refrigeratory storage (%)

Physiological loss in weight during storage under refrigeration was calculated as mentioned previously in the case of storage at room temperature.

3.14 Plant analysis

Plant samples were first dried in shade, then dried in an hot air oven at 70°C, powdered and sieved. A quantity of 0.5 g of plant sample was digested in Kjel plus (Model KPS-020) adding 15 ml of concentrated sulphuric acid and 2-3 g of digestion mixture. Digested sample was made upto 100 ml and used for the estimation of total N, total P and total K contents.

3.14.1 Total N content (%)

Total N content of the plant was estimated by modified microkjeldahl method as given by Jackson (1973).

3.14.2 Total P content (%)

Total P content was determined by the vanadomolybdo phosphoric yellow colour method (Jackson, 1973) and read in a spectronic - 2000 spectrophotometer.

3.14.3 Total K content (%)

Total K content in plant was estimated by using Flame photometer (Jackson, 1973).

3.15 Fruit analysis

Fruits having uniform maturity from the middle harvest were collected as samples from each plot, sliced, first dried in shade and then dried in an hot air oven at 70°C for both experiments I and II. After oven drying, samples were powdered in a grinder and then sieved. About 0.5 g of fruit sample was digested in a Kjel plus (model KPS - 020) using 15 ml concentrated sulfuric acid and 2-3 g of digestion mixture. Digested fruit sample was made upto 100 ml and used for the estimation of crude protein, total P content. total K content and iron content.

3.15.1 Crude protein content (%)

Total nitrogen content of the fruit was estimated by modified microkjeldahl method as given by Jackson (1973). Crude protein content was calculated by multiplying the nitrogen content by the factor 6.25 (Simpson *et al.*, 1965).

3.15.2 Total P content (%)

Total P content of fruit samples was estimated by Vanadomolybdo phosphoric yellow colour method (Jackson, 1973) and read in a Spectronic - 2000 spectrophotometer.

3.15.3 Total K content (%)

Total K content of fruit samples were estimated by using a flame photometer as suggested by Jackson (1973).

3.15.4 Iron content (%)

Iron content of fruit samples was estimated by Atomic Absorption Spectrophotometer after wet digestion of the samples using di-acid mixture as suggested by Perkin - Elmer Corporation (1982).

3.15.5 Ascorbic acid content (mg 100 ml^{-1})

Ascorbic acid content of fruits was estimated by titrimetric method (Gyorgy and Pearson, 1967).

3.16 Uptake studies

The total uptake of nitrogen, phosphorus and potassium by the crop during first and second year were calculated by adding the products of, contents of these nutrients in plant samples and respective plant dry weight, to the products of the nutrient contents of fruit samples and total fruit dry weights and expressed as kg ha^{-1}.

3.17 Soil microbial studies

Initial soil samples were collected from both experiment I and II and were analysed to estimate the microbial population within a day of collection of samples. Soil samples were again collected from each pit after the harvest and were composited to represent the plot and were analysed for microbial population within one day of collection of the samples. The total number of bacteria, fungi and actinomycetes per gram of soil was estimated by the dilution plate technique (Timonin, 1940). Bacteria were estimated at 10^{-8} dilution and fungus at 10^{-4} dilution and actinomycetes at 10^{-6} dilution. Kauster medium was used for growing bacteria and actinomycetes and Martins and Rose Bengal agar for growing fungi.

3.18 Soil analysis

Composite soil samples were collected prior to the conduct of experiment, separately from the sites of experiment I and II and analysed to determine physical composition, soil reaction, available N, available P_2O_5, available K_2O, organic carbon %, CEC and EC. After the final harvest, soil samples were taken from each pit and composited to represent the plot and analysed to determine soil reaction, soil physical properties such as bulk density, particle density, water holding capacity and porosity and chemical properties such as available N, available P_2O_5, available K_2O and organic carbon content of soil.

3.18.1 Soil reaction

Soil reaction was determined by using pH meter with glass electrodes (Jackson, 1973).

3.18.2 Soil physical properties

Soil physical properties such as bulk density, particle density, water holding capacity and porosity were determined by the core method as described by Gupta and Dakshinamoorthi (1980).

3.18.3 Soil chemical properties

3.18.3a Available N (kg ha^{-1})

Available N in soil was estimated by alkaline permanganate method (Subbiah and Asija, 1956).

3.18.3b Available P (P_2O_5 kg ha^{-1})

Available P was estimated by Bray colourimetric method (Jackson, 1973) and readings were taken in a spectronic-2000 Spectrophotometer.

3.18.3c Available K (K_2O kg ha^{-1})

Available K was estimated by using a flame photometer as described by Jackson (1973).

3.18.3d Organic carbon (%)

Organic carbon content (%) of soil samples were estimated by Walkley and Black's rapid titration method (Jackson, 1973).

3.19 Nutrient balance sheet studies

Nutrient balance sheets were worked out for available N, available P_2O_5 and available K_2O in each year for experiment I and II as per the procedure outlined by Sadanandan and Mahapatra (1973).

The following parameters were investigated in the study.

(i) Initial status of nutrient in soil (Y) ... kg ha^{-1}

(ii) Total amount of nutrient added through manures and fertilisers (A) ... kg ha^{-1}

(iii) Amount of nutrient removed by the crop or uptake (B) ... kg ha^{-1}

(iv) Expected nutrient balance (C) = (A-B) + Y ... kg ha^{-1}

(v) Actual nutrient balance or available nutrient status of soil after the experiment (D) ... kg ha^{-1}

(vi) Net loss (-) or gain (+) = (D-C) kg ha^{-1}

Among these parameters, total amount of nutrients added through manures and fertilisers were calculated by considering the nutrient values of manures in each year (Table 2) and standard uniform content and quantities of fertilisers used (Appendix IIa and IIb) and are given in Appendix VII.

3.20 Economics of cultivation

Average values of labour wages and input prices during the experimental periods were taken during 1995-96 and 1996-97 for computing the economics of cultivation to avoid the bias due to disparities in labour wages and input costs during each year for experiment I and II. Total cost of cultivation (Appendix IV) and gross returns were calculated from average input costs and average market price during the period of study given in Appendix III

The following parameters were also investigated.

Net returns (Rs ha^{-1}) = Gross income – Cost of cultivation

$$\text{Benefit-cost ratio} : \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.21 Energy budgeting

Energy budgeting was done in a similar way as the economics of cultivation using the energy equivalents of productive inputs and outputs (Appendix V) for each treatment as per the guide lines given by Chatterjee *et al.* (1989). The following parameters were studied as per the procedure suggested by Baishya and Sharma (1990).

(i) Input energy excluding treatment (MJ) ... A

(ii) Input energy for treatment (MJ) ... B

(iii) Total input energy (x) in MJ ... A+B (Appendix VI)

(iv) Total output energy (MJ) ... Y

(v) Net energy returns (Z) = Y-X

(vi) Energy ratio $= \frac{\text{Net energy returns}}{\text{Total input energy}} = \frac{(Y - X)}{(A + B)}$

3.22 Statistical analysis

Data generated from the experiments were subjected to analysis of variance for a confounded 3^3 design in 9 plot blocks (Federer, 1955).

RESULTS

RESULTS

An investigation was conducted at College of Agriculture, Vellayani in two separate experiments (Experiment I and II) during the year 1995-96 and 1996-97 with the objective of finding out the efficacy of different levels of nitrogen nutrition in different organic-chemical nitrogen ratios at different frequencies of application to achieve maximum productivity in bitter gourd (*Momordica charantia* L.). In Experiment I farm yard manure was the organic source of N while in Experiment II it was replaced by poultry manure. The data collected were statistically analysed and the results are presented in the current chapter.

4.1 Experiment I

4.1.1 Sex ratio

When the organic source of N was farm yard manure different levels of nitrogen, its ratios of substitution or frequencies of application did not have any effect either individually or in combinations on sex ratio at any interval during first and second year of experimentation (Tables 3, 4, 5 and 6).

4.1.2 Days taken to flower

When nitrogen was substituted through an organic source of farm yard manure, its levels significantly influenced the days taken to flower in first year (Table 11). The N levels l_2 and l_3 applied plots recorded less number of days for

Table 3 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on sex ratio.

Experiment - I

Factor	Sex ratio 40 DAS (No. of male flowers per female flower)		Sex ratio 60 DAS (No. of male flowers per female flower)		Sex ratio 90 DAS (No. of male flowers per female flower)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen						
l_1	4.07	1.69	3.68	4.26	12.26	10.72
l_2	5.29	1.68	4.38	4.18	12.14	10.25
l_3	3.28	1.74	3.91	4.87	12.13	10.60
$F_{2,22}$	2.54^{ns}	0.02^{ns}	0.71^{ns}	1.24^{ns}	0.03^{ns}	0.14^{ns}
Ratios						
r_1	3.80	2.16	4.27	4.56	12.00	10.54
r_2	4.60	1.52	4.36	4.53	12.88	11.10
r_3	4.24	1.44	3.34	4.23	11.65	9.94
$F_{2,22}$	0.39^{ns}	3.04^{ns}	1.77^{ns}	0.30^{ns}	2.17^{ns}	0.78^{ns}
Frequencies						
f_1	4.21	1.63	3.64	4.36	12.25	11.07
f_2	3.43	1.85	4.19	4.72	11.77	9.57
f_3	5.00	1.64	4.13	4.23	12.51	10.94
$F_{2,22}$	1.53^{ns}	0.30^{ns}	0.51^{ns}	0.57^{ns}	0.75^{ns}	1.62^{ns}
SEd	1.91	0.68	1.27	1.01	1.29	1.96

ns - Not Significant

Table 4 : Interation effect of levels of nitrogen and its ratios of substitution (L x R)on sex ratio

Experiment - I

Factor	Sex ratio 40 DAS (No. of male flowers per female flower)		Sex ratio 60 DAS (No. of male flowers per female flower)		Sex ratio 90 DAS (No. of male flowers per female flower)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	3.53	2.08	4.40	4.78	11.60	10.70
$l_1 r_2$	4.17	1.58	3.00	4.06	13.00	10.75
$l_1 r_3$	4.52	1.42	3.64	3.95	12.20	10.72
$l_2 r_1$	4.94	2.31	5.03	4.16	11.53	10.86
$l_2 r_2$	5.44	1.31	4.67	4.76	12.47	11.21
$l_2 r_3$	5.49	1.43	3.45	3.62	12.42	8.70
$l_3 r_1$	2.94	2.08	3.36	4.74	12.89	10.06
$l_3 r_2$	4.18	1.67	5.42	4.76	13.17	11.33
$l_3 r_3$	2.73	1.47	2.95	5.11	10.33	10.42
$F_{4,22}$	0.20^{ns}	0.16^{ns}	1.86^{ns}	0.69^{ns}	1.81^{ns}	0.51^{ns}
SEd	1.91	0.68	1.27	1.01	1.29	1.96

ns - Not Significant

Table 5 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on sex ratio.

Experiment - I

Factor	Sex ratio 40 DAS (No. of male flowers per female flower)		Sex ratio 60 DAS (No. of male flowers per female flower)		Sex ratio 90 DAS (No. of male flowers per female flower)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	3.91	1.33	3.29	4.16	11.92	9.61
$l_1 f_2$	2.75	1.92	3.50	5.30	12.04	10.10
$l_1 f_3$	5.56	1.83	4.25	3.34	12.83	12.46
$l_2 f_1$	4.61	1.56	3.83	3.81	12.58	10.64
$l_2 f_2$	4.65	1.40	4.70	4.35	11.20	9.70
$l_2 f_3$	6.61	2.08	4.62	4.39	12.64	10.43
$l_3 f_1$	4.11	2.00	3.81	5.12	12.25	12.97
$l_3 f_2$	2.89	2.22	4.39	4.53	12.08	8.92
$l_3 f_3$	2.85	1.00	3.53	4.97	12.06	9.92
$F_{4,22}$	0.80^{ns}	1.98^{ns}	0.37^{ns}	1.42^{ns}	0.46^{ns}	1.94^{ns}
SEd	1.91	0.68	1.27	1.01	1.29	1.96

ns - Not Significant

Table 6: Interaction effect of ratios of substitution and frequencies of application of nitrogen (Rx F) on sex ratio.

Experiment - I

Factor	Sex ratio 40 DAS (No. of male flowers, per female flower)		Sex ratio 60 DAS (No. of male flowers per female flower)		Sex ratio 90 DAS (No. of male flowers per female flower)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	4.19	1.83	4.43	4.42	12.50	9.89
$r_1 f_2$	4.00	2.22	4.75	4.81	11.54	9.29
$r_1 f_3$	3.22	2.42	3.62	4.46	11.97	12.43
$r_2 f_1$	3.95	1.33	3.50	4.75	13.25	12.25
$r_2 f_2$	2.50	2.22	4.17	5.33	11.58	10.25
$r_2 f_3$	7.33	1.00	5.42	3.50	13.81	10.79
$r_3 f_1$	4.48	1.72	3.00	3.92	11.00	11.08
$r_3 f_2$	3.79	1.10	3.67	4.03	12.20	9.17
$r_3 f_3$	4.46	1.50	3.36	4.73	11.75	9.58
$F_{4,22}$	1.95^{ns}	1.77^{ns}	1.05^{ns}	1.34^{ns}	1.37^{ns}	1.09^{ns}
SEd	1.91	0.68	1.27	1.01	1.29	1.96

ns - Not Significant

Table - 11 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on days required for flowering and harvests

Experiment I

Factor	Days taken to flower		Days taken for the first harvest		Days taken for 50% harvest		Days taken for the final harvest	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
<u>Nitrogen</u>								
l_1	33.67	33.06	47.00	47.00	74.67	73.78	102.11	107.00
l_2	32.61	32.72	47.56	47.44	74.33	74.44	97.22	106.22
l_3	32.67	32.61	47.56	47.89	74.33	74.56	99.89	107.00
$F_{2,22}$	4.80^{*}	1.08^{ns}	0.52^{ns}	0.87^{ns}	0.29^{ns}	0.20^{ns}	3.14^{ns}	1.63^{ns}
<u>Ratios</u>								
r_1	32.83	32.83	47.00	47.89	74.33	74.06	99.44	106.61
r_2	33.11	33.00	47.56	47.00	74.33	75.44	99.88	107.00
r_3	33.00	32.56	47.56	47.44	74.67	73.28	99.88	106.61
$F_{2,22}$	0.27^{ns}	1.02^{ns}	0.52^{ns}	0.87^{ns}	0.29^{ns}	1.38^{ns}	0.06^{ns}	0.41^{ns}
<u>Frequencies</u>								
f_1	32.22	33.22	47.00	47.89	74.67	73.00	100.33	106.61
f_2	33.00	32.44	47.56	47.00	74.33	73.50	99.00	107.00
f_3	33.72	32.72	47.56	47.44	74.33	76.28	99.89	106.61
$F_{2,22}$	7.66^{**}	3.14^{ns}	0.52^{ns}	0.87^{ns}	0.29^{ns}	2.56^{ns}	0.40^{ns}	0.41^{ns}
SEd	0.81	0.67	1.33	1.43	1.07	2.81	3.21	1.06
CD	0.80	-	-	-	-	-	-	-

ns - Not Significant * Significant at 5% level ** Significant at 1% level

Table 12: Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on days required for flowering and harvests

Experiment I

Factor	Days taken to flower		Days taken for the first harvest		Days taken for 50% harvest		Days taken for the final harvest	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	33.83	33.17	47.00	47.00	75.00	74.33	103.00	107.00
$l_1 r_2$	33.33	32.50	47.00	47.00	75.00	74.67	101.67	107.00
$l_1 r_3$	33.83	33.50	47.00	47.00	74.00	72.33	101.67	107.00
$l_2 r_1$	32.00	32.17	47.00	48.33	74.00	74.33	95.00	105.83
$l_2 r_2$	33.33	33.50	48.67	47.00	74.00	75.83	99.00	107.00
$l_2 r_3$	32.50	32.50	47.00	47.00	75.00	73.17	97.67	105.83
$l_3 r_1$	32.67	33.17	47.00	48.33	74.00	73.50	100.33	107.00
$l_3 r_2$	32.67	33.00	47.00	47.00	74.00	75.83	99.00	107.00
$l_3 r_3$	32.67	31.67	48.67	48.33	75.00	74.33	100.33	107.00
$F_{4,22}$	1.08^{ns}	4.27^{*}	1.31^{ns}	0.43^{ns}	1.16^{ns}	0.22^{ns}	0.75^{ns}	0.41^{ns}
SEd	0.81	-	1.33	1.43	1.07	2.81	3.21	1.06
CD	-	1.13	-	-	-	-	-	-

ns - Not Significant

* Significant at 5% level

Table 13 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on days required for flowering and harvests

Experiment I

Factor	Days taken to flower		Days taken for the first harvest		Days taken for 50% harvest		Days taken for the final harvest	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	32.83	33.00	47.00	47.00	75.00	71.17	103.00	107.00
$l_1 f_2$	34.00	33.33	47.00	47.00	75.00	74.67	101.67	107.00
$l_1 f_3$	34.17	32.83	47.00	47.00	74.00	75.50	101.67	107.00
$l_2 f_1$	31.67	33.17	47.00	48.33	75.00	74.33	99.00	105.83
$l_2 f_2$	33.00	32.00	48.67	47.00	73.00	72.33	96.33	107.00
$l_2 f_3$	33.17	33.00	47.00	47.00	75.00	76.67	96.33	105.83
$l_3 f_1$	32.17	33.50	47.00	48.33	74.00	73.50	99.00	107.00
$l_3 f_2$	32.00	32.00	47.00	47.00	75.00	73.50	99.00	107.00
$l_3 f_3$	33.83	32.33	48.67	48.33	74.00	76.67	101.67	107.00
$F_{4,22}$	1.23^{ns}	2.08^{ns}	1.31^{ns}	0.43^{ns}	2.46^{ns}	0.76^{ns}	0.58^{ns}	0.41^{ns}
SEd	0.81	0.67	1.33	1.43	1.07	2.81	3.21	1.06

ns - Not Significant

Table 14 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on days required for flowering and harvests

Experiment I

Factor	Days taken to flower		Days taken for the first harvest		Days taken for 50% harvest		Days taken for the final harvest	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	32.17	33.50	47.00	49.67	75.00	73.17	100.33	105.83
$r_1 f_2$	32.67	32.17	47.00	47.00	74.00	74.67	99.00	107.00
$r_1 f_3$	33.67	32.83	47.00	47.00	74.00	74.33	99.00	107.00
$r_2 f_1$	32.00	33.67	47.00	47.00	74.00	74.67	99.00	107.00
$r_2 f_2$	33.17	32.67	48.67	47.00	74.00	74.67	99.00	107.00
$r_2 f_3$	34.17	32.67	47.00	47.00	75.00	77.00	101.67	107.00
$r_3 f_1$	32.50	32.50	47.00	47.00	75.00	71.17	101.67	107.00
$r_3 f_2$	33.17	32.50	47.00	47.00	75.00	71.17	99.00	107.00
$r_3 f_3$	33.33	32.67	48.67	48.33	74.00	77.50	99.00	105.83
$F_{4,22}$	0.60^{ns}	1.08^{ns}	1.31^{ns}	1.74^{ns}	1.16^{ns}	1.23^{ns}	0.58^{ns}	1.02^{ns}
SEd	0.81	0.67	1.33	1.43	1.07	2.81	3.21	1.06

ns - Not Significant

the appearance of first flower in the crop (32.61 and 32.67 days respectively) than l_1 (33.67 days) although the higher levels did not vary each other. However in the succeeding year this trend was not seen.

The ratios of substitution did not influence the days taken to flower, while the frequencies of application had an effect on this character in 1995-96. Less number of days were required for flowering with f_1 treatment (32.22) and f_2 treatment (33.00 days) which did not differ each other when compared to f_3 treatment (33.72 days).

The influence of L was observed with ratio of substitution (R) during 1996-97 (Table 12). The l_3 dose of N supplied through 2:1 ratio of substitution required less number of days (31.67) for flowering when compared to other combinations.

The LxF or RxF interactions were not significant (Tables 13 and 14).

4.1.3 Scoring of pest and diseases

4.1.3.1 Scoring of pests

4.1.3.1a Aphid - *Aphis malvae* (Koch)

Aphids were absent in 1995-96 upto 60 DAS while on 90 DAS aphids were seen but this pest population was not influenced by any of the treatments. During 1996-97 aphids were observed but were not affected by treatments (Table 19).

Table 19 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on aphid and jassid population

Experiment I

Factor	Number of Aphids						Number of Jassids					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen												
l_1	0	6.02(2.66)	0	0	1.82(1.68)	3.24(2.06)	0	0.53(1.24)	0	1.50(1.58)	1.92(1.71)	5.71(2.60)
l_2	0	6.56(2.76)	0	0	1.62(1.63)	3.75(2.19)	0	0.66(1.29)	0	1.96(1.72)	1.62(1.63)	5.60(2.58)
l_3	0	4.38(2.32)	0	0	0.88(1.38)	3.58(2.14)	0	0.72(1.31)	0	1.46(1.86)	2.20(1.79)	6.29(2.71)
$F_{2,22}$	-	0.65^{ns}	-	-	1.71^{ns}	0.34^{ns}	-	0.18^{ns}	-	1.11^{ns}	0.52^{ns}	0.24^{ns}
Ratios												
r_1	0	5.71(2.59)	0	0	1.43(1.56)	3.54(2.14)	0	0.93(1.40)	0	1.43(1.56)	1.40(1.56)	6.61(2.77)
r_2	0	5.71(2.59)	0	0	0.99(1.41)	3.41(2.10)	0	0.54(1.25)	0	1.79(1.67)	1.66(1.63)	5.81(2.62)
r_3	0	5.45(2.55)	0	0	1.92(1.71)	3.62(2.16)	0	0.44(1.21)	0	2.72(1.94)	2.72(1.94)	5.20(2.50)
$F_{2,22}$	-	0.008^{ns}	-	-	1.52^{ns}	0.06^{ns}	-	1.48^{ns}	-	2.11^{ns}	3.04^{ns}	0.87^{ns}
Frequencies												
f_1	0	5.81(2.62)	0	0	1.13(1.47)	3.04(2.02)	0	0.69(1.30)	0	2.53(1.88)	1.76(1.67)	5.50(2.56)
f_2	0	4.15(2.27)	0	0	1.59(1.61)	3.58(2.15)	0	0.69(1.30)	0	2.24(1.80)	2.17(1.78)	6.24(2.70)
f_3	0	7.07(2.84)	0	0	1.56(1.61)	3.92(2.23)	0	0.15(1.24)	0	1.19(1.48)	1.82(1.68)	5.86(2.63)
$F_{2,22}$	-	1.05^{ns}	-	-	0.45^{ns}	0.93^{ns}	-	0.22^{ns}	-	2.51^{ns}	0.30^{ns}	0.25^{ns}
SEd	-	0.84	-	-	0.37	0.33	-	0.24	-	0.40	0.35	0.43

ns - Not Significant

( ) Transformed mean

Table 20 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on aphid and jassid population

Experiment I

Factor	Number of Aphids						Number of Jassids					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	0	9.69(3.28)	0	0	1.07(1.45)	3.04(2.01)	0	1.02(1.43)	0	0.72(1.31)	0.90(1.38	7.35(2.90)
$l_1 r_2$	0	3.75(2.18)	0	0	1.99(1.74)	2.92(1.98)	0	0.51(1.24)	0	0.59(1.26)	2.42(1.86)	5.66(2.59)
$l_1 r_3$	0	5.25(2.51)	0	0	1.42(1.86)	3.80(2.19)	0	0.12(1.07)	0	3.70(2.17)	2.53(1.89)	4.29(2.31)
$l_2 r_1$	0	6.02(2.66)	0	0	1.86(1.70)	3.71(2.18)	0	0.25(1.50)	0	2.88(1.97)	0.84(1.36)	6.45(2.74)
$l_2 r_2$	0	9.82(3.30)	0	0	0.74(1.33)	4.02(2.25)	0	0.59(1.26)	0	2.28(1.81)	1.37(1.54)	5.10(2.48)
$l_2 r_3$	0	4.34(2.31)	0	0	2.42(1.85)	3.58(2.14)	0	0.25(1.12)	0	0.90(1.38)	2.89(1.97)	5.30(2.52)
$l_3 r_1$	0	2.39(1.85)	0	0	1.37(1.55)	3.93(2.22)	0	0.59(1.26)	0	0.93(1.40)	2.69(1.93)	6.07(2.66)
$l_3 r_2$	0	4.24(2.30)	0	0	0.35(1.17)	3.28(2.08)	0	0.54(1.24)	0	2.72(1.94)	1.22(1.50)	6.78(2.79)
$l_3 r_3$	0	6.95(2.83)	0	0	1.02(1.43)	3.54(2.13)	0	1.02(1.43)	0	4.06(2.26)	1.22(1.50)	6.07(2.67)
$F_{4,22}$	0	1.70^{ns}	-	-	0.96^{ns}	0.26^{ns}	-	1.21^{ns}	-	4.05*	1.52^{ns}	0.48^{ns}
SEd	-	0.84	-	-	0.37	0.33	-	0.24	-	-	0.35	0.43
CD	-	-	-	-	-	-	-	-	-	0.68	-	-

ns - Not Significant * Significant at 5% level ( ) Transformed mean

Table 21 :Interaction effect of levels of nitrogen and its frequencies of application (L x F) on aphid and jassid population

Experiment I

Factor	Number of Aphids						Number of Jassids					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	0	9.96(3.32)	0	0	0.96(1.40)	2.80(1.95)	0	0.88(1.37)	0	1.50(1.59)	0.69(1.30)	5.96(2.64)
$l_1 f_2$	0	2.65(1.91)	0	0	2.17(1.78)	2.35(1.84)	0	0.25(1.12)	0	2.09(1.76)	3.24(2.07)	4.86(2.43)
$l_1 f_3$	0	6.45(2.74)	0	0	2.42(1.86)	4.71(2.40)	0	0.51(1.24)	0	0.93(1.40)	2.06(1.76)	6.39(2.72)
$l_2 f_1$	0	5.97(2.65)	0	0	1.53(1.59)	3.62(2.15)	0	0.82(1.36)	0	3.08(2.02)	2.61(1.90)	4.15(2.27)
$l_2 f_2$	0	4.20(2.28)	0	0	1.62(1.62)	3.62(2.15)	0	1.10(1.46)	0	1.34(1.53)	1.07(1.45)	6.45(2.73)
$l_2 f_3$	0	10.16(3.34)	0	0	1.76(1.66)	4.11(2.26)	0	0.12(1.07)	0	1.56(1.61)	1.31(1.52)	6.40(2.73)
$l_3 f_1$	0	2.57(1.89)	0	0	0.96(1.41)	2.80(1.96)	0	0.42(1.19)	0	3.12(2.03)	2.16(1.79)	6.56(2.76)
$l_3 f_2$	0	5.86(2.63)	0	0	1.02(1.43)	5.00(2.45)	0	0.74(1.33)	0	3.45(2.12)	2.31(1.83)	7.58(2.94)
$l_3 f_3$	0	5.00(2.45)	0	0	0.69(1.30)	3.08(2.02)	0	0.99(1.41)	0	1.07(1.44)	2.10(1.76)	4.90(2.43)
$F_{4,22}$	-	1.46^{ns}	-	-	0.50^{ns}	1.81^{ns}	-	1.58^{ns}	-	0.98^{ns}	2.43^{ns}	1.16^{ns}
SEd	-	0.84	-	-	0.37	0.33	-	0.24	-	0.40	0.35	0.43

ns - Not Significant
( ) Transformed mean

Table 22 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on aphid and jassid population.

Experiment I

Factor	Number of Aphids						Number of Jassids					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	0	6.95(2.82)	0	0	2.72(1.93)	3.00(2.00)	0	1.16(1.47)	0	2.88(1.97)	2.10(1.77)	7.46(2.92)
$r_1 f_2$	0	6.13(2.68)	0	0	1.62(1.63)	2.96(1.99)	0	1.31(1.52)	0	1.10(1.45)	1.04(1.44)	6.62(2.77)
$r_1 f_3$	0	4.19(2.28)	0	0	0.28(1.14)	4.76(2.41)	0	0.42(1.19)	0	0.59(1.26)	2.18(1.47)	5.81(2.61)
$r_2 f_1$	0	3.97(2.24)	0	0	0.12(1.07)	2.45(1.87)	0	0.59(1.26)	0	1.79(1.67)	1.31(1.52)	4.86(2.43)
$r_2 f_2$	0	3.80(2.20)	0	0	1.53(1.59)	3.92(2.23)	0	0.25(1.12)	0	1.66(1.63)	2.31(1.82)	5.96(2.64)
$r_2 f_3$	0	10.09(3.34)	0	0	1.43(1.57)	3.84(2.21)	0	0.82(1.36)	0	1.89(1.71)	2.37(1.55)	6.72(2.78)
$r_3 f_1$	0	6.78(2.80)	0	0	0.96(1.40)	3.75(2.18)	0	0.42(1.19)	0	3.00(2.00)	1.89(1.71)	4.38(2.32)
$r_3 f_2$	0	2.76(1.94)	0	0	1.59(1.62)	3.88(2.22)	0	0.59(1.26)	0	4.43(2.33)	3.33(2.09)	6.18(2.69)
$r_3 f_3$	0	7.47(2.91)	0	0	3.45(2.12)	3.28(2.07)	0	0.35(1.17)	0	1.19(1.48)	3.08(2.02)	5.15(2.48)
$F_{4,22}$	-	1.12^{ns}	-	-	4.04^{*}	0.95^{ns}	-	1.09^{ns}	-	1.74^{ns}	1.13^{ns}	0.59^{ns}
SEd	-	0.84	-	-	-	0.33	-	0.24	-	0.40	0.35	0.43
CD	-	-	-	-	0.62	-	-	-	-	-	-	-

ns - Not Significant   * Significant at 5% level   ( ) Transformed mean

All the interactions produced similar trend as that of main effects and were unaffected by treatment combinations (Tables 20, 21 and 22).

4.1.3.1b Jassid - *Hishimonas phycitis* (Dist.)

When total N was substituted using farm yard manure as organic source, jassid infestation was not observed at 30 DAS and 60 DAS and was unaffected by levels of nitrogen, its substitution ratios or frequencies of application at 90 DAS during the first year. In the succeeding year also the infestation noticed at 30, 60 and 90 DAS were not influenced by the treatments (Table 19).

Tables 20, 21 and 22 indicated that none of the interaction effects significantly affected the jassid population at any stage except the LxR interaction (Table 20) during 1996-97 (second year) at 60 DAS of the crop. Maximum jassid count was noticed (4.06) when highest level of nitrogen ie. 300 kg ha^{-1} was supplied through 2:1 organic-chemical fertiliser nitrogen ratio compared to the count obtained when same dose was supplied through 1:1 ratio (0.93) or when 200 kg N ha^{-1} was supplied through a 1:2 substitution ratio (0.59).

4.1.3.1c Fruit fly - *Bactrocera cucurbitae* (Coq.)

When the organic source used for nitrogen substitution was farm yard manure, its levels of application, ratios of substitution or frequencies of application or their interactions could not influence the percentage of fruit fly infestation in both the years (Table 27, 28, 29 and 30).

4.1.3.1d. Epilachna beetle - *Henosepilachna septima* (Sab.)

No epilachna beetle infestation was noticed in Experiment I in first or second year of field experimentation.

4.1.3.1e Red pumpkin beetle - *Aulocophora foveicollis* (Lucas)

Red pumpkin beetle infestation was not observed in Experiment I in first and second year.

4.1.3.2 Diseases

4.1.3.2a Leaf spot (C.O. *Pseudoperonospora cubensis*)

As depicted in Table 27, when farm yard manure was used as an organic source of N substitution, different levels of N application could not significantly influence the leaf spot infestation at 30 DAS, 60 DAS or 90 DAS during 1995-96. During 1996-97 leaf spot infestation was not at all noticed at 30 DAS and was not under the influence of N levels during 60 DAS. However, at the later growth stage (90 DAS), percentage of leaf spot infestation was maximum (62.41%) when 200 kg N ha^{-1} (l_1) was given compared to the higher levels l_2 (59.68%) and l_3 (48.84%).

Different ratios of N substitution had no influence on fungal leaf spot infestation at all the three stages of observation during 1995-96 and 1996-97 (Table 27).

Table 27 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on fruit fly and leaf spot infestation

Experiment I

Factor	Fruit fly infestation (%)		Leaf spot infestation (%)					
			30 DAS		60 DAS		90 DAS	
	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97
Nitrogen								
l_1	11.74(3.57)	14.83(3.98)	1.22(1.50)	0	7.58(2.93)	5.35(2.52)	29.91(5.56)	62.41(7.90)
l_2	12.25(3.64)	16.16(4.14)	1.59(1.62)	0	7.58(2.94)	5.06(2.25)	25.72(5.18)	59.68(7.80)
l_3	10.36(3.37)	14.58(3.95)	1.62(1.63)	0	7.29(2.88)	4.34(2.32)	26.24(5.23)	48.84(7.07)
$F_{2,22}$	0.98^{ns}	1.10^{ns}	0.15^{ns}	-	0.007^{ns}	0.30^{ns}	0.40^{ns}	15.00^{**}
Ratios								
r_1	11.89(3.60)	14.37(3.92)	2.69(1.92)	0	8.00(3.00)	3.93(2.23)	28.38(5.43)	58.29(7.71)
r_2	11.39(3.53)	14.68(3.96)	1.16(1.47)	0	7.52(2.93)	5.05(2.46)	29.97(5.52)	58.44(7.71)
r_3	10.90(3.46)	16.51(4.18)	0.82(1.35)	0	6.84(2.82)	4.76(2.41)	24.20(5.02)	52.88(7.35)
$F_{2,22}$	0.24^{ns}	2.03^{ns}	2.54^{ns}	-	0.008^{ns}	0.24^{ns}	0.66^{ns}	3.19^{ns}
Frequencies								
f_1	11.39(3.52)	15.62(4.08)	0.93(1.40)	0	5.55(2.57)	2.90(1.97)	23.90(5.00)	59.84(7.80)
f_2	11.25(3.50)	15.57(4.07)	3.28(2.08)	0	11.96(3.61)	4.90(2.43)	32.29(5.77)	55.40(7.52)
f_3	11.67(3.56)	14.38(3.92)	4.58(2.36)	0	5.60(2.58)	6.39(2.72)	25.94(5.20)	54.35(7.45)
$F_{2,22}$	0.05^{ns}	0.75^{ns}	5.34^{*}	-	3.00^{ns}	3.64^{*}	1.51^{ns}	2.53^{ns}
SEd	0.42	2.43	0.57	-	1.03	0.76	0.98	0.35
CD	-	-	0.55	-	-	0.75	-	0.35

ns - Not Significant ( ) Transformed mean * Significant at 5% level **Significant at 1% level

Table 28 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on fruit fly and leaf spot infestation

Experiment I

Factor	Fruit fly infestation (%)		Leaf spot infestation (%)					
			30 DAS		60 DAS		90 DAS	
	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97
$l_1 r_1$	11.82(3.59)	14.78(3.97)	2.96(2.00)	0	8.06(3.02)	5.97(2.65)	31.37(5.70)	60.31(7.83)
$l_1 r_2$	10.83(3.45)	13.32(3.78)	0.69(1.31)	0	4.66(2.39)	5.15(2.48)	29.14(5.49)	59.37(7.77)
$l_1 r_3$	12.54(3.68)	16.40(4.17)	0.39(1.19)	0	10.42(3.38)	4.90(2.43)	29.14(5.49)	64.61(8.10)
$l_2 r_1$	12.32(3.65)	14.72(3.96)	3.71(2.17)	0	8.98(3.16)	4.11(2.27)	27.30(5.32)	62.28(7.95)
$l_2 r_2$	13.90(3.86)	16.17(4.14)	0(1.00)	0	9.11(3.18)	3.24(2.06)	30.02(5.58)	61.09(7.88)
$l_2 r_3$	10.56(3.40)	17.59(4.31)	1.79(1.67)	0	5.05(2.47)	4.86(2.43)	20.53(4.64)	56.15(7.56)
$l_3 r_1$	11.53(3.55)	13.62(3.82)	1.53(1.59)	0	7.07(2.84)	2.06(1.76)	26.67(5.26)	52.73(7.33)
$l_3 r_2$	9.69(3.27)	14.57(3.95)	3.41(2.10)	0	9.24(3.21)	7.07(2.84)	29.14(5.49)	55.10(7.49)
$l_3 r_3$	9.82(3.29)	15.55(4.07)	0.41(1.19)	0	5.16(2.60)	4.52(2.35)	23.21(4.93)	39.58(6.37)
$F_{4,22}$	0.63^{ns}	0.35^{ns}	2.23^{ns}	-	0.68^{ns}	0.76^{ns}	0.18^{ns}	3.70^{*}
SEd	0.42	2.43	0.57	-	1.03	0.76	0.98	-
CD	-	-	-	-	-	-	-	0.60

ns - Not Significant ( ) Transformed mean * Significant at 5% level

Table 29 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on fruit fly and leaf spot infestation

Experiment I

Factor	Fruit fly infestation (%)		Leaf spot infestation (%)					
			30 DAS		60 DAS		90 DAS	
	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97
$l_1 f_1$	11.67(3.56)	15.08(4.01)	0.39(1.19)	0	4.15(2.28)	8.67(3.11)	24.40(5.04)	65.26(8.14)
$l_1 f_2$	10.56(3.41)	12.38(3.79)	2.96(2.00)	0	13.90(3.87)	5.00(2.46)	38.06(6.26)	59.22(7.77)
$l_1 f_3$	12.99(3.74)	16.04(4.12)	0.69(1.31)	0	5.96(2.64)	2.96(2.00)	27.94(5.38)	59.68(7.80)
$l_2 f_1$	12.18(3.63)	16.83(4.22)	1.22(1.50)	0	6.40(2.72)	4.24(2.29)	22.91(4.90)	62.68(7.99)
$l_2 f_2$	13.06(3.75)	16.65(4.20)	3.62(2.16)	0	11.82(3.58)	7.35(2.90)	31.95(5.75)	56.61(7.60)
$l_2 f_3$	11.46(3.54)	15.00(4.00)	0.39(1.19)	0	5.25(2.51)	1.43(1.56)	22.91(4.90)	59.84(7.81)
$l_3 f_1$	10.36(3.37)	14.96(3.99)	1.22(1.50)	0	6.24(2.70)	8.18(3.03)	24.40(5.04)	51.85(7.27)
$l_3 f_2$	10.16(3.35)	16.68(4.20)	3.28(2.08)	0	10.29(3.37)	2.72(1.94)	27.20(5.31)	50.70(7.19)
$l_3 f_3$	10.49(3.40)	12.10(3.62)	0.69(1.31)	0	5.65(2.59)	2.92(1.98)	27.30(5.32)	44.29(6.73)
$F_{4,22}$	0.32^{ns}	1.70^{ns}	0.13^{ns}	-	0.18^{ns}	1.13^{ns}	0.26^{ns}	0.74^{ns}
SEd	0.42	2.43	0.57	-	1.03	0.76	0.98	0.35

ns - Not Significant ( ) Transformed mean

Table 30 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on fruit fly and leaf spot infestation

Experiment I

Factor	Fruit fly infestation (%)		Leaf spot infestation (%)					
			30 DAS		60 DAS		90 DAS	
	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97
$r_1 f_1$	11.32(3.52)	15.06(4.01)	2.5(1.88)	0	5.40(2.53)	6.45(2.73)	22.72(4.87)	61.57(7.92)
$r_1 f_2$	12.76(3.72)	15.48(4.06)	4.29(2.39)	0	12.84(3.73)	4.62(2.38)	32.89(5.83)	54.35(7.44)
$r_1 f_3$	11.60(3.56)	12.58(3.69)	1.22(1.50)	0	6.62(2.76)	1.43(1.57)	30.02(5.58)	59.21(7.76)
$r_2 f_1$	12.25(3.64)	15.79(4.10)	0.69(1.31)	0	6.67(2.78)	7.12(2.86)	25.83(5.19)	64.61(8.10)
$r_2 f_2$	9.50(3.24)	15.03(4.00)	2.20(1.79)	0	9.89(3.30)	5.45(2.55)	31.95(5.75)	61.09(7.88)
$r_2 f_3$	12.62(3.70)	13.25(3.77)	0.69(1.31)	0	6.24(2.70)	2.92(1.98)	30.70(5.64)	50.12(7.16)
$r_3 f_1$	10.56(3.40)	16.02(4.13)	0(1.00)	0	4.66(2.39)	7.07(2.85)	23.21(4.93)	53.46(7.39)
$r_3 f_2$	11.53(3.55)	16.20(4.15)	3.20(2.05)	0	13.29(3.79)	4.56(2.37)	31.95(5.75)	51.27(7.23)
$r_3 f_3$	10.70(3.42)	17.31(4.28)	0(1.00)	0	4.15(2.28)	2.96(2.00)	18.18(4.39)	55.06(7.42)
$F_{4,22}$	0.64^{ns}	0.80^{ns}	0.37^{ns}	-	0.21^{ns}	0.07^{ns}	0.49^{ns}	2.49^{ns}
SEd	0.42	2.43	0.57	-	1.03	0.76	0.98	0.35

ns - Not Significant ( ) Transformed mean

Different frequencies of N application significantly influenced the leaf spot infestation at 30 DAS during 1995-96. It was maximum (4.58%) with f_3 treatment wherein both organic and chemical N sources were applied as basal and fortnightly equal splits while moderate (3.28 %) and minimum (0.93%) infestations were noticed with f_2 and f_1 frequencies respectively. Leaf spot infestation was however unaffected by frequencies of N application at 60 DAS and 90 DAS. During 1996-97, leaf spot infestation was not observed at 30 DAS and not influenced by different frequencies of N application at 90 DAS. But it did show variation at 60 DAS and the response was similar to that observed during the previous year with maximum leaf spot infestation recorded (6.39%) with f_3 and minimum (2.90%) with f_1 (Table 27).

Interaction effects are depicted in Tables 28, 29 and 30.

None of interaction effects could significantly influence the percentage of leaf spot infestation at any stage of observation during both the years, except the LxR interaction at 90 DAS (Table 28) during the second year (1996-97) of field experimentation. In this case, infestation was maximum (64.61%) with l_1r_3 combination wherein 200 kg N was applied through 2:1 organic-chemical N substitution ratio and was minimum (39.58%) with l_3r_3 in which 300 kg N was applied through 2:1 substitution ratio.

4.1.3.2b Mosaic

No viral mosaic infestation was observed in both the years.

4.1.4 Harvests and Yield

4.1.4.1 Harvests

4.1.4.1a Days to first harvest

Levels of N, ratios of substitution or frequencies of application did not significantly influence the days required for 1st harvest in first and second years of experimentation (Table 11).

Interaction effects depicted in Tables 12, 13 and 14 also showed that they could not affect the days required for the first harvest in first or second year.

4.1.4.1b Days to 50 per cent harvest

When farm yard manure was used as organic source, different levels of nitrogen, its ratios of substitution or frequencies of application did not influence the days required for 50 per cent harvest (Table 11) during first and second year of field experimentation.

As depicted in Tables 12, 13 and 14 none of the interaction effects could significantly influence the days required for 50 per cent harvest in first or second year.

4.1.4.1c Days to final harvest

Days required for the final harvest was also not under the influence of main effects (Table 11) or interaction effects of treatments (Tables 12, 13 and 14) in both the years of experimentation.

4.1.4.1d Number of harvests

Total number of harvests was unaffected by different levels of application of nitrogen, its ratios of substitution and frequencies of application during 1995-96 and 1996-97 (Table 35). Various interaction effects too could not significantly influence the number of harvests during both the years (Tables 36, 37 and 38).

4.1.4.2 Yield and yield attributes

4.1.4.2a Number of fruits plant^{-1}

As depicted in Table 35, different levels of nitrogen, ratios of substitution or its frequencies of application did not significantly influence the number of fruits plant^{-1} during 1995-96 and 1996-97. None of the interaction effects could influence the number of fruits plant^{-1} during both the years of experimentation (Tables 36, 37 and 38).

4.1.4.2b Fruit yield plant^{-1}

As shown in Table 35, different levels of nitrogen, its ratios of substitution or frequencies of application could not influence the fruit yield plant^{-1} in first and second years. None of the interaction effects influenced the fruit yield plant^{-1} during first and second years of field experimentation (Tables 36, 37 and 38).

Table 35 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on number of harvests, yield and yield attributes

Experiment I

Factor	Number of harvests		Fruit yield (t ha^{-1})		Fruit yield/plant(kg)		Number of fruits/ Plant	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen								
l_1	8.89	10.00	10.14	11.35	4.06	4.54	36.39	38.28
l_2	8.28	9.83	8.86	10.29	3.54	4.11	31.11	35.89
l_3	8.61	9.89	9.85	10.74	3.94	4.29	36.44	37.17
$F_{2,22}$	0.24^{ns}	0.84^{ns}	1.66^{ns}	1.19^{ns}	1.67^{ns}	1.19^{ns}	1.87^{ns}	0.67^{ns}
Ratios								
r_1	8.56	9.83	9.22	10.90	3.69	4.36	33.00	37.94
r_2	8.61	10.00	9.29	10.86	3.72	4.34	33.06	37.72
r_3	8.61	9.89	10.34	10.62	4.14	4.25	37.89	35.67
$F_{2,22}$	0.06^{ns}	0.84^{ns}	1.43^{ns}	0.09^{ns}	1.43^{ns}	0.09^{ns}	1.57^{ns}	0.74^{ns}
Frequencies								
f_1	8.67	9.83	9.82	10.81	3.93	4.32	35.39	36.94
f_2	8.50	10.00	9.48	10.45	3.79	4.18	33.28	35.94
f_3	8.61	9.89	9.55	11.12	3.82	4.45	35.28	38.44
$F_{2,22}$	0.40^{ns}	0.84^{ns}	0.12^{ns}	0.47^{ns}	0.12^{ns}	0.47^{ns}	0.28^{ns}	0.74^{ns}
SEd	0.40	0.27	1.57	1.47	1.41	0.59	6.71	4.38

ns - Not Significant

Table 36 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on number of harvests, yield and yield attributes

Experiment I

Factor	Number of harvests		Fruit yield (t ha^{-1})		Fruit yield/plant(kg)		Number of fruits/ Plant	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	9.00	10.00	9.95	11.56	3.98	4.62	36.00	38.50
$l_1 r_2$	8.83	10.00	9.53	10.90	3.81	4.36	34.17	38.67
$l_1 r_3$	8.83	10.00	10.96	11.61	4.38	4.64	39.00	37.67
$l_2 r_1$	8.00	9.67	7.85	10.40	3.14	4.16	26.83	36.67
$l_2 r_2$	8.50	10.00	8.69	10.33	3.48	4.13	30.67	36.67
$l_2 r_3$	8.33	9.83	10.03	10.13	4.01	4.05	35.83	34.33
$l_3 r_1$	8.67	9.83	9.86	10.74	3.94	4.30	36.17	38.67
$l_3 r_2$	8.50	10.00	9.67	11.34	3.87	4.53	34.33	37.83
$l_3 r_3$	8.67	9.83	10.04	10.13	4.02	4.05	38.83	35.00
$F_{4,22}$	0.75^{ns}	0.30^{ns}	0.37^{ns}	0.32^{ns}	0.37^{ns}	0.33^{ns}	0.26^{ns}	0.08^{ns}
SEd	0.40	0.27	1.57	1.47	1.41	0.59	6.71	4.38

ns - Not Significant

Table 37 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on number of harvests, yield and yield attributes **Experiment I**								
Factor	Number of harvests		Fruit yield (t ha^{-1})		Fruit yield/plant(kg)		Number of fruits/ Plant	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	9.00	10.00	10.76	12.00	4.30	4.80	38.00	39.67
$l_1 f_2$	8.83	10.00	9.84	10.69	3.94	4.27	36.17	36.17
$l_1 f_3$	8.83	10.00	9.83	11.38	3.93	4.55	35.00	39.00
$l_2 f_1$	8.50	9.67	8.63	9.83	3.45	3.93	29.83	33.67
$l_2 f_2$	8.17	10.00	9.06	10.51	3.62	4.20	31.00	36.83
$l_2 f_3$	8.17	9.83	8.88	10.53	3.55	4.21	32.50	37.17
$l_3 f_1$	8.50	9.83	10.08	10.62	4.03	4.25	38.33	37.50
$l_3 f_2$	8.50	10.00	9.53	10.15	3.81	4.06	32.67	34.83
$l_3 f_3$	8.83	9.83	9.95	11.45	3.98	4.58	38.33	39.17
$F_{4,22}$	0.58^{ns}	0.30^{ns}	0.19^{ns}	0.47^{ns}	0.19^{ns}	0.47^{ns}	0.35^{ns}	0.56^{ns}
SEd	0.40	0.27	1.57	1.47	1.41	0.59	6.71	4.38

ns - Not Significant

Table 38 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on number of harvests, yield and yield attributes

Experiment I

Factor	Number of harvests		Fruit yield ($t\ ha^{-1}$)		Fruit yield/plant(kg)		Number of fruits/ Plant	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	8.67	9.50	9.63	10.89	3.85	4.36	35.00	37.33
$r_1 f_2$	8.50	10.00	8.60	9.88	3.44	3.95	29.50	37.83
$r_1 f_3$	8.50	10.00	9.43	11.93	3.77	4.77	34.50	38.67
$r_2 f_1$	8.50	10.00	9.47	11.08	3.79	4.43	33.83	37.50
$r_2 f_2$	8.50	10.00	9.34	10.07	3.74	4.03	31.83	34.33
$r_2 f_3$	8.83	10.00	9.07	11.42	3.63	4.57	33.50	41.33
$r_3 f_1$	8.83	10.00	10.37	10.47	4.15	4.19	37.33	36.00
$r_3 f_2$	8.50	10.00	10.49	11.39	4.20	4.55	38.50	35.67
$r_3 f_3$	8.50	9.67	10.16	10.02	4.07	4.01	37.83	35.33
$F_{4,22}$	0.58^{ns}	1.91^{ns}	0.16^{ns}	1.16^{ns}	0.16^{ns}	1.16^{ns}	0.22^{ns}	0.63^{ns}
SEd	0.40	0.27	1.57	1.47	1.41	0.59	6.71	4.38

ns - Not Significant

4.1.4.2c Fruit yield (t ha^{-1})

When farm yard manure was used as organic source in Experiment I, different levels of nitrogen, its ratios of substitution or frequencies of application did not significantly influence the bitter gourd fruit yield (t ha^{-1}) during 1995-96 and 1996-97 (Table 35). Fruit yield was not influenced by treatment interactions too, during both the years (Tables 36, 37 and 38).

4.1.5 Total dry matter production (g $plant^{-1}$)

Different levels of nitrogen, its ratios of substitution or frequencies of application did not significantly influence the total dry matter production $plant^{-1}$ during 1995-96 and 1996-97 (Table 43). Same trend was noticed in case of interaction effects wherein none of the interactions could significantly affect the dry matter production during both the years of field experimentation (Tables 44, 45 and 46).

4.1.6 Root studies

4.1.6.1 Depth of root penetration (cm)

As shown in Table 43, levels of N, its ratios of substitution or frequencies of application did not significantly influence the depth of root penetration during 1995-96 and 1996-97. The LxR, LxF or RxF interactions too could not influence the root penetration during both the years of experimentation (Tables 44, 45 and 46).

Table 43 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on total dry matter production of plant, depth of root penetration and root dry weight

Experiment - I

Factor	Total dry matter production(g plant^{-1})		Depth of root penetration(cm)		Root dry weight (g)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen						
l_1	413.18	585.04	37.22	42.28	3.77	4.54
l_2	417.57	562.88	37.31	46.00	3.84	4.39
l_3	460.95	554.41	36.86	43.28	3.83	5.01
$F_{2,22}$	2.14^{ns}	0.42^{ns}	0.017^{ns}	1.93^{ns}	0.007^{ns}	0.63^{ns}
Ratios						
r_1	425.32ns	582.28	44.11	45.31	4.53	4.75
r_2	438.67	580.71	46.61	43.14	3.34	4.59
r_3	487.71	579.34	48.67	46.11	3.57	4.61
$F_{2,22}$	2.70^{ns}	0.003^{ns}	0.81^{ns}	0.83^{ns}	1.80^{ns}	0.04^{ns}
Frequencies						
f_1	461.39	581.87	39.19	48.75	4.36	4.72
f_2	442.47	588.14	37.94	45.58	3.56	5.04
f_3	447.84	572.32	36.25	42.22	3.53	4.17
$F_{2,22}$	0.24^{ns}	0.10^{ns}	0.22^{ns}	1.48^{ns}	0.99^{ns}	1.16^{ns}
SEd	59.97	75.38	5.42	4.15	1.42	1.23

ns - Not Significant

Table 44 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on total dry matter production of plant, depth of root penetration and root dry weight

Experiment - I

Factor	Total dry matter production(g plant^{-1})		Depth of root penetration(cm)		Root dry weight (g)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	465.68	576.19	43.42	40.00	4.90	4.33
$l_1 r_2$	446.28	576.89	34.50	41.92	2.81	4.38
$l_1 r_3$	507.60	632.03	33.75	44.92	3.60	4.90
$l_2 r_1$	357.51	563.79	43.58	45.58	5.35	4.64
$l_2 r_2$	416.76	542.35	37.08	45.67	2.89	3.86
$l_2 r_3$	478.44	582.49	31.25	46.75	3.28	4.68
$l_3 r_1$	452.77	606.85	36.33	47.33	3.35	5.27
$l_3 r_2$	452.97	622.89	38.25	41.83	4.31	5.52
$l_3 r_3$	477.10	533.50	36.00	37.67	3.84	4.24
$F_{4,22}$	0.67^{ns}	0.51^{ns}	1.34^{ns}	1.78^{ns}	1.40^{ns}	0.75^{ns}
SEd	59.97	75.38	5.42	4.15	1.42	1.23

ns - Not Significant

Table 45 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on total dry matter production of plant, depth of root penetration and root dry weight

Experiment - I

Factor	Total dry matter production(g plant^{-1})		Depth of root penetration(cm)		Root dry weight (g)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	494.36	597.71	38.08	41.50	4.31	4.63
$l_1 f_2$	462.33	563.78	38.25	47.67	3.17	4.91
$l_1 f_3$	462.87	593.62	35.33	37.67	3.84	4.06
$l_2 f_1$	420.56	554.50	35.33	45.83	4.61	4.43
$l_2 f_2$	421.41	585.42	37.08	44.17	3.65	4.75
$l_2 f_3$	410.74	548.71	39.50	48.00	3.25	4.00
$l_3 f_1$	469.26	593.40	38.17	43.92	4.15	5.11
$l_3 f_2$	443.68	615.21	38.50	44.92	3.85	5.47
$l_3 f_3$	469.90	574.62	33.92	41.00	3.50	4.45
$F_{4,22}$	0.13^{ns}	0.25^{ns}	0.58^{ns}	2.15^{ns}	0.19^{ns}	0.01^{ns}
SEd	59.97	75.38	5.42	4.15	1.42	1.23

ns - Not Significant

Table 46 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on total dry matter production of plant, depth of root penetration and root dry weight.

Experiment - I

Factor	Total dry matter production(g plant^{-1})		Depth of root penetration(cm)		Root dry weight (g)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	448.93	591.50	39.92	43.58	5.67	4.81
$r_1 f_2$	400.30	553.33	39.50	47.33	3.44	4.96
$r_1 f_3$	426.73	602.01	43.92	45.00	4.50	4.47
$r_2 f_1$	440.91	569.68	34.83	43.50	3.96	4.49
$r_2 f_2$	436.16	590.68	38.83	45.67	2.94	5.47
$r_2 f_3$	438.94	581.76	36.17	40.25	3.11	3.79
$r_3 f_1$	494.34	584.44	40.83	46.17	3.45	4.87
$r_3 f_2$	490.95	620.40	35.50	43.75	4.29	4.70
$r_3 f_3$	477.84	533.18	28.67	41.42	2.99	4.26
$F_{4,22}$	0.16^{ns}	0.66^{ns}	1.39^{ns}	0.41^{ns}	0.98^{ns}	0.29^{ns}
SEd	59.97	75.38	5.42	4.15	1.42	1.23

ns - Not Significant

4.1.6.2 Root dry weight (g)

In Experiment I, root dry weight (g $plant^{-1}$) was not affected by main effects of treatments viz., different levels of N application, ratios of substitution and frequencies of application during 1995-96 and 1996-97 (Table 43). Different interactions too could not affect the root dry weight during both the years of field trial (Tables 44, 45 and 46).

4.1.7 Keeping quality and shelf life studies

4.1.7.1 Shelf life of fruits at room temperature (days)

As depicted in Table 51, different levels of nitrogen did not have any marked influence on shelf life of fruits at room temperature storage during 1995-96 and 1996-97.

Different ratios of organic-chemical N substitution had prominent influence on shelf life during 1995-96. Shelf life of the fruits was highest (4.28 days) when nitrogen was applied through 2:1 organic-chemical N substitution (r_3) compared to r_1 with 1:1 substitution ratio (3.17 days) and r_2 with 1:2 substitution ratio (3.72 days) using farm yard manure as organic source. Shelf life was not influenced by ratios of substitution during 1996-97 (Table 51).

Different frequencies of application also had significant influence on shelf life of fruits at room temperature during 1995-96. Shelf life was maximum with the f_3 frequency (5.27 days) when compared to f_2 (4.22 days) or f_1 (3.78 days) frequencies. However the f_2 and f_1 frequencies did not differ each other (Table

Plate 4. Shelf life of fruits on 4 th day of room temperature storage(Expt.I)
(FT_{23} - $l_3r_2f_2$, FT_{25} - $l_3r_3f_1$, FT_{27} - $l_3r_3f_3$)

Plate 5. Shelf life of fruits on 4 th day of room temperature storage (Expt.II)
(PT_{24} - $l_3r_2f_3$, PT_5 - $l_1r_2f_2$, PT_{22} - $l_3r_2f_1$
PT_{25} - $l_3r_3f_1$, PT_{26} - $l_3r_3f_2$, PT_{27} - $l_3r_3f_3$)

Table 51 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on shelf life of fruits and the Physiological loss in weight during storage

Experiment I

Factor	Shelf life of fruits (days)				Physiological loss in weight (%)			
	At room temperature		Under refrigeration		At room temperature		Under refrigeration	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen								
l_1	4.06	4.44	13.22	15.39	23.62	21.61	24.86	26.05
l_2	3.39	4.83	10.17	15.11	18.84	23.71	23.66	28.85
l_3	3.72	4.83	10.44	15.56	23.17	23.57	24.88	26.89
$F_{2,22}$	3.20^{ns}	0.71^{ns}	11.93^{**}	0.44^{ns}	3.25^{ns}	0.78^{ns}	3.04^{ns}	1.05^{ns}
Ratios								
r_1	3.17	4.61	12.44	14.89	19.10	23.49	24.92	23.23
r_2	3.72	4.44	12.11	14.56	21.39	20.98	24.01	22.36
r_3	4.28	5.06	14.28	16.61	19.14	24.43	23.47	22.21
$F_{2,22}$	8.89^{**}	1.40^{ns}	2.31^{ns}	10.54^{**}	1.60^{ns}	1.79^{ns}	2.81^{ns}	2.27^{ns}
Frequencies								
f_1	3.78	4.83	12.39	15.39	22.94	25.76	23.09	24.94
f_2	4.22	4.11	13.83	15.44	22.99	24.96	24.79	26.20
f_3	5.27	5.17	12.61	15.22	19.70	24.19	22.51	24.65
$F_{2,22}$	8.09^{**}	4.07^{*}	1.03^{ns}	0.16^{ns}	1.59^{ns}	1.12^{ns}	2.52^{ns}	2.27^{ns}
SEd	0.56	0.80	2.30	1.02	4.40	4.00	2.23	1.64
CD	0.55	0.78	2.25	1.00	-	-	-	-

ns - Not Significant   * Significant at 5% level   ** Significant at 1% level

Table 52 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on shelf life of fruits and the Physiological loss in weight during storage

Experiment I

Factor	Shelf life of fruits (days)				Physiological loss in weight (%)			
	At room temperature		Under refrigeration		At room temperature		Under refrigeration	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	3.83	4.50	13.17	14.67	24.89	20.64	24.98	24.53
$l_1 r_2$	3.67	4.17	12.67	15.00	27.44	19.30	23.13	24.41
$l_1 r_3$	4.67	4.67	13.83	16.50	28.53	24.90	26.47	26.21
$l_2 r_1$	3.00	4.33	10.17	14.50	24.64	23.77	24.61	24.62
$l_2 r_2$	2.83	4.83	8.67	14.83	25.08	22.78	22.26	28.86
$l_2 r_3$	4.33	5.33	11.67	16.00	26.80	24.60	24.11	28.08
$l_3 r_1$	2.67	5.00	14.00	15.50	24.77	26.08	25.17	24.53
$l_3 r_2$	3.67	4.33	15.00	13.83	21.64	20.85	20.64	28.82
$l_3 r_3$	3.83	5.17	17.33	17.33	23.10	23.80	19.84	27.32
$F_{4,22}$	5.03^{**}	0.49^{ns}	0.41^{ns}	1.43^{ns}	1.87^{ns}	0.62^{ns}	1.88^{ns}	1.40^{ns}
SEd	-	0.80	2.30	1.02	4.40	4.00	2.23	1.64
CD	0.95	-	-	-	-	-	-	-

ns - Not Significant ** Significant at 1% level

Table 53 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on shelf life of fruits(days) and the Physiological loss in weight during storage

Experiment I

Factor	Shelf life of fruits (days)				Physiological loss in weight (%)			
	At room temperature		Under refrigeration		At room temperature		Under refrigeration	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	4.33	4.67	12.17	15.50	24.59	26.54	24.60	28.20
$l_1 f_2$	5.17	4.00	14.50	15.33	28.67	28.65	25.25	27.16
$l_1 f_3$	5.67	5.67	13.00	15.33	17.60	29.64	24.72	24.79
$l_2 f_1$	3.00	4.50	11.67	15.33	21.48	28.89	23.03	26.80
$l_2 f_2$	2.83	5.17	10.83	15.33	16.84	28.21	25.82	24.51
$l_2 f_3$	3.33	5.83	8.50	14.67	18.21	24.05	22.13	24.25
$l_3 f_1$	3.00	5.33	13.83	15.33	22.74	26.84	21.64	28.82
$l_3 f_2$	3.67	3.17	16.17	15.67	29.48	25.01	23.31	26.92
$l_3 f_3$	3.50	6.00	16.33	15.67	17.28	28.87	20.69	26.93
$F_{4,22}$	8.89**	1.69^{ns}	1.03^{ns}	0.22^{ns}	2.47^{ns}	2.44^{ns}	0.41^{ns}	1.77^{ns}
SEd	-	1.34	2.30	1.02	4.40	4.00	2.23	1.64
CD	0.95	-	-	-	-	-	-	-

ns - Not Significant ** Significant at 1% level

Table 54 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on shelf life of fruits and the Physiological loss in weight during storage

Experiment I

Factor	Shelf life of fruits (days)				Physiological loss in weight (%)			
	At room temperature		Under refrigeration		At room temperature		Under refrigeration	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
r1 f1	3.33	4.50	11.83	14.83	27.38	28.13	24.07	22.83
$r_1 f_2$	3.17	5.17	14.17	15.50	26.39	24.52	26.11	24.09
$r_1 f_3$	3.00	4.17	11.33	14.33	28.53	26.83	24.58	22.76
$r_2 f_1$	3.00	4.03	10.50	14.33	28.16	28.92	23.50	21.86
$r_2 f_2$	4.83	3.17	12.17	14.50	28.20	25.59	22.98	23.85
$r_2 f_3$	3.33	5.43	13.67	14.83	27.81	28.42	19.55	21.37
$r_3 f_1$	4.00	5.27	14.83	17.00	23.27	28.22	21.71	30.13
$r_3 f_2$	4.67	5.00	15.17	16.33	28.41	26.76	25.29	30.65
$r_3 f_3$	5.17	5.50	12.83	16.50	24.76	26.31	23.42	29.83
$F_{4,22}$	5.25^{**}	4.70^{**}	1.30^{ns}	0.70^{ns}	1.46^{ns}	1.05^{ns}	1.43^{ns}	0.24^{ns}
SEd	-	-	2.30	1.02	4.40	4.00	2.23	1.64
CD	0.95	1.36	-	-	-	-	-	-

ns - Not Significant ** Significant at 1% level

51). Shelf life at room temperature was influenced by different frequencies of application during 1996-97 too. It was maximum (5.17 days) with the f_3 frequency which was significantly superior to the f_2 (4.11 days) and f_1 (4.83 days) although f_2 and f_1 treatments did not differ each other.

As depicted in Table 52, the LxR interaction significantly influenced the shelf life of fruits at room temperature during 1995-96. Application of 200 kg N through 2:1 organic-chemical N ratio (l_1r_3) recorded the highest shelf life of fruits ie. 4.67 days which was significantly higher when compared to the application of same quantity of N either through 1:1 ratio (l_1r_1) or 1:2 ratio (l_1r_2) which resulted in a shelf life of 3.83 days and 3.67 days respectively. Enhancing the N level from 200 to 250 kg slightly reduced the shelf life of fruits although shelf life was still higher (4.33 days) with l_2r_3 treatment when compared to l_2r_2 (2.83 days) or l_2r_1 (3 days) which did not vary each other. Further enhancement in the level of nitrogen from 250 to 300 kg ha^{-1} also lowered the shelf life of fruits though it was still higher (3.83 days) with l_3r_3 treatment combination, compared to l_3r_1 (2.67 days) although it did not significantly differ from l_3r_2 (3.67 days) treatment combination. Though the shelf life in days tended to decrease with each increment in the level of nitrogen, l_1r_3, l_2r_3 and l_3r_3 combinations which recorded a shelf life of 4.67, 4.33 and 3.83 days did not significantly differ each other.

The LxF interaction (Table 53) significantly influenced the shelf life of fruits at room temperature during 1995-96. Application of 200 kg N ha^{-1} through basal and fortnightly split applications (l_1f_3) registered the highest shelf life of 5.67 days compared to l_1f_1 (4.33 days) combination wherein the organic part of same quantity of N was applied in full as basal along with fortnightly split applications of chemical N. However the l_1f_2 combination wherein 200 kg N ha^{-1} was applied as basal and as 2 splits (organic source) combined with the fortnightly split application of chemical N, which recorded a shelf life of 5.17 days did not vary from l_1f_3 or l_1f_1. Increasing the N level from 200 to 300 kg N ha^{-1} significantly lowered the shelf life of fruits at room temperature, although the organic source was applied as basal + fortnightly intervals, and the enhancement from 250 to 300 kg N ha^{-1} did not produce any significant difference. The LxF interaction had no effect on shelf life of fruits at room temperature during 1996-97.

The RxF interaction (Table 54) did influence the shelf life of fruits during 1995-96 as well as 1996-97. During the first year of experimentation highest shelf life of 5.17 days was recorded with r_3f_3 treatment wherein the nutrient nitrogen was applied through 2:1 organic-chemical N substitution ratio with total quantity of farm yard manure and fertiliser source as basal and at fortnightly intervals. Shelf life was lowest (3.00 days) with r_1f_3 or r_2f_1 treatments where nitrogen was supplied through either 1:1 or 1:2 organic-chemical N ratio wherein either organic+chemical N were applied as basal and at fortnightly split doses or the organic source completely applied as basal. During the second year (1996-97) also similar trend was noticed wherein shelf life of fruits at room temperature was maximum with r_3f_3 treatment (5.50 days) and minimum with r_2f_2 treatment (3.17 days).

4.1.7.2 Shelf life of fruits under refrigeration (days)

Main effects of treatments on shelf life of fruits under refrigeration are depicted in Table 51.

Different levels of N application significantly influenced the shelf life of fruits under refrigeration during 1995-96, wherein it decreased significantly from 13.22 to 10.17 as the N level was enhanced from 200 to 250 kg N ha^{-1} although the next higher level (250 to 300 kg N ha^{-1}) did not produce any significant variation in shelf life (10.44 days). However during the succeeding year of 1996-97 rates of N nutrition had no influence on shelf life of fruits under refrigeration (Table 51).

Different ratios of N substitution could not influence the shelf life of fruits under refrigeration during 1995-96 although the ratios of N substitution did have an influence during the succeeding year. Supply of N through 2:1 organic-chemical N ratio recorded significantly higher shelf life (16.61 days) when compared to 1:1 (14.89 days) or 1:2 (14.56 days) ratios. However the 1:1 and 1:2 ratios of substitution did not differ each other (Table 51).

Different frequencies of application did not influence the shelf life of fruits under refrigeratory storage during 1995-96 or 1996-97 (Table 51).

None of the interaction effects could significantly influence the shelf life of fruits under refrigeration during 1995-96 or 1996-97 (Tables 52, 53 and 54).

4.1.7.3 Physiological loss in weight at room temperature storage (%)

Different levels of N application, ratios of substitution or frequencies of application did not influence the physiological loss in weight during storage of fruits at room temperature during 1995-96 or 1996-97 when farm yard manure was used as organic source for N substitution (Table 51). Interaction effects too did not have any significant influence on physiological loss in weight during both the years of field experimentation (Tables 52, 53 and 54).

4.1.7.4 Physiological loss in weight under refrigeratory storage (%)

As depicted in Table 51, different levels of N application, its ratios of substitution or frequencies of application did not have any significant influence on physiological loss in weight during storage of fruits under refrigeration during 1995-96 and 1996-97.

During both the years of field experimentation none of the interaction effects had any significant influence on physilogical loss in weight under refrigeratory storage (Tables 52, 53 and 54).

4.1.8 Plant analysis

4.1.8.1 Total N content in plant (%)

Effects of levels of nitrogen, ratios of substitution and frequencies of application on total N content in plant is depicted in Table 59.

During 1995-96 the main effect of levels of N did not have any effect on total plant N content. However in the succeeding year (1996-97), with the increase in nitrogen level from 200 to 300 kg ha^{-1} plant N content also significantly improved from 1.75 (l_1) per cent to 2.11 per cent (l_3). However the lower levels of nitrogen application (l_1 and l_2) did not differ each other which recorded 1.75 and 1.87 per cent total N contents respectively (Table 59).

Table 59 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on total N, P and K contents of plant

Experiment - I

Factor	Total Plant N (%)		Total Plant P (%)		Total Plant K (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
<u>Nitrogen</u>						
l_1	2.11	1.75	0.32	0.29	2.02	2.01
l_2	1.93	1.87	0.33	0.32	2.24	2.24
l_3	1.81	2.11	0.34	0.33	2.44	2.50
$F_{2,22}$	2.09^{ns}	10.40^{**}	3.47^{*}	9.83^{**}	10.98^{**}	11.22^{**}
<u>Ratios</u>						
r_1	1.89	1.84	0.33	0.31	2.11	2.17
r_2	2.00	1.91	0.33	0.31	2.24	2.15
r_3	1.96	1.98	0.32	0.32	2.33	2.41
$F_{2,22}$	0.29^{ns}	1.42^{ns}	0.34^{ns}	0.99^{ns}	3.45^{*}	3.79^{*}
<u>Frequencies</u>						
f_1	1.96	2.11	0.34	0.32	2.21	2.30
f_2	1.94	1.89	0.32	0.31	2.18	2.25
f_3	1.94	1.74	0.33	0.30	2.29	2.19
$F_{2,22}$	0.01^{ns}	10.56^{**}	2.57^{ns}	1.38^{ns}	0.89^{ns}	0.57^{ns}
SEd	0.31	0.17	0.02	0.02	0.18	0.22
CD	-	0.17	0.02	0.02	0.18	0.23

ns - Not Significant ** Significant at 1% level *Significant at 5% level

Table 60 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on total N,P and K contents of plant

Experiment - I

Factor	Total Plant N (%)		Total Plant P (%)		Total Plant K (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	1.94	1.73	0.35	0.29	1.98	2.08
$l_1 r_2$	2.27	1.72	0.35	0.29	2.03	1.95
$l_1 r_3$	2.10	1.81	0.33	0.29	2.06	1.99
$l_2 r_1$	2.19	1.83	0.32	0.32	2.12	2.07
$l_2 r_2$	1.92	1.88	0.33	0.30	2.35	2.16
$l_2 r_3$	1.68	1.90	0.33	0.33	2.24	2.47
$l_3 r_1$	1.55	1.98	0.32	0.32	2.23	2.37
$l_3 r_2$	1.81	2.13	0.32	0.33	2.36	2.36
$l_3 r_3$	2.09	2.23	0.31	0.34	2.69	2.77
$F_{4,22}$	0.01^{ns}	0.31^{ns}	0.64^{ns}	1.29^{ns}	1.50^{ns}	1.36^{ns}
SEd	0.31	0.17	0.02	0.02	0.18	0.22

ns - Not Significant

Table 61 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on total N, P and K contents of plant

Experiment - I

Factor	Total Plant N (%)		Total Plant P (%)		Total Plant K (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	1.99	1.87	0.37	0.29	1.94	2.01
$l_1 f_2$	1.98	1.76	0.32	0.30	1.94	1.95
$l_1 f_3$	2.35	1.63	0.33	0.29	2.18	2.06
$l_2 f_1$	2.08	2.10	0.33	0.32	2.34	2.15
$l_2 f_2$	1.96	1.86	0.31	0.32	2.18	2.34
$l_2 f_3$	1.75	1.65	0.34	0.31	2.20	2.21
$l_3 f_1$	1.82	2.36	0.32	0.35	2.35	2.73
$l_3 f_2$	1.89	2.06	0.32	0.33	2.43	2.47
$l_3 f_3$	1.74	1.93	0.31	0.31	2.50	2.30
$F_{4,22}$	2.49^{ns}	0.41^{ns}	1.69^{ns}	1.29^{ns}	1.05^{ns}	1.61^{ns}
SEd	0.31	0.17	0.02	0.02	0.18	0.22

ns - Not Significant

Table 62 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on total N, P and K contents of plant

Experiment - I

Factor	Total Plant N (%)		Total Plant P (%)		Total Plant K (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	1.95	1.98	0.33	0.31	2.08	2.27
$r_1 f_2$	1.89	1.85	0.33	0.32	2.04	2.28
$r_1 f_3$	1.84	1.70	0.33	0.30	2.20	1.97
$r_2 f_1$	1.94	2.16	0.34	0.31	2.23	2.18
$r_2 f_2$	2.10	1.89	0.33	0.31	2.28	2.19
$r_2 f_3$	1.97	1.68	0.32	0.30	2.23	2.09
$r_3 f_1$	2.00	2.18	0.35	0.33	2.32	2.45
$r_3 f_2$	1.84	1.93	0.29	0.31	2.22	2.28
$r_3 f_3$	2.03	1.83	0.33	0.31	2.45	2.51
$F_{4,22}$	0.31^{ns}	0.31^{ns}	2.37^{ns}	0.38^{ns}	0.48^{ns}	1.23^{ns}
SEd	0.31	0.17	0.02	0.02	0.18	0.22

ns - Not Significant

Different ratios of substitution did not influence the total plant N content during 1995-96 or 1996-97.

Various frequencies of application had marked influence only during 1996-97. Maximum total N content of 2.11 per cent was recorded in plants when f_1 frequency was followed which was significantly superior to f_2 (1.89 per cent) and f_3 (1.74 per cent) frequencies eventhough f_2 and f_3 frequencies were on a par (Table 59).

As indicated by Tables 60, 61 and 62, interaction effects could not significantly influence the total N content in plants during 1995-96 or 1996-97.

4.1.8.2 Total P content in plant (%)

As depicted in Table 59, the total P content in plant increased significantly with increase in levels of nitrogen from l_1 (200 kg ha^{-1}) to l_3 (300 kg ha^{-1}) and maximum total plant P content of 0.34 per cent was recorded with the application of l_3 which was significantly superior to l_2 (0.33 per cent) and l_1 (0.32 per cent) during 1995-96. During the second year of experimentation (1996-97), trend observed during previous year was repeated wherein increase in levels of N from 200 to 300 kg ha^{-1} increased the total P content in plant and was maximum (0.33 per cent) with the application of l_3 which was significantly superior to l_1 (0.29 per cent). However the two higher levels (l_3 and l_2) did not significantly differ each other.

Different ratios of substitution or frequencies of application did not have any influence on total P content in plant during 1995-96 or 1996-97 (Table 59).

Interaction effects were not significant to influence the total plant P content during 1995-96 and 1996-97 (Tables 60, 61 and 62).

4.1.8.3 Total K content in plant (%)

Main effects of treatments on K content in plants are depicted in Table 59.

Different levels of N nutrition significantly influenced the total K content in plant during 1995-96. Total K content in plant significantly increased with increasing levels of N from 200 (l_1) to 250 (l_2) and 300 (l_3) kg ha^{-1} which registered a total K content of 2.44, 2.24 and 2.02 per cent with l_3, l_2 and l_1 treatments respectively. This trend was repeated during 1996-97, wherein maximum total K content of 2.50 per cent was recorded with l_3 (300 kg ha^{-1}) which was superior to l_2 (250 kg N ha^{-1}) with a total K content of 2.24 per cent which in turn was significantly higher than the K content recorded with the application of 200 kg N (2.01 per cent).

Different ratios of N substitution significantly influenced the total K content in plants during 1995-96 wherein it was maximum (2.33 per cent) with r_3 ratio (2:1 organic-chemical N) which was significantly superior to the content obtained with r_1 (2.11 per cent). The r_2 treatment (1:2 ratio) which recorded a total K content of 2.24 per cent did not vary from r_3. During 1996-97 also similar results were obtained, wherein highest K content of 2.41 per cent was recorded with r_3 which was significantly higher than the K content recorded with r_1 (2.17 per cent) and r_2 (2.15 per cent) which were on a par each other (Table 59).

Different frequencies of applications could not influence the total K content during 1995-96 or 1996-97 (Table 59).

None of the interaction effects (Tables 60, 61 and 62) could significantly influence the total K content of plant during 1995-96 or 1996-97.

4.1.9 Fruit Analysis

4.1.9.1 Crude protein content of fruits (%)

Main effects of the treatment are depicted in Table 67.

During 1995-96, crude protein content of fruit was maximum (21.78 per cent) with the application of 300 kg N (l_3) which was significantly superior to l_2 (250 kg N) and l_1 (200 kg N) which recorded crude protein contents 19.51 and 18.66 per cent respectively which were on a par each other. During the second year also (1996-97), same trend was observed, wherein highest crude protein content of 20.91 per cent was recorded with the application of 300 kg N ha^{-1} (l_3) which was significantly superior to l_1 (200 kg N ha^{-1}) which recorded 19.28 per cent. However the l_2 (250 kg) treatment which recorded a crude protein content of 19.78 per cent was on a par with l_1 and l_3 levels of N application (Table 67).

Different ratios of N substitution significantly influenced the crude protein content during 1995-96 although the effect was not significant during 1996-97. Highest crude protein content of 21.03 per cent was obtained when N was supplied through 2:1 organic-chemical N substitution ratio in r_3 which was significantly higher

Table 67 : Effect levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on crude protein, total P, total K,iron and ascorbic acid contents of fruits

Experiment - I

Factor	Crude protein content of fruit(%)		Total P content of fruit (%)		Total K content of fruit (%)		Iron content of fruit (%)		Ascorbic acid content of fruit (mg 100ml^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen										
l_1	18.66	19.28	1.01	1.03	6.13	6.05	0.08	0.09	145.53	148.05
l_2	19.51	19.78	1.06	1.08	6.44	6.44	0.08	0.09	143.30	148.85
l_3	21.78	20.91	1.08	1.09	6.78	6.60	0.09	0.10	115.97	125.39
$F_{2,22}$	25.15**	3.71**	1.97^{ns}	4.77*	15.47**	13.83**	1.81^{ns}	0.62^{ns}	12.45**	15.04**
Ratios										
r_1	19.21	19.71	1.05	1.03	6.29	6.24	0.08	0.09	141.76	139.77
r_2	19.71	19.43	1.01	1.07	6.53	6.33	0.08	0.10	144.98	136.47
r_3	21.03	20.83	1.09	1.09	6.54	6.52	0.08	0.09	147.56	148.06
$F_{2,22}$	8.49**	2.90^{ns}	2.61^{ns}	3.33^{ns}	2.84^{ns}	2.41^{ns}	0.85^{ns}	1.19^{ns}	2.79^{ns}	2.98^{ns}
Frequencies										
f_1	20.45	19.65	1.03	1.07	6.43	6.22	0.08	0.09	143.66	141.93
f_2	19.56	20.44	1.04	1.07	6.41	6.44	0.09	0.10	145.44	143.36
f_3	19.40	19.07	1.08	1.05	6.52	6.43	0.08	0.09	145.20	147.01
$F_{2,22}$	1.92^{ns}	0.88^{ns}	1.10^{ns}	0.53^{ns}	0.43^{ns}	2.58^{ns}	1.22^{ns}	2.40^{ns}	2.64^{ns}	5.24^{ns}
SEd	0.97	1.30	0.08	0.05	0.25	0.22	0.01	0.01	14.35	13.97
CD	0.95	1.27	-	0.04	0.25	0.21	-	-	13.56	13.24

ns - Not Significant ** Significant at 1% level *Significant at 5% level

Table 68 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on crude protein, total P, total K, iron and ascorbic acid contents of fruit

Experiment - I

Factor	Crude protein content of fruit(%)		Total P content of fruit (%)		Total K content of fruit (%)		Iron content of fruit (%)		Ascorbic acid content of fruit (mg 100ml⁻¹)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	18.71	19.20	1.03	1.02	6.03	5.86	0.08	0.09	134.94	149.05
$l_1 r_2$	18.21	18.89	0.96	1.01	6.06	6.09	0.08	0.09	159.57	138.17
$l_1 r_3$	19.05	19.75	1.04	1.05	6.30	6.19	0.08	0.09	140.60	156.97
$l_2 r_1$	18.31	20.13	1.04	1.04	6.32	6.45	0.08	0.09	139.36	154.90
$l_2 r_2$	20.11	19.09	1.06	1.11	6.57	6.28	0.09	0.10	133.96	145.11
$l_2 r_3$	20.11	20.11	1.07	1.09	6.44	6.58	0.07	0.09	166.57	146.54
$l_3 r_1$	20.62	19.79	1.08	1.05	6.53	6.39	0.09	0.10	140.98	115.36
$l_3 r_2$	20.81	20.33	1.00	1.09	6.96	6.62	0.07	0.10	141.41	120.13
$l_3 r_3$	23.93	22.62	1.17	1.13	6.88	6.79	0.09	0.09	135.51	140.68
$F_{4,22}$	3.31^{*}	1.03^{ns}	0.76^{ns}	0.82^{ns}	0.72^{ns}	0.77^{ns}	1.10^{ns}	0.40^{ns}	2.06^{ns}	2.22^{ns}
SEd	-	1.30	0.08	0.05	0.25	0.22	0.01	0.01	19.48	10.31
CD	1.64	-	-	-	-	-	-	-	-	-

ns - Not Significant   *Significant at 5% level

Table 69 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on crude protein total P, total K, iron and ascorbic acid contents of fruit

Experiment - I

Factor	Crude protein content of fruit(%)		Total P content of fruit (%)		Total K content of fruit (%)		Iron content of fruit (%)		Ascorbic acid content of fruit (mg 100ml^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	18.52	19.23	0.98	1.03	6.08	5.84	0.08	0.09	149.30	147.98
$l_1 f_2$	18.34	19.78	1.00	1.03	6.03	6.13	0.09	0.10	154.89	148.23
$l_1 f_3$	19.11	18.83	1.05	1.02	6.29	6.19	0.07	0.09	140.91	167.98
$l_2 f_1$	20.36	18.95	1.04	1.08	6.60	6.42	0.08	0.08	142.03	152.53
$l_2 f_2$	19.29	19.84	1.03	1.10	6.41	6.41	0.08	0.10	134.97	148.76
$l_2 f_3$	18.88	20.54	1.10	1.06	6.31	6.49	0.08	0.09	152.90	145.27
$l_3 f_1$	22.47	20.77	1.06	1.12	6.61	6.41	0.08	0.09	149.65	145.29
$l_3 f_2$	21.04	21.71	1.10	1.07	6.81	6.77	0.09	0.10	136.46	133.09
$l_3 f_3$	21.84	20.85	1.09	1.08	6.95	6.62	0.09	0.10	141.80	135.99
$F_{4,22}$	1.05^{ns}	1.81^{ns}	0.20^{ns}	0.51^{ns}	1.50^{ns}	0.70^{ns}	2.64^{ns}	0.40^{ns}	1.89^{ns}	2.39^{ns}
SEd	0.97	1.30	0.08	0.05	0.25	0.22	0.01	0.01	19.48	10.31

ns - Not Significant

Table 70 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on crude protein, total P, total K, iron and ascorbic acid contents of fruit

Experiment - I

Factor	Crude protein content of fruit(%)		Total P content of fruit (%)		Total K content of fruit (%)		Iron content of fruit (%)		Ascorbic acid content of fruit (mg 100ml^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	19.83	19.10	1.02	1.05	6.13	6.15	0.08	0.08	138.53	131.19
$r_1 f_2$	18.66	20.66	1.05	1.04	6.25	6.23	0.09	0.10	143.50	136.54
$r_1 f_3$	19.15	19.36	1.08	1.01	6.49	6.34	0.08	0.09	143.26	151.59
$r_2 f_1$	20.77	19.34	1.00	1.07	6.63	6.36	0.08	0.09	143.62	130.06
$r_2 f_2$	18.81	19.51	1.02	1.09	6.47	6.34	0.09	0.10	169.57	139.91
$r_2 f_3$	19.54	19.45	1.00	1.05	6.50	6.29	0.08	0.09	131.75	133.43
$r_3 f_1$	20.74	20.51	1.06	1.11	6.53	6.16	0.08	0.08	128.83	134.55
$r_3 f_2$	21.21	21.16	1.06	1.07	6.53	6.74	0.08	0.09	153.24	153.63
$r_3 f_3$	21.14	20.82	1.17	1.09	6.56	6.66	0.09	0.09	140.61	156.01
$F_{4,22}$	1.23^{ns}	0.27^{ns}	0.59^{ns}	0.34^{ns}	0.73^{ns}	1.81^{ns}	2.49^{ns}	2.02^{ns}	2.64^{ns}	1.27^{ns}
SEd	0.97	1.30	0.08	0.05	0.25	0.22	0.01	0.01	19.48	10.31

ns - Not Significant

than the protein content recorded with r_2 (1:2) ratio (19.71 per cent) and r_1 (1:1) ratio (19.21 per cent) although r_2 and r_1 did not vary each other (Table 67).

Different frequencies of application had no effect on crude protein content of fruits during 1995-96 or 1996-97 (Table 67).

The L x R interaction (Table 68) did influence the crude protein content during 1995-96 although it did not have any effect during 1996-97. Maximum crude protein content of 23.93 per cent was recorded when 300 kg N was applied through 2:1 N substitution ratio in l_3r_3 when compared to the application of lowest level of N (200 kg) through 2:1 ratio (l_1r_3) producing 19.05 per cent crude protein content or through 1:2 ratio (l_1r_2) with 18.21 per cent crude protein content or through 1:1 ratio (l_1r_1) producing 18.71 per cent crude protein contents in fruits.

The LxF (Table 69) or RxF (Table 70) interactions had no influence on crude protein content of bitter gourd fruits during 1995-96 or 1996-97.

4.1.9.2 Total P content of fruits (%)

Different levels of N application did not have any influence on the total P content of fruits during 1995-96 (Table 67). However during 1996-97, increasing levels of N increased the P content of fruits and was maximum (1.09 per cent) with the application of 300 kg N (l_3) which was significantly superior to the total P content obtained with the application of 200 kg N (1.03 per cent). However the 250 kg N treatment (l_2) which recorded a total P content of 1.08 per cent did not vary from l_3 treatment.

Different ratios of N substitution or frequencies of application did not have any effect on total P content of fruits during 1995-96 and 1996-97 (Table 67).

As indicated by Tables 68, 69 and 70, the LxR or LxF or RxF interactions could not influence the total P content of fruits during 1995-96 or 1996-97.

4.1.9.3 Total K content of fruits (%)

During 1995-96, different levels of N application significantly influenced the total K content of fruits (Table 67). Application of 300 kg N ha^{-1} (l_3) recorded a total K content of 6.78 per cent which was significantly superior to l_2 treatment (6.44 per cent) which inturn was significantly higher than the total K content resulted (6.13 per cent) with the application of lowest level or 200 kg N ha^{-1}. During 1996-97 also, total K content in fruits was higher (6.60 per cent) with the application of 300 kg N (l_3) which was significantly superior to 6.05 per cent total K content recorded with the application of 200 kg N (l_1). However the 250 kg N treatment (l_2) which resulted in a total K content of 6.44 per cent was on a par with l_3 treatment.

Different ratios of substitution (R) or frequencies of application (F) could not influence the total K content of bitter gourd fruits during 1995-96 or 1996-97 (Table 67).

The L x R interaction (Table 68) or LxF interaction (Table 69) or RxF interaction (Table 70) did not influence the total K content of bitter gourd fruits during 1995-96 or 1996-97.

4.1.9.4 Iron content of fruits (%)

Different levels of N, ratios of N substitution or frequencies of N application did not influence the iron content of bitter gourd fruits during 1995-96 and 1996-97 (Table 67).

The LxR (Table 68), LxF (Table 69) or RxF (Table 70) interactions too could not influence the iron content of fruits during 1995-96 and 1996-97.

4.1.9.5 Ascorbic acid content of fruits (mg 100 ml^{-1})

As depicted in Table 67, ascorbic acid content of bitter gourd fruits was influenced by different levels of N application. During 1995-96, when N level was raised from 200 (l_1) or 250 (l_2) kg N ha^{-1} to 300 kg N ha^{-1} (l_3), the ascorbic acid content of fruits significantly reduced to 115.97 mg 100 ml^{-1} with l_3, wherein 145.53 and 143.30 mg 100 ml^{-1} were the ascrobic acid contents recorded with l_1 and l_2 treatments respectively. During 1996-97 also similar trend was noticed wherein the ascorbic acid content of fruits was reduced to 125.39 mg 100 ml^{-1} when 300 kg N (l_3) was applied as compared to l_2 (148.85 mg 100 ml^{-1}) or l_1 (148.05 mg 100 ml^{-1}) treatments.

Different ratios of organic-chemical N substitution or different frequencies of application had no influence on ascorbic acid content of fruits during 1995-96 or 1996-97 (Table 67).

None of the interaction effects could significantly influence the ascorbic acid content of fruits during both the years of field experimentation (Tables 68, 69 and 70).

4.1.10 Soil Biological properties

4.1.10.1 Soil Bacterial Population ($1x10^8$ g^{-1})

Effect of different levels of nitrogen, its ratios of substitution and frequencies of application are depicted in Table 75.

During 1995-96, different levels of N application significantly influenced the soil bacterial population and population build up increased with increasing levels of N and the population count was higher than the initial value of 11.9 ($1x10^8$ g^{-1}). Application of highest level of N or l_3 (300 kg) recorded the soil bacterial population of 16.38 ($1x10^8$ g^{-1}) which was significantly higher than the population build up when 250 kg N or l_2 was applied ie. 15.64 ($1x10^8$ g^{-1}). The soil bacterial population was minimum when lowest level of N (200 kg N) was applied ie. 13.21 (1×10^8 g^{-1}). Different levels of nitrogen application however did not influence the soil bacterial population during 1996-97.

Different ratios of N substitution significantly influenced the soil bacterial population during 1995-96 and was significantly higher when N was supplied through 2:1 organic- chemical N substitution ratio which resulted in a bacterial population of 16.30 ($1x10^8$ g^{-1}) which was significantly higher than the bacterial population recorded with 1:1 ratio of N substitution ie. 14.76 ($1x10^8$ g^{-1}). Application of fertiliser source in greater proportion (1:2 N substitution ratio) resulted in lower bacterial population of 14.13 ($1x10^8$ g^{-1}) compared to other two treatments. During the succeeding year (1996-97), soil bacterial population was unaffected by ratios of N substitution (Table 75).

Table 75 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on soil microbial population

Experiment - I

Factor	Soil bacterial population (1×10^8 g^{-1})		Soil fungal population (1×10^4 g^{-1})		Soil actinomycetes population (1×10^6 g^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
<u>Nitrogen</u>						
l_1	13.21(3.77)	15.97(4.12)	77.14(8.84)	62.20(7.95)	1.75(1.66)	2.40(1.84)
l_2	15.64(4.08)	16.55(4.19)	76.61(8.81)	59.06(7.75)	1.78(1.67)	2.42(1.85)
l_3	16.38(4.17)	16.89(4.24)	68.88(8.36)	58.90(7.74)	1.73(1.65)	2.44(1.86)
$F_{2,22}$	98.08^{**}	1.32^{ns}	14.82^{**}	1.30^{ns}	2.23^{ns}	2.77^{ns}
<u>Ratios</u>						
r_1	14.76(3.97)	16.22(4.15)	75.21(8.73)	63.84(7.99)	1.68(1.64)	2.49(1.87)
r_2	14.13(3.89)	16.64(4.20)	72.61(8.58)	59.37(7.77)	1.85(1.69)	2.53(1.88)
r_3	16.30(4.16)	16.64(4.20)	74.69(8.70)	57.98(7.68)	2.13(1.77)	2.42(1.85)
$F_{2,22}$	42.66^{**}	0.33^{ns}	1.33^{ns}	2.34^{ns}	4.23^{*}	0.46^{ns}
<u>Frequencies</u>						
f_1	15.56(4.07)	16.13(4.14)	73.82(8.65)	60.46(7.84)	1.68(1.64)	2.42(1.85)
f_2	14.76(3.97)	16.13(4.14)	74.16(8.67)	59.99(7.81)	1.85(1.69)	2.53(1.88)
f_3	14.84(3.98)	17.23(4.27)	74.34(8.69)	59.52(7.78)	2.13(1.77)	2.49(1.87)
$F_{2,22}$	5.89^{**}	2.57^{ns}	0.05^{ns}	0.10^{ns}	0.73^{ns}	0.36^{ns}
SEd	-	0.14	0.2	0.31	0.10	0.07
CD	0.06	-	0.2	-	0.09	–

ns - Not Significant   ** Significant at 1% level   * Significant at 5% level   ( ) Transformed mean

Table - 76 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on soil microbial population.

Experiment I

Factor	Soil bacterial population (1×10^8 g^{-1})		Soil fungal population (1×10^4 g^{-1})		Soil actinomycetes population (1×10^6 g^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	12.46 (3.67)	15.56 (4.07)	76.08 (8.78)	66.56 (8.22)	1.25 (1.50)	2.13 (1.77)
$l_1 r_2$	14.36 (3.92)	16.55 (4.19)	77.32 (8.85)	60.30 (7.83)	1.85 (1.69)	2.20 (1.79)
$l_1 r_3$	12.83 (3.72)	15.97 (4.12)	77.85 (8.88)	59.68 (7.79)	2.16 (1.78)	2.27 (1.81)
$l_2 r_1$	14.84 (3.98)	16.22 (4.15)	79.10 (8.95)	59.99 (7.82)	1.92 (1.71)	2.61 (1.90)
$l_2 r_2$	16.72 (4.21)	17.06 (4.25)	72.62 (8.58)	60.46 (7.84)	1.72 (1.65)	2.49 (1.87)
$l_2 r_3$	15.40 (4.05)	16.47 (4.18)	78.03 (8.89)	56.50 (7.58)	1.72 (1.65)	2.16 (1.78)
$l_3 r_1$	17.23 (4.27)	16.97 (4.24)	70.23 (8.44)	61.72 (7.93)	1.92 (1.71)	2.80 (1.95)
$l_3 r_2$	14.13 (3.89)	16.30 (4.16)	68.05 (8.31)	57.06 (7.63)	2.02 (1.74)	2.92 (1.98)
$l_3 r_3$	17.92 (4.35)	17.57 (4.31)	68.55 (8.34)	57.67 (7.67)	2.45 (1.87)	2.76 (1.94)
$F_{4,22}$	12.71^{**}	0.73^{ns}	1.01^{ns}	0.44^{ns}	2.77^{ns}	0.95^{ns}
SEd	—	0.14	0.20	0.31	0.10	0.07
CD	0.11	—	—	—	—	—

ns - Not Significant

** - Significant at 1% level

( ) - Transformed mean

Table - 77 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on soil microbial population

Experiment I

Factor	Soil bacterial population (1×10^8 g^{-1})		Soil fungal population (1×10^4 g^{-1})		Soil actinomycetes population (1×10^6 g^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	12.61 (3.69)	15.00 (4.00)	76.08 (8.78)	62.04 (7.94)	1.72 (1.65)	2.02 (1.74)
$l_1 f_2$	14.21(3.90)	15.89 (4.11)	77.85 (8.88)	65.42 (8.15)	1.78 (1.67)	2.27 (1.81)
$l_1 f_3$	12.83 (3.72)	17.23 (4.27)	77.32 (8.85)	61.09 (7.88)	1.72 (1.65)	2.34 (1.83)
$l_2 f_1$	15.24 (4.03)	16.47 (4.18)	78.03 (8.89)	58.59 (7.72)	1.68 (1.64)	2.45 (1.86)
$l_2 f_2$	16.30 (4.16)	15.97 (4.12)	74.86 (8.71)	59.84 (7.80)	1.89 (1.70)	2.57 (1.89)
$l_2 f_3$	15.40 (4.05)	17.31 (4.28)	76.79 (8.82)	59.52 (7.78)	1.78 (1.67)	2.24 (1.80)
$l_3 f_1$	16.55 (4.19)	16.97 (4.24)	67.72 (8.29)	60.93 (7.87)	2.16 (1.78)	2.80 (1.95)
$l_3 f_2$	16.05 (4.13)	16.47 (4.18)	70.06 (8.43)	55.10 (7.49)	2.31 (1.82)	2.72 (1.93)
$l_3 f_3$	16.38 (4.17)	17.31 (4.28)	69.22 (8.38)	57.82 (7.67)	1.95 (1.72)	2.96 (1.99)
$F_{4, 22}$	4.07^{*}	0.62^{ns}	0.53^{ns}	0.33^{ns}	0.29^{ns}	1.05^{ns}
SEd	—	0.14	0.20	0.31	0.10	0.07
CD	0.11	—	—	—	—	—

ns - Not Significant

* - Significant at 5% level

( ) - Transformed mean

Table - 78 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on soil microbial population.

Experiment I

Factor	Soil bacterial population (1 x 10^8 g^{-1})		Soil fungal population (1 x 10^4 g^{-1})		Soil actinomycetes population (1 x 10^6 g^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	14.76 (3.97)	16.13 (4.14)	73.30 (8.62)	62.04 (7.94)	1.43 (1.56)	2.42 (1.85)
$r_1 f_2$	15.16 (4.02)	15.48 (4.06)	75.91 (8.77)	65.42 (8.15)	1.85 (1.69)	2.53 (1.88)
$r_1 f_3$	14.44 (3.93)	17.06 (4.26)	76.26 (8.79)	61.09 (7.88)	1.78 (1.67)	2.57 (1.89)
$r_2 f_1$	15.89 (4.11)	15.81 (4.10)	72.78 (8.59)	58.59 (7.72)	2.16 (1.78)	2.42 (1.85)
$r_2 f_2$	13.59 (3.83)	16.54 (4.20)	72.61 (8.58)	59.84 (7.80)	1.89 (1.70)	2.68 (1.92)
$r_2 f_3$	15.48 (4.06)	17.49 (4.30)	72.27 (8.56)	59.52 (7.78)	1.56 (1.60)	2.49 (1.87)
$r_3 f_1$	17.40 (4.30)	16.38 (4.17)	75.38 (8.74)	60.93 (7.87)	2.02 (1.74)	2.42 (1.85)
$r_3 f_2$	14.05 (3.88)	16.30 (4.16)	73.99 (8.66)	55.10 (7.49)	2.24 (1.80)	2.34 (1.83)
$r_3 f_3$	14.60 (3.96)	17.23 (4.27)	74.51 (8.70)	57.82 (7.67)	2.13 (1.77)	2.45 (1.86)
$F_{4,22}$	5.18^{**}	0.31^{ns}	0.34^{ns}	0.85^{ns}	1.91^{ns}	0.32^{ns}
SEd	—	0.14	0.20	0.31	0.10	0.07
CD	0.06	—	—	—	—	—

ns - Not Significant

** - Significant at 1% level

( ) - Transformed mean

Different frequencies of application significantly influenced the soil bacterial population only during 1995-96 wherein higher soil bacterial population of 15.56 ($1x10^8$ g^{-1}) was recorded with f_1 frequency which was significantly higher than that obtained with f_2 frequency [14.76 ($1x10^8$ g^{-1})] or f_3 frequency [14.84 ($1x10^8$ g^{-1})] although the f_2 was on a par with f_3 (Table 75).

The LxR interaction (Table 76) significantly influenced the soil bacterial population during 1995-96. Application of highest level of N (300 kg) through 2:1 organic-chemical N substitution ratio in l_3r_3 treatment combination resulted in significantly higher soil bacterial population of 17.92 ($1x10^8$ g^{-1}) compared to all other treatment combinations. The lowest bacterial population of 12.46 ($1x10^8 g^{-1}$) was recorded with the application of 200 kg N through 1:1 substitution ratio in l_1r_1 combination. However these effects were not significant during the succeeding year of 1996-97.

The LxF interaction significantly influenced the soil bacterial population during 1995-96 (Table 77). The population build up was higher with the application of 300 kg N with full basal application of organic source and fortnightly split application of chemical N source (l_3f_1) which resulted in maximum soil bacterial population of 16.55 ($1x10^8$ g^{-1}). Lowest soil bacterial population of 12.61 ($1x10^8$ g^{-1}) was recorded with the application of 200 kg N through f_1 frequency (l_1f_1). The LxF interaction had no influence on soil bacterial population during 1996-97.

The RxF interaction significantly influenced the soil bacterial population during 1995-96 (Table 78). When nutrient N was supplied through 2:1 organic-chemical N substitution ratio with organic source fully applied as basal dose and fertiliser source in equal splits at fortnightly intervals (r_3f_1), more soil bacterial population of 17.40 ($1x10^8$ g^{-1}) was recorded which was higher than all other treatment combinations. The population count was minimum ie. 13.59 ($1x10^8$ g^{-1}) when nutrient N was supplied though 1:2 organic- chemical N substitution ratio at f_2 frequency. Soil bacterial population was unaffected by R x F interaction during 1996-97.

4.1.10.2 Soil Fungal Population ($1x10^4$ g^{-1})

Effects of different levels of N, ratios of N substitution and frequencies of application on soil fungal population are depicted in Table 75. During 1995-96, increasing levels of N had a depressing effect on soil fungal population although it did not have any influence during 1996-97. Higher fungal population was noticed with the application of lowest level of N (200 kg)which recorded a count of 77.14 ($1x10^4$ g^{-1}) which was further reduced to 76.61 and 68.88 ($1x10^4$ g^{-1}) as the N level was enhanced to 250 and 300 kg N ha^{-1} respectively.

Different ratios of N substitution or frequencies of application did not influence the soil fungal population during 1995-96 or 1996-97 (Table 75).

The LxR (Table 76), LxF (Table 77) or RxF (Table 78) interactions could not influence the soil fungal population during 1995-96 or 1996-97.

4.1. 10.3 Soil Actinomycetes Population ($1x10^6$ g^{-1})

As depicted in Table 75, different levels of N application did not influence the soil actinomycetes population during 1995-96 or 1996-97.

Different ratios of substitution significantly influenced the soil actinomycetes population during 1995-96 wherein the population was significantly higher [(2.13 ($1x10^6$ g^{-1})] with 2:1 organic-chemical N substitution ratio (r_3) compared to 1:2 ratio (r_2) or 1:1 ratio (r_1) which produced 1.85 and 1.68 (1×10^6 g^{-1}) soil actinomycetes population respectively and population count in general was higher than the initial value of $1x10^6$ g^{-1}. During 1996-97 these effects were not significant.

Different frequencies of application had no influence on soil actinomycetes population (Table 75) during 1995-96 or 1996-97. Various interaction effects (Tables 76, 77 and 78) had not influenced the soil actinomycetes population during 1995-96 or 1996-97.

4.1.11 Soil physico-chemical properties

4.1.11.1 Soil Reaction (pH)

Main effects of levels, ratios of substitution or frequencies of application are indicated in Table 83.

Different levels of N did not influence the soil reaction during 1995-96 or 1996-97.

Different ratios of N substitution however modified the soil reaction during 1995-96 wherein the 1:1 substitution ratio produced the higher pH of 5.65 which did not differ from the pH recorded with 2:1 ratio (5.64) and it was reduced to 5.53 when 1:2 N substitution ratio was followed. All the treatments produced

Table - 83 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on physico chemical properties of soil.

Experiment I

Factor	Bulk density ($g\ cc^{-1}$)		Water holding capacity (%)		Particle density ($g\ cc^{-1}$)		Porosity (%)		Soil reaction (pH)		Organic carbon content (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
<u>Nitrogen</u>												
l_1	1.29	1.29	33.70	34.75	2.87	2.82	43.94	43.12	5.57	5.57	0.72	0.75
l_2	1.29	1.29	33.94	35.57	2.93	2.82	43.61	45.48	5.64	5.66	0.75	0.83
l_3	1.27	1.27	34.44	34.45	2.89	2.89	43.33	46.68	5.62	5.56	0.78	0.83
$F_{2,22}$	1.91^{ns}	1.91^{ns}	2.35^{ns}	1.33^{ns}	0.68^{ns}	2.58^{ns}	0.76^{ns}	13.72**	3.28^{ns}	2.73^{ns}	1.65^{ns}	1.28^{ns}
<u>Ratios</u>												
r_1	1.29	1.29	33.21	34.86	2.90	2.82	43.51	44.40	5.65	5.65	0.77	0.89
r_2	1.31	1.31	33.11	33.75	2.90	2.89	42.32	44.74	5.53	5.48	0.73	0.76
r_3	1.25	1.26	34.76	3616	2.89	2.80	45.05	46.14	5.64	5.65	0.74	0.94
$F_{2,22}$	25.52**	30.25**	6.62**	5.83**	0.01^{ns}	4.47*	14.99**	3.54*	9.10**	7.53**	0.73^{ns}	8.40**
<u>Frequencies</u>												
f_1	1.28	1.28	32.82	34.77	2.87	2.78	43.21	44.56	5.68	5.53	0.87	1.01
f_2	1.29	1.29	32.39	34.72	2.86	2.86	42.79	45.52	5.54	5.50	0.69	0.77
f_3	1.28	1.29	35.88	35.27	2.96	2.89	44.88	45.19	5.60	5.55	0.69	0.72
$F_{2,22}$	2.13^{ns}	1.29^{ns}	28.14**	0.37^{ns}	2.58^{ns}	5.66*	9.79**	1.00^{ns}	10.26**	2.28ns	19.18**	48.01**
SEd	0.02	0.01	1.02	1.50	0.10	0.07	1.06	1.47	0.07	0.10	0.07	0.07
CD	0.02	0.01	1.05	1.47	—	0.07	1.04	1.43	0.06	0.10	0.07	0.07

ns - Not Significant   * - Significant at 5% level   ( ) - Transformed mean

** - Significant at 1% level

Table - 84 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on physico-chemical properties of soil

Experiment I

Factor	Bulk density (g cc^{-1})		Water holding capacity (%)		Particle density (g cc^{-1})		Porosity (%)		Soil reaction (pH)		Organic carbon content (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	1.29	1.30	31.58	35.32	2.79	2.77	42.90	42.37	5.60	5.58	0.83	0.67
$l_1 r_2$	1.28	1.31	33.60	32.67	2.88	2.87	42.97	43.22	5.45	5.45	0.73	0.75
$l_1 r_3$	1.28	1.29	35.93	36.25	2.94	2.82	45.95	43.76	5.65	5.67	0.69	0.62
$l_2 r_1$	1.28	1.28	34.99	35.10	3.04	2.79	42.41	45.52	5.72	5.78	0.81	0.92
$l_2 r_2$	1.33	1.33	30.84	30.26	2.90	2.88	41.48	44.46	5.57	5.52	0.69	0.61
$l_2 r_3$	1.24	1.28	33.01	35.33	2.84	2.81	43.95	46.44	5.65	5.68	0.75	0.84
$l_3 r_1$	1.28	1.30	33.08	34.15	2.86	2.83	42.22	45.29	5.63	5.58	0.69	0.89
$l_3 r_2$	1.31	1.30	34.91	32.31	2.92	2.94	42.50	46.54	5.58	5.48	0.76	0.83
$l_3 r_3$	1.23	1.21	35.95	36.90	2.89	2.89	45.26	48.20	5.63	5.60	0.88	1.07
$F_{4,22}$	6.78**	10.65**	10.23**	3.20*	2.44^{ns}	0.06^{ns}	9.79**	0.74^{ns}	1.49^{ns}	0.86^{ns}	7.45**	9.35**
SEd	–	–	–	–	0.10	0.07	–	1.47	0.07	0.10	–	–
CD	0.03	0.02	1.83	2.54	–	–	1.80	–	–	–	0.12	0.11

ns - Not Significant

** - Significant at 1% level

* - Significant at 5% level

Table - 85 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on physico - chemical properties of soil.

Experiment I

Factor	Bulk density ($g\ cc^{-1}$)		Water holding capacity (%)		Particle density ($g\ cc^{-1}$)		Porosity (%)		Soil reaction (pH)		Organic carbon content (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	1.28	1.29	32.74	34.13	2.83	2.73	43.43	42.80	5.58	5.62	0.87	0.95
$l_1 f_2$	1.29	1.31	33.99	33.69	2.89	2.90	44.61	43.82	5.52	5.57	0.62	0.57
$l_1 f_3$	1.29	1.30	34.39	36.42	2.90	2.83	43.78	42.74	5.60	5.62	0.68	0.71
$l_2 f_1$	1.29	1.29	31.17	36.55	2.90	2.75	43.23	44.60	5.77	5.88	0.78	0.89
$l_2 f_2$	1.29	1.30	31.44	34.72	2.82	2.83	42.85	45.73	5.63	5.62	0.73	0.82
$l_2 f_3$	1.29	1.29	36.23	35.44	3.06	2.89	45.76	46.11	5.53	5.68	0.74	0.77
$l_3 f_1$	1.27	1.27	34.55	33.63	2.88	2.87	41.87	46.29	5.70	5.79	0.97	1.19
$l_3 f_2$	1.30	1.26	31.74	35.77	2.87	2.84	41.90	47.02	5.48	5.42	0.72	0.91
$l_3 f_3$	1.26	1.27	37.04	33.90	2.92	2.95	45.11	46.73	5.67	5.55	0.66	0.69
$F_{4,22}$	1.60^{ns}	0.94^{ns}	6.41**	2.70^{ns}	1.19^{ns}	2.03^{ns}	4.34**	0.28^{ns}	5.08**	1.23^{ns}	3.45*	10.00**
SEd	0.02	0.01	–	1.50	0.10	0.07	–	1.47	–	0.10	–	–
CD	–	–	1.83	–	–	–	1.80	–	0.11	–	0.12	0.11

ns - Not Significant

** - Significant at 1% level

* - Significant at 5% level

Table - 86 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on physico-chemical properties of soil.

Experiment I

Factor	Bulk density (g cc^{-1})		Water holding capacity (%)		Particle density (g cc^{-1})		Porosity (%)		Soil reaction (pH)		Organic carbon content (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	1.27	1.29	33.05	34.91	2.82	2.75	43.56	41.48	5.77	5.85	0.95	1.08
$r_1 f_2$	1.31	1.31	30.67	33.96	2.88	2.81	42.17	45.54	5.58	5.52	0.59	0.69
$r_1 f_3$	1.28	1.29	35.92	35.72	2.97	2.84	45.79	46.17	5.60	5.58	0.78	0.81
$r_2 f_1$	1.28	1.29	33.29	33.75	2.85	2.81	41.21	46.26	5.57	5.55	0.87	0.90
$r_2 f_2$	1.33	1.32	33.59	34.46	2.97	2.96	43.91	45.27	5.48	5.40	0.73	0.76
$r_2 f_3$	1.31	1.32	32.47	33.03	2.88	2.92	44.83	42.70	5.55	5.50	0.60	0.58
$r_3 f_1$	1.29	1.27	32.12	35.66	2.95	2.79	44.86	45.94	5.72	5.80	0.99	0.99
$r_3 f_2$	1.26	1.26	32.91	35.75	2.73	2.81	43.28	45.76	5.57	5.58	0.75	0.86
$r_3 f_3$	1.24	1.25	39.27	37.07	2.80	2.92	47.03	48.71	5.65	5.57	0.69	0.78
$F_{4,22}$	10.23**	2.10^{ns}	15.12**	1.09^{ns}	1.64^{ns}	1.20^{ns}	9.57**	6.54**	1.10^{ns}	1.17^{ns}	5.97**	11.11**
SEd	–	0.01	–	1.50	0.10	0.07	–	–	0.07	0.10	–	–
CD	0.03	–	1.83	–	–	–	1.80	2.48	–	–	0.12	0.11

ns - Not Significant ** - Significant at 1% level higher pH value when compared to the initial value of 5.4. During 1996-97 also similar trend was observed wherein N application through an organic-chemical N ratio of 1:1 or 2:1 produced a soil pH of 5.65 which was significantly higher than the pH recorded with 1:2 ratio (5.48) as well as the initial pH (5.5); Table 83 and Table 1.

Different frequencies of application significantly influenced the soil reaction during 1995-96 wherein higher pH of 5.68 was recorded with f_1 frequency which was significantly higher than f_3 (5.60) which inturn was greater than the pH obtained with f_2 treatment (5.54). All the frequencies recorded higher pH as compared to the initial value of 5.4. Different frequencies of application however did not influence the soil reaction during 1996-97 (Table 83).

The LxR interaction (Table 84) and RxF interaction (Table 86) did not have any influence on soil reaction during 1995-96 or 1996-97.

However LxF interaction (Table 85) significantly influenced the soil reaction only during 1995-96. Soil pH was significantly higher (5.77) when 250 kg N was applied with the organic source fully as basal dose and chemical N in equal fortnightly splits in l_2f_1 combination which was on a par with l_3f_1 which resulted in a pH of 5.70 compared to the lowest pH (5.48) recorded with l_3f_2 treatment combination.

4.1.11.2 Organic carbon content of soil (%)

Influence of main effects on soil organic carbon content is depicted in Table 83.

During 1995-96 or 1996-97, different levels of N did not have any influence on organic carbon content in soil (Table 83).

Different ratios of substitution also did not influence the organic carbon content of soil during 1995-96. However, during 1996-97, supply of N through 2:1 ratio recorded maximum organic carbon content of 0.94 per cent which was almost more than 2 times the initial organic carbon content (0.40%) and was on a par with r_1 (1:1) which resulted in 0.89 per cent organic carbon content. The r_2 (1:2) ratio however recorded the lowest organic carbon content of 0.76 per cent (Table 83).

Different frequencies of application significantly influenced the organic carbon content during 1995-96 and there was almost 3 times increase as compared to the initial content of 0.29 per cent. It was markedly higher with f_1 frequency (0.87 per cent) compared to f_2 or f_3 frequencies both recording 0.69 per cent organic carbon content. During 1996-97 also organic carbon content was influenced by different frequencies of application wherein the content was higher (1.01 per cent) with the f_1 frequency which was superior to f_2 (0.77 per cent) and f_3 (0.72 per cent) which did not differ each other.

The LxR interaction is depicted in Table 84. During 1995-96, application of highest level of N (300 kg) through 2:1 N substitution ratio produced maximum organic carbon content of 0.88 per cent in l_3r_3 treatment combination which was on par with l_2r_1 and l_1r_1 which produced 0.81 and 0.83 per cent organic carbon contents respectively. During 1996-97 also maximum organic carbon content of

1.07 was obtained with l_3r_3 combination and the content was minimum (0.61 per cent) with l_2r_2 treatment combination.

The LxF interaction depicted in Table 85 shows that during 1995-96, application of highest level of N (300 kg) at f_1 frequency resulted in maximum organic carbon content of 0.97 per cent in l_3f_1 combination while the content was minimum (0.62 per cent) with l_1f_2 which was on a par with l_1f_3 (0.68 per cent) or l_3f_3 (0.66 per cent) combinations. This trend was repeated during 1996-97 wherein maximum organic carbon content of 1.19 per cent was recorded with l_3f_1 combination and minimum (0.57 per cent) with l_1f_2 combination.

The RxF interaction (Table 86) significantly influenced the organic carbon content of soil. During 1995-96, maximum organic carbon content of 0.99 per cent was recorded with r_3f_1 combination which was on a par with r_1f_1 combination (0.95 per cent). Organic carbon content was minimum (0.59 per cent) with r_1f_2 combination which did not differ from r_2f_3 (0.60 per cent). Trend was almost similar during 1996-97 also wherein r_1f_1 combination recorded the highest organic carbon content of 1.08 per cent which was on a par with r_3f_1 recording 0.99 per cent organic carbon content.

4.1.11.3 Soil Physical Properties

4.1.11.3a Bulk density (g cc^{-1})

Main effects of the treatments (L, R or F) on bulk density of soil are depicted in Table 83.

Different levels of N application could not influence the bulk density of soil during 1995-96 or 1996-97.

Different ratios of N substitution significantly influenced the soil bulk density. During the first year of experimentation, bulk density was minimum (1.25) with 2:1 (r_3) ratio, followed by r_1 (1.29) and r_2 (1.31) and all the treatments produced lower bulk densities when compared to initial value of 1.41. During the second year (1996-97) also similar trend was noticed wherein bulk density was lower when compared to initial value of 1.29. The r_3 treatment produced significantly lower bulk density (1.26) as compared to r_2 (1.31) or r_1 (1.29); Table 83.

Bulk density of soil was not influenced by different frequencies of application during 1995-96 or 1996-97 (Table 83).

As depicted in Table 84, bulk density was under the influence of LxR interaction during both the years of experimentation. During 1995-96 application of 300 kg N through 2:1 organic-chemical N ratio recorded the lowest bulk density of 1.23 in l_3r_3 combination which was on a par with l_2r_3 (1.24). Bulk density was highest (1.33) with l_2r_2 combination. Similar trend was noticed during 1996-97 too, wherein l_3r_3 combination recorded the lowest bulk density of 1.21 followed by l_2r_3 and l_2r_1 both resulting in a bulk density of 1.28. Like the previous year, bulk density was highest (1.33) with l_2r_2 combination during 1996-97 too.

The LxF interaction (Table 85) did not influence the soil bulk density during 1995-96 or 1996-97.

The RxF interaction (Table 86) significantly influenced the bulk density only during 1995-96 wherein low bulk density was observed with r_3f_3 combination (1.24) which was on a par with r_3f_2 combination which recorded a bulk density of 1.26. Bulk density was significantly higher (1.33) with the r_2f_2 combination.

4.1.11.3b Water holding capacity (%)

Main effects of L, R or F on water holding capacity of soil are depicted in Table 83.

Different N levels had no influence on water holding capacity of soil during 1995-96 or 1996-97.

Different ratios of substitution significantly influenced the water holding capacity during 1995-96, wherein application of N through 2:1 ratio of substitution in r_3 resulted in maximum water holding capacity of 34.76 per cent which was significantly higher than the same observed with r_1 (33.21) or r_2 (33.11) although r_1 and r_2 were on a par. All the ratios produced higher water holding capacity as compared to the initial value of 30.25 per cent. During 1996-97 also similar trend was noticed wherein maximum water holding capacity of 36.16 per cent was recorded with r_3 which was significantly superior to r_1 (34.86 per cent) or r_2 (33.75 per cent) which were on a par each other and higher than the initial value (32.35 per cent); Table 83.

Different frequencies of application significantly influenced the water holding capacity of soil only during 1995-96 wherein it was maximum (35.88 per cent) with the f_3 frequency compared to f_2 (32.39 per cent) and f_1 (32.82 per cent) which did not differ each other (Table 83).

The LxR interaction influencing the water holding capacity of the soil is depicted in Table 84. During 1995-96, maximum water holding capacity of 35.95 per cent was observed with the l_3r_3 combination which was on a par with l_1r_3 which recorded the value of 35.93 per cent and lowest water holding capacity of 30.84 per cent was recorded with l_2r_2 combination. During 1996-97 too nearly similar trend was noticed wherein maximum water holding capacity of 36.90 per cent was noticed with the application of l_3r_3 combination which was on a par with l_1r_3 recording a value of 36.25 per cent.

The LxF interaction (Table 85) significantly influenced the water holding capacity of soil during 1995-96 wherein it was maximum (37.04 per cent) with l_3f_3 combination followed by l_2f_3 (36.23 per cent) which were on a par. However water holding capacity was unaffected by LxF interaction during 1996-97.

The RxF interaction (Table 86) significantly influenced the water holding capacity of soil during 1995-96 which was maximum with r_3f_3 treatment combination (39.27 per cent) and was significantly superior to all other treatment combinations. Water holding capacity was minimum (30.67 per cent) with the r_1f_2 treatment combination. During 1996-97, water holding capacity of soil was not under the influence of RxF interaction.

4.1.11.3c Particle Density (g cc^{-1})

Effect of levels of N application, ratios of substitution and frequencies of application are depicted in Table 83.

Different levels of N application had no effect on soil particle density during 1995-96 or 1996-97.

Different ratios of substitution also did not influence the particle density during 1995-96. However during 1996-97, particle density in general was lower than the initial value of 2.95 although it was higher (2.89) with r_2 (1:2 ratio) which was significantly greater than r_1 (1:1 ratio) or r_3 (2:1 ratio) recording the values 2.82 and 2.80 respectively which were on a par each other (Table 83).

Different frequencies of application did not influence the particle density during 1995-96, although it was higher with f_3 frequency (2.89) when compared to f_2 (2.86) or f_1 (2.78) wherein f_3 and f_2 did not significantly differ each other, during 1996-97 (Table 83).

The LxR or LxF or RxF interactions (Tables 84, 85 and 86) did not significantly influence the particle density of soil during 1995-96 or 1996-97.

4.1.11.3d Porosity (%)

Effect of levels of N, its ratios of substitution or frequencies of application on porosity of soil are depicted in Table 83.

Different N levels had no influence on porosity during 1995-96. However during 1996-97 as the N level was increased from 200 to 250 kg ha^{-1}, the porosity significantly increased from 43.12 per cent to 45.48 per cent eventhough the next higher level (300 kg) did not produce significant variation in porosity (46.68 per cent).

Different ratios of substitution significantly influenced the soil porosity during 1995-96 (Table 83). Maximum soil porosity of 45.05 per cent was recorded when N was supplied through 2:1 ratio of N substitution compared to 1:1 (r_1) and 1:2 (r_2) ratios producing 43.51 per cent and 42.32 per cent soil porosity respectively. During the succeeding year of 1996-97 also similar trend was noticed wherein maximum soil porosity of 46.14 per cent was recorded with 2:1 N substitution ratio (r_3) compared to 44.74 and 44.40 per cent soil porosities registered with r_2 (1:2) and r_1 (1:1) ratios respectively although the r_2 and r_1 treatments did not differ each other.

Different frequencies of N nutrition significantly influenced the soil porosity during 1995-96, wherein it was higher (44.88 per cent) with f_3 frequency followed by f_1 (43.21 per cent) although the f_1 treatment was on a par with f_2 treatment recording 42.79 per cent soil porosity. Soil porosity was not under the influence of frequencies of N application during 1996-97 (Table 83).

The LxR interaction (Table 84) significantly influenced the soil porosity during 1995-96 although the effect was not significant during 1996-97. Application of 200 kg N through 2:1 ratio of N substitution (r_3) recorded the maximum soil porosity of 45.95 per cent in l_1r_3 which did not differ from l_3r_3 in which 300 kg N was applied though 2:1 N substitution ratio resulting in a porosity of 45.26 per cent. Soil porosity was lowest (41.48 per cent) when 250 kg N was applied though 1:2 N substitution ratio in l_2r_2.

The LxF interaction (Table 85) significantly influenced the soil porosity only during 1995-96. Maximum soil porosity (45.76 per cent) was recorded with the application of 250 kg N through f_3 in l_2f_3 combination which was on a par with l_3f_3 (300 kg N + f_3 frequency) recording 45.11 per cent soil porosity. Soil porosity was lowest when highest level of N (300 kg) was supplied through f_1 frequency (41.87 per cent) which was on a par with l_3f_2 (41.90 per cent) or l_2f_2 (42.85 per cent). The LxF interaction effect was not significant during 1996-97.

The RxF interaction (Table 86) significantly influenced the soil porosity during 1995-96 and 1996-97. During the first year, highest soil porosity of 47.03 per cent was noticed when nutrient N was supplied through 2:1 substitution ratio at f_3 frequency in r_3f_3 and lowest value was recorded (41.21 per cent) when N was supplied through 1:2 ratio of substitution at f_1 frequency. During 1996-97 also similar trend was observed wherein porosity was highest (48.71 per cent) with r_3f_3 combination although the lowest porosity was recorded with r_1f_1 combination (41.48 per cent).

4.1.12 Nutrient Balance Studies

4.1.12.1 Nitrogen balance in soil

4.1.12.1a N-uptake (kg ha^{-1})

Main effects of the treatment are depicted in Table 91.

Different levels of N significantly influenced the N-uptake during 1995-96 wherein maximum uptake of 36.64 kg ha^{-1} was recorded with the application of highest level of N (300 kg) which was significantly higher than 200 kg N level (l_1) or 250 kg N level (l_2) recording 33.66 and 30.14 kg ha^{-1} respectively, although

Table - 91 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on N-balance in soil.

Experiment I

Factor	N - Uptake by crop (kg ha^{-1})		Expected N Balance in Soil (kg ha^{-1})		Actual N Balance/Available N-content in soil (kg ha^{-1})		Net loss (-) or gain (+) of N (kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen								
l_1	33.66	39.82	351.36	360.92	193.39	263.25	-157.97	-97.67
l_2	30.14	39.39	404.88	411.36	199.14	260.81	-205.75	-150.54
l_3	36.64	43.94	448.39	456.80	197.39	299.31	-250.99	-157.49
$F_{2,22}$	3.94*	1.42^{ns}	880.26**	519.83**	1.47^{ns}	205.89**	239.19**	145.30**
Ratios								
r_1	30.53	40.58	404.49	410.16	219.17	278.58	-185.32	-131.58
r_2	32.39	40.14	402.63	410.60	175.27	262.21	-227.37	-148.40
r_3	37.52	42.42	397.51	408.32	195.48	282.59	-202.03	-125.73
$F_{2,22}$	4.87*	0.33^{ns}	4.89*	0.33^{ns}	81.99**	51.67**	49.54**	18.80**
Frequencies								
f_1	34.86	41.11	400.16	409.63	190.42	289.21	-209.74	-120.42
f_2	32.38	40.73	402.64	409.01	212.38	261.68	-190.26	-147.33
f_3	32.19	40.30	401.83	410.44	187.11	272.48	-214.72	-137.96
$F_{2,22}$	0.59^{ns}	0.12^{ns}	0.61^{ns}	0.11^{ns}	32.01**	85.21**	18.47**	25.33**
SEd	4.92	6.31	4.91	6.31	7.28	-	-	-
CD	4.81	-	4.80	6.17	7.12	4.41	8.82	7.96

ns - Not Significant

* - Significant at 5 % level

** - Significant at 1 % level

Table - 92 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on N-balance in soil

Experiment I

Factor	N - Uptake by crop ($kg\ ha^{-1}$)		Expected N Balance in Soil ($kg\ ha^{-1}$)		Actual N Balance/Available N-content in soil ($kg\ ha^{-1}$)		Net loss (-) or gain (+) of N ($kg\ ha^{-1}$)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	32.61	39.56	352.41	361.19	205.93	271.26	-216.48	-89.92
$l_1 r_2$	31.65	37.93	353.37	362.81	170.39	266.04	-182.99	-96.77
$l_1 r_3$	36.72	41.97	348.30	358.77	203.84	252.45	-144.46	-106.32
$l_2 r_1$	24.87	39.98	410.15	410.77	219.52	260.81	-190.63	-149.95
$l_2 r_2$	30.98	37.16	404.04	413.58	177.71	249.31	-226.33	-164.27
$l_2 r_3$	34.56	41.02	400.46	409.72	200.18	272.31	-200.28	-137.41
$l_3 r_1$	34.10	42.21	450.92	458.54	232.06	303.67	-218.86	-154.86
$l_3 r_2$	34.54	45.32	450.48	455.42	177.71	271.27	-272.78	-184.15
$l_3 r_3$	41.27	44.28	443.76	456.46	182.41	323.01	-261.34	-133.46
$F_{4,22}$	0.50^{ns}	0.23^{ns}	0.50^{ns}	0.24^{ns}	8.32**	41.35**	5.05*	10.87**
SEd	4.92	6.31	4.91	6.31	–	–	–	–
CD	–	–	–	–	12.33	7.63	8.82	13.79

ns - Not Significant

* - Significant at 5 % level

** - Significantat at 1% level

Table - 93 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on N-balance in soil.

Experiment I

Factor	N - Uptake by crop ($kg\ ha^{-1}$)		Expected N Balance in Soil ($kg\ ha^{-1}$)		Actual N Balance/Available N-content in soil ($kg\ ha^{-1}$)		Net loss (-) or gain (+) of N ($kg\ ha^{-1}$)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	34.90	41.41	350.12	359.33	168.82	284.33	-181.30	-75.00
$l_1 f_2$	32.08	39.01	352.94	361.73	232.07	238.86	-120.88	-122.87
$l_1 f_3$	32.00	39.04	351.03	361.70	179.27	266.56	-171.75	-95.14
$l_2 f_1$	31.45	37.61	403.57	413.13	207.50	261.34	-196.07	-151.80
$l_2 f_2$	30.60	40.62	404.42	410.12	209.07	243.56	-195.35	-166.56
$l_2 f_3$	36.37	39.93	406.66	410.81	180.84	277.54	-225.81	-133.27
$l_3 f_1$	38.23	44.32	446.79	456.42	194.95	321.96	-251.85	-134.46
$l_3 f_2$	34.47	45.56	450.55	455.18	196.00	302.63	-254.55	-152.56
$l_3 f_3$	37.21	41.93	447.81	458.81	201.23	273.36	-246.58	-185.46
$F_{4,22}$	0.22^{ns}	0.24^{ns}	0.21^{ns}	0.24^{ns}	2.36^{ns}	1.68^{ns}	1.07^{ns}	1.82^{ns}
SEd	4.92	6.31	4.91	6.31	8.33	4.35	14.37	10.12

ns - Not Significant

Table - 94 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on N- balance in soil.

Experiment I

Factor	N - Uptake by crop (kg ha^{-1})		Expected N Balance in Soil (kg ha^{-1})		Actual N Balance/Available N-content in soil (kg ha^{-1})		Net loss (-) or gain (+) of N (kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	33.21	40.30	401.82	410.44	185.54	292.70	-216.27	-117.75
$r_1 f_2$	27.89	39.46	407.13	411.29	240.95	273.36	-166.18	-137.93
$r_1 f_3$	30.49	41.98	404.53	408.76	231.02	269.70	-173.51	-139.06
$r_2 f_1$	34.00	40.74	401.02	410.00	203.84	294.79	-197.18	-115.22
$r_2 f_2$	31.42	39.88	403.60	410.86	171.44	248.79	-232.17	-162.07
$r_2 f_3$	31.75	39.80	403.28	410.94	150.53	243.04	-252.75	-167.90
$r_3 f_1$	37.37	42.30	397.65	408.44	181.89	280.15	-215.76	-128.29
$r_3 f_2$	37.84	40.85	397.18	404.89	224.75	262.90	-172.44	-141.99
$r_3 f_3$	31.34	39.12	397.68	411.62	179.80	304.72	-217.89	-106.91
$F_{4,22}$	0.27^{ns}	0.44^{ns}	0.26^{ns}	0.45^{ns}	47.33**	60.63**	30.92**	16.53**
SEd	4.92	6.31	4.91	6.31	–	–	–	–
CD	–	–	–	–	12.33	7.63	15.28	13.79

ns - Not Significant
** - Significant at 1% level

the l_2 and l_1 levels were on a par. The N levels did not produce any significant influence on N-uptake during 1996-97.

During 1995-96, N-uptake was maximum (37.52 kg ha^{-1}) when nitrogen was applied through 2:1 organic-chemical N substitution ratio in r_3 which was significantly superior to r_2 (1:2 ratio) and r_1 (1:1 ratio) recording 32.39 and 30.53 kg N ha^{-1} respectively. These effects were however not significant during 1996-97 (Table 91).

Different frequencies of application had no effect on N-uptake during 1995-96 or 1996-97 (Table 91).

The LxR interaction (Table 92) or LxF interaction (Table 93) or RxF interaction (Table 94) did not influence the N-uptake during both the years.

4.1.12.1b Expected N balance in soil (kg ha^{-1})

Main effects of the treatment on expected N balance in soil are given in Table 91.

Different levels of N application significantly influenced the expected N balance in soil. During 1995-96, it increased significantly from 351.36 kg N ha^{-1} to 404.88 kg N ha^{-1} and then to 448.39 kg N ha^{-1} as the N level was enhanced from 200 (l_1) to 250 (l_2) and 300 (l_3) kg N ha^{-1} respectively. This trend was confirmed during the succeeding year wherein expected N balance in soil was maximum (456.80 kg N ha^{-1}) with the application of l_3 (300 kg) which was significantly higher than l_2 (250 kg) or l_1 (200 kg) recording 411.36 kg and 360.92 kg N ha^{-1} respectively.

Different ratios of substitution significantly influenced the expected N balance in soil. During 1995-96 expected N balance in soil was significantly higher with r_1 (1:1) or r_2 (1:2) ratio recording 404.49 kg and 402.63 kg N ha^{-1} than r_3 (2:1) ratio which recorded 397.51 kg N ha^{-1} although the r_1 and r_2 were on a par. Different ratios of N substitution however did not influence the expected N balance during 1996-97 (Table 91).

Different frequencies of application of N did not have any effect on expected N balance in soil during 1995-96 or 1996-97 (Table 91).

Different interactions (Tables 92, 93 and 94) did not influence the expected N balance in soil during both the years of field experimentation.

4.1.12.1c Actual N balance or Available N content of soil (kg ha^{-1})

Effects of levels of nitrogen application, ratios of organic-chemical N substitution and frequencies of application on actual N balance or available N content of the soil after the conduct of experiment are depicted in Table 91.

During 1995-96, different levels of N did not influence the actual N balance of the soil. However during 1996-97, application of l_1 (200 kg N) and l_2 (250 kg N) produced 263.25 kg and 260.81 kg N ha^{-1} actual N balances respectively, which were on a par in effect. The highest level of N application in l_3 (300 kg) recorded significantly higher actual N balance of 299.31 kg which was superior to the lower levels. All the levels produced higher available nitrogen content in soil as compared to the initial status of 200.74 kg ha^{-1}.

During 1995-96, when organic and fertiliser sources of N were applied in equal proportion in 1:1 ratio of N substitution, actual N balance or available N content in soil was highest (219.17 kg) which was followed by r_3 (2:1) ratio recording 195.48 kg and r_2 (1:2) ratio recording 175.27 kg ha^{-1} expected N balances respectively. However during the succeeding year of 1996-97 the r_1 and r_3 ratios of substitution recorded higher actual N balances of 278.58 and 282.59 kg ha^{-1} respectively which did not differ each other while the actual N balance was lower (262.21 kg) with r_2 (1:2) ratio. Actual N balances in soil were markedly higher during 1996-97 compared to 1995-96 (Table 91).

Different frequencies of application had noticeable influence on actual N balance of soil during both the years. During 1995-96 it was highest (212.38 kg) with f_2 which was significantly superior to f_1 (190.42 kg) or f_3 (187.11 kg) which were on a par in effect and were higher than the initial value (185.02 kg). However during the succeeding year of 1996-97, available N content in soil was maximum (289.21 kg) with f_1 which was significantly superior to f_3 (272.48 kg) or f_2 (261.68 kg N ha^{-1}). All the frequencies of application produced substantial increases in actual N balance of soil during the second year of field experimentation compared to the first year of experimentation (Table 91).

The LxR interaction shown in Table 92 significantly influenced the actual N balance of soil during both first and second year of experimentation. During the first year (1995-96), maximum value (232.06 kg) was recorded with the application of 300 kg N through 1:1 ratio of substitution in l_3r_1 combination which was significantly superior to all other treatment combinations and actual N balance of soil was minimum (170.39 kg) with l_1r_2 combination in which 200 kg N was supplied through 1:2 N substitution ratio and was on a par with l_2r_2 (177.71 kg) or l_3r_2 (177.71 kg) or l_3r_3 (182.41 kg). During 1996-97, all the treatment combinations resulted in higher available N content in soil compared to the previous year and was maximum (323.01 kg) with l_3r_3 combination followed by l_3r_1 combination recording an actual N balance of 303.67 kg N ha^{-1}.

The LxF interaction (Table 93) could not influence the actual N balance in soil during 1995-96 or 1996-97.

The RxF interaction however significantly influenced the actual N balance in soil (Table 94). During 1995-96, application of nutrient N through 1:1 substitution ratio at f_2 frequency (basal + 40th and 70th day of application of organic source along with fortnightly split dose of chemical N source) resulted in maximum actual N balance of 240.95 kg ha^{-1} and the value was minimum (150.53 kg) with r_2f_3 combination where both organic and chemical N sources were applied as basal + fortnightly split doses through 1:2 ratio of N substitution. During 1996-97 the trend was slightly different wherein the actual N balance of soil was maximum with the application of r_3f_3 combination (304.72 kg N ha^{-1}) and was minimum (243.04 kg N ha^{-1}) with r_2f_3 combination.

4.1.12.1d The Net loss (-) or gain (+) of N (kg ha^{-1})

As shown in Table 91, different levels of N application significantly influenced the net loss (-) or gain (+) of N in soil and in general it resulted in a net loss of nutrient N Nitrogen loss significantly increased with increase in N levels and was maximum (-250.99 kg ha^{-1}) with the application of 300 kg N (l_3) which was significantly higher than the losses at l_2 (-205.75 kg) or l_1 (-157.97 kg). During 1996-97 also, similar trend was noticed wherein net loss of N was maximum (-157.49 kg) when 300 kg N (l_3 was applied although it was on a par with 250 kg N (l_2) resulting in a net loss of -150.54 kg and N-loss was minimum -97.67 kg with lowest level of N application. However, the net loss of N was reduced during 1996-97 compared to the previous year.

Different ratios of N-substitution significantly influenced the net loss of N during 1995-96 wherein the loss was maximum (-227.37 kg) with r_2 in which 1:2 ratio of N substitution was done followed by r_3 and r_1 ratios resulting in a net N loss of -202.03 kg and -185.32 kg N ha^{-1} respectively. This trend was repeatedly observed during 1996-97 wherein net loss of N was maximum (-148.40 kg) with r_2 when compared to r_1 (1:1) or r_3 (2:1) ratio recording -131.58 kg and -125.73 kg N ha^{-1} respectively.

Different frequencies of application significantly influenced the net loss of N during both the years of experimentation. During 1995-96, the net loss was higher (-214.72 kg N ha^{-1}) with f_3 frequency which was on a par with f_1 recording a net loss of -209.74 kg. Minimum net loss of N occurred with f_2 frequency (-190.26 kg). However during 1996, net loss of N was reduced with all the frequencies of N application, although it was maximum (-147.33 kg) with f_2 when compared to f_3 (-137.96 kg) or f_1 (-120.42 kg).

The LxR interaction (Table 92) significantly influenced the net loss of N during both the years of experimentation. Net loss of N was maximum (-272.78 kg) when 300 kg N was applied through 1:2 ratio of N substitution in l_3r_2 followed by l_3r_3 (-261.34 kg). Net loss of N was lowest (-144.46 kg) with l_1r_3 combination wherein 200 kg N was applied through 2:1 ratio of N substitution. During 1996-97 the net loss of N was however considerably lower although it was maximum (-184.15 kg N) with l_3r_2 combination.

The LxF interaction (Table 93) did not influence the net loss or gain of N during 1995-96 or 1996-97.

The RxF interaction (Table 94) significantly influenced the net loss or gain of N during both the years of field experimentation. During the first year of experimentation, the net loss of N was maximum (-252.75 kg) when nutrient N was applied through 1:2 ratio of substitution at f_3 frequency in r_2f_3 combination followed by r_2f_2 combination recording -232.17 kg N ha^{-1}. During 1996-97, the net loss of N was comparatively lower than previous year and the value was greater (-167.90 kg ha^{-1}) with r_2f_3 combination which was on a par with r_2f_2 recording a net loss of -162.07 kg ha^{-1}.

4.1.12.2 Phosphorus balance in Soil

4.1.12.2a P-Uptake (P_2O_5 kg ha^{-1})

Different levels of N application did not influence the P-uptake by the crop during 1995-96 or 1996-97 (Table 99).

Different ratios of organic-chemical N substitution significantly influenced the P-uptake during 1995-96 (Table 99). Maximum P-uptake of 26.14 kg. P_2O_5 ha^{-1} was obtained with r_3 (2:1) substitution ratio which was significantly higher

Table - 99 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on P - balance in soil.

Experiment I

Factor	P - Uptake by crop (P_2O_5 kg ha^{-1})		Expected P Balance in Soil (P_2O_5 kg ha^{-1})		Actual P Balance/Available P-content in soil (P_2O_5 kg ha^{-1})		Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
<u>Nitrogen</u>								
l_1	23.84	27.93	83.74	83.62	19.99	49.68	-63.74	-33.94
l_2	21.85	27.50	100.73	99.92	19.64	50.46	-81.09	-49.46
l_3	24.83	28.91	112.74	114.15	27.79	50.35	-84.95	-63.81
$F_{2,22}$	1.69^{ns}	0.30^{ns}	115.33**	133.53**	6.80**	0.06^{ns}	32.02**	69.46**
<u>Ratios</u>								
r_1	22.50	27.65	100.07	99.77	21.44	48.23	-78.63	-51.54
r_2	21.87	28.29	75.70	72.68	19.84	41.38	-55.86	-31.30
r_3	26.14	28.40	121.43	125.24	26.14	50.87	-95.29	-74.36
$F_{2,22}$	3.89*	0.09^{ns}	382.80**	395.12**	3.43^{ns}	25.52**	98.35**	157.55**
<u>Frequencies</u>								
f_1	23.50	28.48	99.07	98.87	33.05	52.15	-66.02	-46.72
f_2	22.97	27.75	99.60	99.59	16.34	46.40	-83.26	-53.19
f_3	24.04	28.11	98.53	99.23	18.03	51.93	-80.50	-47.30
$F_{2,22}$	0.21^{ns}	0.07^{ns}	0.20^{ns}	0.08^{ns}	27.10**	3.80*	21.52**	1.99^{ns}
SEd	3.51	3.97	3.51	3.97	5.30	5.02	-	5.35
CD	3.43	-	3.43	3.88	5.18	4.90	10.14	5.26

ns - Not Significant

* - Significant at 5 % level

** - Significant at 1 % level

Table 100. Interaction effect of levels nitrogen and its ratios of substitution on (LxR) P - balance in soil

Experiment II

Factor	P - Uptake by crop (P_2O_5 kg ha^{-1})		Expected P Balance in Soil (P_2O_5 kg ha^{-1})		Actual P Balance/Available P-content in soil (P_2O_5 kg ha^{-1})		Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	24.09	28.01	83.48	83.54	28.07	55.41	-55.41	-28.14
$l_1 r_2$	21.27	26.64	66.50	63.97	13.11	42.75	-53.39	-21.22
$l_1 r_3$	26.14	29.16	101.23	103.33	18.80	50.87	-82.44	-52.46
$l_2 r_1$	18.86	26.86	103.71	100.57	16.20	51.73	-87.51	-48.84
$l_2 r_2$	21.54	27.61	75.83	73.16	22.25	43.64	-53.58	-29.52
$l_2 r_3$	25.13	28.04	122.64	126.03	20.47	56.00	-102.17	-70.03
$l_3 r_1$	24.54	28.08	113.04	115.20	20.06	67.55	-92.98	-47.65
$l_3 r_2$	22.79	30.64	84.78	80.91	24.17	37.74	-60.61	-43.17
$l_3 r_3$	27.15	28.00	140.42	146.35	39.15	45.75	-101.27	-100.61
$F_{4,22}$	0.58^{ns}	0.35^{ns}	7.26**	8.15**	7.23**	2.22^{ns}	7.13**	9.45**
SEd	3.51	3.97	-	-	-	5.02	-	-
CD	-	-	5.94	6.72	8.98	-	10.14	9.11

ns - Not Significant
** - Significant at 1 % level

Table - 101 Interaction effect of levels nitrogen and its frequencies of application (LxF) on P - balance in soil.

Experiment I

Factor	P - Uptake by crop (P_2O_5 kg ha^{-1})		Expected P Balance in Soil (P_2O_5 kg ha^{-1})		Actual P Balance/Available P content in soil (P_2O_5 kg ha^{-1})		Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	24.57	29.17	83.00	82.38	28.16	48.57	-54.85	-33.82
$l_1 f_2$	22.82	26.59	84.75	84.96	16.35	50.27	-68.41	-34.69
$l_1 f_3$	24.12	28.05	83.45	83.50	15.47	50.19	-67.99	-33.31
$l_2 f_1$	21.10	26.83	101.47	100.59	26.17	52.79	-75.30	-47.80
$l_2 f_2$	21.72	28.56	100.85	98.86	15.53	43.18	-85.32	-55.68
$l_2 f_3$	22.71	27.11	99.86	100.31	17.22	55.41	-82.64	-44.90
$l_3 f_1$	24.82	29.43	112.75	113.63	44.83	55.10	-67.92	-58.53
$l_3 f_2$	24.38	28.12	113.19	114.95	17.13	45.75	-96.06	-69.20
$l_3 f_3$	25.28	29.18	112.30	114.89	21.42	50.19	-90.88	-63.70
$F_{4,22}$	0.10^{ns}	0.25^{ns}	0.10^{ns}	0.25^{ns}	2.73^{ns}	1.93^{ns}	2.23^{ns}	1.12^{ns}
SEd	3.51	3.97	3.51	3.97	5.30	5.02	5.99	5.36

ns - Not Significant

Table - 102 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on P - balance in soil.

Experiment I

Factor	P - Uptake by crop (P_2O_5 kg ha^{-1})		Expected P Balance in Soil (P_2O_5 kg ha^{-1})		Actual P Balance/Available P content in soil (P_2O_5 kg ha^{-1})		Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	22.92	28.21	99.65	99.21	32.21	57.12	-67.44	-42.10
$r_1 f_2$	21.02	25.84	101.55	101.57	20.98	58.14	-90.41	-43.43
$r_1 f_3$	23.55	28.90	99.02	98.52	21.94	59.42	-78.05	-39.10
$r_2 f_1$	22.17	28.57	75.40	72.41	23.28	46.75	-52.12	-25.65
$r_2 f_2$	22.25	27.47	75.32	73.51	19.10	33.18	-56.23	-40.33
$r_2 f_3$	21.19	28.85	76.38	72.13	17.15	44.21	-59.23	-27.92
$r_3 f_1$	25.39	28.66	122.18	124.98	43.67	52.59	-78.51	-72.40
$r_3 f_2$	25.66	29.95	121.92	123.68	18.77	47.88	-103.14	-75.80
$r_3 f_3$	27.37	26.59	120.20	127.05	15.97	52.16	-104.23	-74.89
$F_{4,22}$	0.29^{ns}	0.53^{ns}	0.30^{ns}	0.53^{ns}	5.31**	1.69^{ns}	2.15^{ns}	1.66^{ns}
SEd	3.51	3.97	3.51	3.97	-	5.02	5.99	5.36
CD	-	-	-	-	8.98	-	-	-

ns - Not Significant

** - Significant at 1 % level

than the uptakes recorded with r_2 (21.87 kg P_2O_5 ha^{-1}) or r_1 (22.50 kg P_2O_5 ha^{-1}) ratios which were on a par in effect. P-uptake was not influenced by N substitution ratios during 1996-97. Different frequencies of application had no effect on P-uptake during both the years of field trial.

The LxR (Table 100) or LxF (Table 101) or RxF interactions (Table 102) could not influence the P-uptake by crop during 1995-96 or 1996-97.

4.1.12.2b Expected P balance in soil (P_2O_5 kg ha^{-1})

Influence of main effects of the treatment on expected P balance of soil is shown in Table 99.

Different levels of N-application significantly influenced the expected P balance during both 1995-96 and 1996-97. During 1995-96, increase in levels of N from 200 to 250 and then to 300 kg ha^{-1} significantly increased the expected P balance in soil from 83.74 to 100.73 and 112.74 kg P_2O_5 ha^{-1} respectively. During 1996-97 also similar trend was noticed wherein application of highest dose (300 kg N ha^{-1}) of N in l_3 produced the maximum expected P balance of 114.15 kg P_2O_5 ha^{-1} which was significantly superior to l_2 or l_1 recording expected P balances 99.92 and 83.62 kg P_2O_5 ha^{-1} respectively.

Different ratios of substitution of N significantly influenced the expected P balance of soil during 1995-96 which was significantly higher (121.43 kg P_2O_5 ha^{-1}) with r_3 (2:1) ratio of organic - chemical N substitution than r_1 (1:1) or r_2 (1:2) ratios recording expected P balance of 100.07 and 75.70 P_2O_5 kg ha^{-1} respectively. Similar trend was observed during 1996-97 too wherein maximum expected P balance of 125.24 kg P_2O_5 ha^{-1} was observed with r_3 ratio which was significantly superior to r_1 (99.77 kg P_2O_5 ha^{-1}) or r_2 (72.68 kg P_2O_5 ha^{-1}).

The expected P-balance of soil was not under the influence of frequencies of N application during 1995-96 or 1996-97.

The LxR interaction (Table 100) significantly influenced the expected P balance of soil during both the years. During 1995-96, it was maximum (140.42 kg P_2O_5 ha^{-1}) when 300 kg N was applied through 2:1 ratio of organic-chemical N ratio of substitution in l_3r_3 combination and was minimum (66.50 kg P_2O_5 ha^{-1}) when 200 kg N applied through 1:2 ratio of substitution in l_1r_2 combination. The same trend was observed during 1996-97 too wherein highest expected P balance of 146.35 kg P_2O_5 ha^{-1} was recorded with l_3r_3 combination and lowest with l_1r_2 combination (63.97 kg P_2O_5 ha^{-1}).

The LxF (Table 101) or RxF (Table 102) interactions did not influence the expected P balance during 1995-96 or 1996-97.

4.1.12.2c Actual P balance or available P content of soil (P_2O_5 kg ha^{-1})

Effects of levels of N application, ratios of substitution and frequencies of application on actual P balance or available P content of soil are depicted in Table 99.

During 1995-96, increasing the N level from 200 kg (l_1) or 250 kg (l_2) to 300 kg (l_3) significantly increased the available P content of soil to 27.79 kg P_2O_5

ha^{-1} while the available P contents at l_1 (19.99 kg P_2O_5 ha^{-1}) or l_2 (19.64 kg P_2O_5 ha^{-1}) were on a par. These effects were not significant during 1996-97.

Different ratios of N substitution significantly influenced the actual P balance of soil only during 1996-97 (Table 99) and the balance was greater than the initial value of 23.09 kg P_2O_5 ha^{-1}. Application of nutrient N through 2:1 (r_3) ratio of organic-chemical N substitution produced significantly higher actual P balance of 50.87 kg P_2O_5 ha^{-1} than r_2 (1:2) ratio recording 41.38 kg P_2O_5 ha^{-1} though it was on a par with r_1 (1:1) ratio which produced 48.23 kg P_2O_5 ha^{-1}.

Different frequencies of N application significantly influenced the actual P balance during 1995-96 as well as 1996-97. During the first year, nitrogen nutrition through f_1 frequency recorded significantly higher actual P balance of 33.05 kg P_2O_5 ha^{-1} when compared to f_2 or f_3 frequencies recording 16.34 and 18.03 kg P_2O_5 ha^{-1} which did not differ each other. During the second year of field experimentation (1996-97), slightly different trend was noticed wherein both f_1 and f_3 frequencies produced significantly higher actual P balances of 52.15 and 51.93 kg P_2O_5 ha^{-1} respectively when compared to f_2 frequency (46.40 kg P_2O_5 ha^{-1}) and the f_1 and f_3 treatments were on a par. Actual P balance of soil showed marked increase during second year compared to the first year of experimentation.

The LxR interaction had significant influence on actual P balance of soil (Table 100). During 1995-96, the actual P balance of soil was maximum (39.15 kg P_2O_5 ha^{-1}) when 300 kg N was applied through 2:1 ratio of N substitution in l_3r_3 combination compared to all other treatment combinations. The lowest actual

P balance was observed (13.11 kg P_2O_5 ha^{-1}) with l_1r_2 combination. The LxR interaction had no influence on actual P balance of soil during 1996-97.

The LxF interaction did not influence the actual P balance of soil during 1995-96 or 1996-97 (Table 101).

The RxF interaction (Table 102) significantly influenced the actual P balance of soil during 1995-96 although it did not have any influence during 1996-97. Actual soil P balance after the crop harvest was highest (43.67 kg P_2O_5 ha^{-1}) when nutrient N was applied through 2:1 ratio of N substitution at f_1 frequency in r_3f_1 combination and it was minimum (15.97 kg P_2O_5 ha^{-1}) with r_3f_3 combination.

4.1.12.2d Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})

Main effects of treatments on net loss (-) or gain (+) of P in soil are depicted in Table 99.

During 1995-96 net loss of P was maximum (-84.95 kg P_2O_5 ha^{-1}) with l_3 (300 kg N) which was on a par with l_2 (250 kg) resulting in a net loss of -81.09 kg P_2O_5 ha^{-1} and the loss was minimum (-63.74 kg P_2O_5 ha^{-1}) with l_1 (200 kg) treatment. During 1996-97, increase in levels of N application significantly increased the net loss of P which was significantly higher with l_3 (-63.81 kg P_2O_5 ha^{-1}) when compared to l_2 (-49.46 kg P_2O_5 ha^{-1}) and was minimum (-33.94 kg P_2O_5 ha^{-1}) with lowest dose of N application (200 kg N) in l_1.

Different ratios of N substitution significantly affected the net loss or gain of P in soil during both the years of field experimentation. During the first year the net loss was significantly greater (-95.29 kg P_2O_5 ha^{-1}) with 2:1 ratio of N substitution in r_3 when compared to r_1 (-78.63 kg P_2O_5 ha^{-1}) and the net loss was minimum with r_2 (1:2) ratio of N substitution (-55.86 kg P_2O_5 ha^{-1}). Similar trend was observed during the succeeding year of 1996-97 too wherein enhancing organic - chemical N ratio from 1:1 (r_1) to 2:1 (r_2) significantly increased the net loss of P from -51.54 to -74.36 kg P_2O_5 ha^{-1} while minimum loss was recorded (-31.30 kg P_2O_5 ha^{-1}) with r_2 (1:2) ratio of N substitution.

Different frequencies of N nutrition significantly influenced the net loss or gain of P only during 1995-96 wherein basal + 2 split (f_2) applications of organic source recorded the maximum net loss of -83.26 kg P_2O_5 ha^{-1} which was on a par with net loss of P (-80.50 kg P_2O_5 ha^{-1}) recorded with basal + fortnightly split application of organic and chemical N sources in f_3 frequency. The net loss was minimum (-66.02 kg P_2O_5 ha^{-1}) with full basal organic source application in f_1.

The LxR interaction (Table 100) significantly influenced the net loss or gain of P during both the years of field experimentation. During 1995-96, the net loss was maximum (-102.17 kg P_2O_5 ha^{-1}) when 250 kg N was applied through 2:1 ratio of N substitution in l_2r_3 combination which did not differ from l_3r_3 combination recording a net loss of -101.27 kg P_2O_5 ha^{-1}. Minimum net loss was observed (-53.39 kg P_2O_5 ha^{-1}) when 200 kg N was supplied through 1:2 ratio of N substitution in l_1r_2 combination. During 1996-97 the net loss of P was maximum (-100.61 kg P_2O_5 ha^{-1}) with l_3r_3 combination (300 kg N + 2:1 ratio) and was minimum with l_1r_2 combination which recorded a net loss of -21.22 kg P_2O_5 ha^{-1} although it did not differ from l_1r_1 and l_2r_2 combinations recording net losses of -28.14 kg and -29.52 kg P_2O_5 ha^{-1} respectively.

The LxF interaction (Table 101) or RxF interaction (Table 102) could not influence the net loss or gain of P during 1995-96 or 1996-97.

4.1.12.3 K Balance in soil

4.1.12.3a K-Uptake by crop (K_2O kg ha^{-1})

Main effects of the treatments did not influence the K-uptake by crop during 1995-96 or 1996-97 (Table 107).

None of the interaction effects was significant to influence the K-uptake by crop during both the years of field experimentation (Tables 108, 109 and 110).

4.1.12.3b Expected K balance in soil (K_2O kg ha^{-1})

Main effects of the treatment are depicted in Table 107.

Increase in levels of N from 200 to 300 kg ha^{-1} significantly increased the expected K balance in soil and highest value was obtained (200.17 kg K_2O ha^{-1}) with 300 kg dose (l_3) which was significantly greater than the K balance recorded with l_2 (187.18 K_2O ha^{-1}) which inturn was superior to l_1 recording 156.49 kg K_2O ha^{-1} in soil. This trend was repeated during the succeeding year (1996-1997) wherein l_3 (300 kg) recorded the maximum expected K balance of

Table - 107 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on K - balance in soil

Experiment I

Factor	K - Uptake by crop (K_2O Kg ha^{-1})		Expected K Balance in Soil (K_2O Kg ha^{-1})		Actual K Balance/Available K content in Soil (K_2O Kg ha^{-1})		Net loss (-) or gain (+) of K (K_2O Kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen								
l_1	76.03	87.30	156.49	168.26	127.23	182.19	-39.26	+13.92
l_2	70.35	86.81	187.18	192.78	126.48	174.27	-60.70	-18.51
l_3	82.35	94.85	200.17	208.45	133.65	173.81	-66.75	-34.64
$F_{2,22}$	2.28^{ns}	1.29^{ns}	31.86^{**}	26.14^{**}	2.46^{ns}	2.84^{ns}	7.72^{**}	33.78^{**}
Ratios								
r_1	70.58	88.27	186.94	191.32	118.72	176.96	-68.22	-14.36
r_2	74.72	89.32	141.13	150.21	108.27	157.55	-32.86	+7.34
r_3	83.42	91.36	215.76	227.97	140.37	165.76	-75.63	-58.84
$F_{2,22}$	2.72^{ns}	0.16^{ns}	89.71^{**}	96.39^{**}	12.70^{**}	4.54^{*}	13.75^{**}	32.50^{**}
Frequencies								
f_1	77.57	87.84	179.95	191.65	132.91	165.01	-47.04	-26.63
f_2	74.38	89.68	183.14	189.81	113.49	163.52	-69.64	-22.92
f_3	76.78	91.45	180.74	188.04	120.96	171.73	-60.02	-16.31
$F_{2,22}$	0.17^{ns}	0.21^{ns}	0.17^{ns}	0.21^{ns}	2.54^{ns}	0.91^{ns}	3.39^{ns}	0.78^{ns}
SEd	11.92	11.89	11.92	11.89	13.78	13.72	18.49	17.75
CD	-	-	11.66	11.62	13.48	13.42	18.08	17.36

ns - Not Significant * - Significant at 5 % level ** - Significant at 1% level

Table - 108 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on K-balance in soil.

Experiment I

Factor	K - Uptake by crop (K_2O Kg ha^{-1})		Expected K Balance in Soil (K_2O Kg ha^{-1})		Actual K Balance/Available K content in Soil (K_2O Kg ha^{-1})		Net loss (-) or gain (+) of K (K_2O Kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	73.19	85.55	159.33	170.01	132.16	206.08	-27.17	+36.07
$l_1 r_2$	71.06	85.10	128.47	138.73	96.32	170.24	-32.15	+31.52
$l_1 r_3$	83.85	91.24	181.67	196.06	123.20	170.24	-58.47	-25.82
$l_2 r_1$	60.45	86.55	197.07	193.06	118.72	165.76	-78.35	-27.28
$l_2 r_2$	70.46	83.52	145.07	155.70	112.00	172.48	-33.07	+16.79
$l_2 r_3$	80.13	90.37	219.39	229.61	118.72	154.56	-100.67	-64.94
$l_3 r_1$	78.13	92.73	204.41	210.91	105.28	159.04	-99.13	-51.87
$l_3 r_2$	82.66	99.35	149.86	156.22	116.48	129.92	-33.38	-26.30
$l_3 r_3$	86.28	92.48	246.24	258.24	179.20	172.48	-67.75	-85.76
$F_{4,22}$	0.34^{ns}	033^{ns}	2.68^{ns}	2.73^{ns}	9.04**	5.57**	4.32**	1.61^{ns}
SEd	11.92	11.89	11.92	11.89	-	-	-	17.75
CD	-	-	-	-	23.35	23.24	31.31	-

ns - Not Significant

** - Significant at 1% level

Table - 109 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on K - balance in soil

Experiment I

Factor	K - Uptake by crop (K_2O Kg ha^{-1})		Expected K Balance in Soil (K_2O Kg ha^{-1})		Actual K Balance/Available K content in Soil (K_2O Kg ha^{-1})		Net loss (-) or gain (+) of K (K_2O Kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	79.18	87.99	153.35	167.57	127.68	188.16	-25.67	+20.59
$l_1 f_2$	72.59	83.82	159.94	171.74	114.24	183.68	-45.70	+11.94
$l_1 f_3$	76.34	90.08	156.18	165.48	109.76	174.72	-46.42	+9.24
$l_2 f_1$	71.69	82.22	185.83	197.37	138.88	159.04	-46.95	-38.33
$l_2 f_2$	71.16	89.66	186.36	189.93	107.52	165.76	-78.84	-14.06
$l_2 f_3$	68.19	88.55	189.34	191.04	103.04	168.00	-86.30	-23.04
$l_3 f_1$	81.84	93.30	200.68	210.01	132.16	147.84	-68.52	-62.17
$l_3 f_2$	79.41	95.54	203.11	207.76	118.72	141.12	-84.39	-66.64
$l_3 f_3$	85.81	95.71	196.72	207.59	140.08	172.48	-57.35	-35.11
$F_{4,22}$	0.18^{ns}	0.19^{ns}	0.18^{ns}	0.19^{ns}	2.38^{ns}	2.26^{ns}	2.35^{ns}	1.88^{ns}
SEd	11.92	11.89	11.92	11.89	22.35	13.72	18.49	17.75

ns - Not Significant

Table - 110 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on K - balance in soil.

Experiment I

Factor	K - Uptake by crop (K_2O Kg ha^{-1})		Expected K Balance in Soil (K_2O Kg ha^{-1})		Actual K Balance/Available K content in Soil (K_2O Kg ha^{-1})		Net loss (-) or gain (+) of K (K_2O Kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	72.02	87.17	185.50	192.42	138.88	168.00	-46.62	-24.42
$r_1 f_2$	65.70	82.36	191.82	197.24	103.04	192.64	-88.78	-4.60
$r_1 f_3$	74.03	95.29	183.50	184.30	114.24	170.24	-69.26	-14.06
$r_2 f_1$	76.89	89.81	138.97	149.73	112.00	161.28	-26.97	+11.55
$r_2 f_2$	73.89	86.70	141.97	152.83	100.80	145.60	-41.17	-7.23
$r_2 f_3$	73.40	91.46	142.46	148.08	112.0	165.76	-30.46	+17.69
$r_3 f_1$	83.80	86.53	215.38	232.80	147.84	165.76	-67.54	-67.04
$r_3 f_2$	83.56	99.97	215.63	219.36	136.64	152.32	-78.99	-56.93
$r_3 f_3$	82.90	87.59	216.28	231.74	136.64	179.20	-80.36	-52.54
$F_{4,22}$	0.15^{ns}	1.00^{ns}	0.15^{ns}	1.00^{ns}	1.04^{ns}	3.35^{*}	0.72^{ns}	1.14^{ns}
SEd	11.92	11.89	11.92	11.89	13.79	-	18.49	17.75
CD	-	-	-	-	-	23.24	-	-

ns - Not Significant

* - Significant at 5 % level

208.45 kg K_2O ha^{-1} which was superior to l_2 (192.78 kg K_2O ha^{-1}) and l_1 (168.26 kg K_2O ha^{-1}).

Different ratios of organic-chemical N substitution influenced the expected K balance during both the years of field experimentation. During 1995-96, the expected K balance was significantly higher with r_3 (2:1) ratio of substitution (215.76 kg K_2O ha^{-1}) when compared to r_1 (1:1) ratio recording a K balance of 186.94 kg and r_2 (1:2) ratio registering 141.13 kg K_2O ha^{-1}. During the succeeding year also similar result was obtained wherein the expected K balance in soil was maximum (227.97 kg K_2O ha^{-1}) with r_3 (2:1) in comparison with r_1 (191.32 kg K_2O ha^{-1}) or r_2 (150.21 kg K_2O ha^{-1}); Table 107.

The expected K balances of soil during 1995-96 and 1996-97 were unaffected by frequencies of N application (Table 107).

Various interaction effects (Tables 108, 109 and 110) had no influence on expected K balances of soil during 1995-96 or 1996-97.

4.1.12.3c Actual K balance or Available K content in soil (K_2O kg ha^{-1})

Effect of levels of N nutrition, its ratios of substitution and frequencies of application on actual K balance or available K content of soil are given in Table 107.

Different levels of N application had no influence on actual K balance of soil during 1995-96 or 1996-97.

Different ratios of substitution significantly influenced the actual K balances of soil during 1995-96 and 1996-97. During 1995-96, N nutrition through 2:1 ratio of substitution produced significantly higher actual K balance of 140.37 kg K_2O ha^{-1} which was superior to r_2 (1:2) or r_1 (1:1) ratios producing 108.27 kg and 118.72 kg K_2O ha^{-1} respectively which were on a par each other and were greater than initial K status of soil (107.52 kg K_2O ha^{-1}). During the succeeding year of 1996-97, actual K content in soil was maximum (176.96 kg K_2O ha^{-1}) with 1:1 ratio of organic - chemical N substitution (r_1) compared to r_2 (1:2 ratio) or r_3 (2:1 ratio) recording 157.55 kg and 165.76 kg K_2O ha^{-1} which did not vary each other. All the ratios enhanced the actual K balance of soil as compared to the initial value of 134.40 kg K_2O ha^{-1} (Table 107).

Different frequencies of application had no influence on actual K content of soil during 1995-96 or 1996-97 (Table 107).

The LxR interaction (Table 108) affected the actual K content of soil during 1995-96 as well as 1996-97. During 1995-96, application of 300 kg N through 2:1 ratio of N substitution (l_3r_3 combination) recorded the maximum actual K content of 179.20 kg K_2O ha^{-1} which was significantly superior to all other combinations while the content was lowest (96.32 kg K_2O ha^{-1}) when 200 kg N was supplied through 1:2 ratio of N substitution in l_1r_2 combination. During 1996-97, actual K balance in soil was highest (206.08 kg K_2O ha^{-1}) where 200 kg N was applied through 1:1 substitution ratio in l_1r_1 combination and was lowest when 300 kg N was supplied through 1:2 ratio of N substitution in l_3r_2 combination (129.92 kg K_2O ha^{-1}).

The LxF interaction (Table 109) had not influenced the actual K balance of soil during both the years of field experimentation.

The RxF interaction (Table 110) significantly influenced the actual K balance of soil only during the second year (1996-97) of field experimentation wherein it was maximum (192.64 kg K_2O ha^{-1}) when nutrient N was applied through 1:1 ratio at f_2 frequency (basal + 2 splits of organic source) in r_1f_2 combination although it was on a par with r_3f_3 and r_1f_3 combinations recording 179.20 kg and 170.24 kg K_2O ha^{-1} respectively.

4.1. 12.3d Net loss (-) or gain of K in soil (K_2O kg ha^{-1})

Effect of different levels of N nutrition, its ratios of substitution and frequencies of application are indicated in Table 107.

During 1995-96, net loss of K occurred and was significantly higher (-66.75 kg K_2O ha^{-1}) when highest level of N (300 kg) was applied in l_3 compared to the lowest level of N application (200 kg) recording -39.26 kg K_2O ha^{-1} in l_1 although the l_3 level was on a par with l_2 which recorded net loss of -60.70 kg K_2O ha^{-1}. During the succeeding year also similar trend was noticed wherein higher level of N application resulted in a net loss of -34.64 kg and -18.51 kg K_2O ha^{-1} respectively for l_3 and l_2 treatments which were on a par each other while the lowest dose of N (l_1) resulted in a positive balance or net gain of 13.92 kg K_2O ha^{-1} in soil.

Different ratios of N substitution significantly influenced the net loss or gain of K during both the years of field experimentation. During 1995-96, application of nutrient N through 2:1 ratio of N substitution (r_3) resulted in maximum net loss of -75.63 kg K_2O ha^{-1} which was on a par with r_1 (1:1) ratio of substitution recording -68.22 kg K_2O ha^{-1}. The net loss of K was minimum (-32.86 kg K_2O ha^{-1}) with r_2 or 1:2 ratio of N substitution. During 1996-97 also the net loss of K was higher (-58.84 kg K_2O ha^{-1}) with r_3 (2:1) ratio in comparison with r_1 (1:1) ratio which registered only -14.36 kg net loss of K_2O. Net gain of K occurred when N was applied through 1:2 ratio of N substitution (7.34 kg K_2O ha^{-1}) in r_2 (Table 107).

Different frequencies of application had no influence on net loss or gain of K during 1995-96 or 1996-97 (Table 107).

The LxR interaction (Table 108) significantly affected the net loss or gain of K only during 1995-96. When 250 kg N was supplied through 2:1 ratio of N substitution in l_2r_3 combination, it recorded the maximum net loss of -100.67 kg K_2O ha^{-1} which did not vary significantly from -99.13 kg, and -78.35 kg K_2O ha^{-1} net losses recorded with l_3r_1, and l_2r_1 combinations respectively. The LxF (Table 109) or RxF interactions (Table 110) could not influence the net loss or gain of K during both the years.

4.1.13 Energy Budgeting

4.1.13.1 Total Energy Output (MJ ha^{-1})

Different levels of N application, ratios of substitution or frequencies of application of N did not have any influence on total energy output during 1995-96 or 1996-97 (Table 115).

Table - 115 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequenceis of application of nitrogen on energy budgeting.

Experiment I

Factor	Total energy output (MJ ha^{-1})		Net energy - returns (MJ ha^{-1})		Energy ratio	
	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97
Nitrogen						
l_1	10307.17	12916.44	-5049.19	-2352.34	-0.33	-0.15
l_2	9111.03	12519.17	-9080.33	-5562.59	-0.50	-0.31
l_3	10003.26	13242.33	-11023.10	-7634.30	-0.52	-0.37
$F_{2,22}$	2.16^{ns}	0.40^{ns}	52.01**	22.12**	19.96**	11.89**
Ratios						
r_1	9251.44	12913.56	-9939.92	-5168.13	-0.48	-0.28
r_2	9570.60	12878.67	-8945.77	-5564.57	-0.47	-0.29
r_3	10599.42	12885.72	-7266.94	-4816.54	-0.40	-0.26
$F_{2,22}$	2.78^{ns}	0.001^{ns}	5.24*	0.44^{ns}	3.80*	0.34^{ns}
Frequencies						
f_1	10061.61	12920.61	-7659.35	-4684.81	-0.42	-0.25
f_2	9596.33	13125.22	-8359.83	-4715.15	-0.46	-0.26
f_3	9763.52	12632.11	-9133.44	-6149.28	-0.48	-0.32
$F_{2,22}$	0.31^{ns}	0.19^{ns}	3.05^{ns}	2.19^{ns}	1.38^{ns}	1.19^{ns}
SEd	1267.63	1697.63	1267.61	1697.57	0.07	0.10
CD	-	-	1239.34	1659.70	0.07	0.09

ns - Not Significant   * - Significant at 5 % level   ** - Significant at 1 % level

Table - 116 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on energy budgeting.

Experiment I

Factor	Total energy output (MJ ha^{-1})		Net energy - returns (MJ ha^{-1})		Energy ratio	
	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97
$l_1 r_1$	10149.42	12662.00	-5206.94	-2606.84	-0.34	-0.17
$l_1 r_2$	9728.60	12782.50	-5885.16	-2772.76	-0.38	-0.18
$l_1 r_3$	11043.48	13304.83	-4055.48	-1677.43	-0.27	-0.11
$l_2 r_1$	7764.37	12525.67	-10426.99	-5555.89	-0.57	-0.31
$l_2 r_2$	9108.73	11993.17	-9410.23	-6453.19	-0.51	-0.35
$l_2 r_3$	10460.00	13038.67	-7403.76	-4678.69	-0.41	-0.26
$l_3 r_1$	9840.55	13553.00	-11185.81	-7341.66	-0.53	-0.36
$l_3 r_2$	9874.45	13860.33	-11541.91	-7467.76	-0.54	-0.35
$l_3 r_3$	10294.78	12313.67	-10341.58	-8093.49	-0.51	-0.40
$F_{4,22}$	0.79^{ns}	0.55^{ns}	0.74^{ns}	0.46^{ns}	0.89^{ns}	0.50^{ns}
SEd	1267.63	1697.63	1267.61	1697.57	0.07	0.10

ns - Not Significant

Table - 117 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on energy budgeting.

Experiment I

Factor	Total energy output (MJ ha^{-1})		Net energy - returns (MJ ha^{-1})		Energy ratio	
	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97
$l_1 f_1$	10745.48	13137.67	-4140.48	-1660.78	-0.28	-0.11
$l_1 f_2$	10079.28	12485.50	-5041.88	-2548.06	-0.33	-0.17
$l_1 f_3$	10096.73	13126.17	-5965.23	-2848.19	-0.37	-0.18
$l_2 f_1$	9217.82	12382.17	-8503.14	-5229.19	-0.48	-0.30
$l_2 f_2$	9176.53	13045.67	-8779.63	-4800.89	-0.49	-0.27
$l_2 f_3$	8938.75	12129.67	-9958.21	-6657.69	-0.53	-0.36
$l_3 f_1$	10221.53	13242.00	-10334.43	-7164.46	-0.50	-0.35
$l_3 f_2$	9533.18	13844.50	-11257.98	-6796.49	-0.54	-0.34
$l_3 f_3$	10255.07	12640.50	-11476.89	-8941.96	-0.53	-0.41
$F_{4,22}$	0.16^{ns}	0.28^{ns}	0.16^{ns}	0.28^{ns}	0.25^{ns}	0.21^{ns}
SEd	1267.63	1697.63	1267.61	1697.57	0.07	0.10

ns - Not Significant

Table - 118 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on energy budgeting.

Experiment I

Factor	Total energy output (MJ ha^{-1})		Net energy - returns (MJ ha^{-1})		Energy ratio	
	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97
$r_1 f_1$	9780.93	13148.17	-7240.03	-4463.18	-0.44	-0.24
$r_1 f_2$	8712.20	12342.83	-9243.96	-5503.63	-0.50	-0.31
$r_1 f_3$	9261.20	13249.67	-9635.76	-5537.59	-0.50	-0.29
$r_2 f_1$	9600.37	12575.00	-8445.59	-5398.06	-0.46	-0.29
$r_2 f_2$	9500.43	13241.50	-8780.73	-4966.09	-0.48	-0.27
$r_2 f_3$	9610.98	12819.50	-9610.98	-6329.56	-0.49	-0.32
$r_3 f_1$	10803.53	13038.67	-6592.43	-4193.19	-0.37	-0.22
$r_3 f_2$	10576.37	13791.33	-7054.79	-3675.73	-0.39	-0.20
$r_3 f_3$	10418.37	11827.17	-8153.59	-6580.69	-0.43	-0.34
$F_{4,22}$	0.15^{ns}	0.60^{ns}	0.15^{ns}	0.60^{ns}	0.16^{ns}	0.63^{ns}
SEd	1267.63	1697.63	1267.61	1697.57	0.07	0.10

ns - Not Significant

Various interaction effects (Tables 116, 117 and 118) too could not significantly influence the total energy output.

4.1.13.2 Net Energy Returns (MJ ha^{-1})

Main effects of the treatment are depicted in Table 115.

Increase in levels of N showed a net energy loss (negative returns) during both the years. During 1995-96, net energy loss was maximum (-11023.10 MJ ha^{-1}) with 300 kg N ha^{-1} (l_3) which was significantly higher than the net energy losses at 250 kg (-9080.33 MJ ha^{-1}) and 200 kg (-5049.19 MJ ha^{-1}) respectively. During 1996-97 also similar result was obtained

wherein net energy loss was higher (-7634.30 MJ ha^{-1}) with l_3 compared to l_2 and l_1 recording -5562.59 and -2352.34 MJ ha^{-1} net energy losses respectively. However net energy loss was moderated during the second year compared to the previous year.

Different ratios of substitution significantly influenced the net energy returns only during 1995-96 wherein negative returns were obtained with different ratios of N substitution. When nutrient N was supplied through 1:1 ratio of organic-chemical N substitution, maximum net energy loss or negative returns was obtained (-9939.92 MJ ha^{-1}) which did not differ from the 1:2 (r_2) ratio recording -8945.77 MJ ha^{-1} net energy loss. However both r_1 and r_2 ratios resulted in significantly higher net energy losses in comparison with r_3 (2:1 ratio) which recorded an energy loss of only -7266.94 MJ ha^{-1} (Table 115).

Different frequencies of N application had no significant influence on net energy returns during both 1995-96 and 1996-97 (Table 115).

The LxR interaction (Table 116) or LxF interaction (Table 117) or RxF interaction (Table 118) had no effect on net energy returns during 1995-96 or 1996-97.

4.1.13.3 Energy ratio

Main effects of the treatment on energy ratio are depicted in Table 115.

During 1995-96, application of 250 or 300 kg N ha^{-1} recorded energy ratios -0.50 and -0.52 respectively which indicated more energy losses while the lowest level of N application (200 kg N) recorded an energy ratio of -0.33 which was significantly higher than l_2 or l_3 which were on a par each other. During 1996-97 also similar trend was experienced wherein l_3 and l_2 levels recorded energy ratios -0.37 and -0.31 respectively which did not differ each other while l_1 produced an energy ratio of -0.15 which indicated moderate energy loss compared to higher levels of N application.

Different ratios of N substitution significantly influenced the energy ratio only during 1995-96 wherein application of N through 2:1 organic-chemical N substitution ratio recorded an energy ratio of -0.40 which indicated moderate energy losses which was significantly different from r_1 or r_2 recording -0.48 and -0.47 energy ratios indicating higher energy losses although r_1 and r_2 ratios were on a par in effect (Table 115).

Different frequencies of application did not influence the energy ratio during 1995-96 or 1996-97 (Table 115).

The LxR or LxF or RxF interactions could not affect the energy ratio during 1995-96 and 1996-97 (Tables 116, 117 and 118).

4.1.14 Economics of Cultivation

4.1.14.1 Gross returns (Rs. ha^{-1})

Gross returns were not influenced by main effect of the treatment (Table 123).

Various interaction effects (Tables 124, 125 and 126) too could not influence the gross returns.

4.1.14.2 Net returns (Rs. ha^{-1})

Net returns was significantly influenced by levels of N application (Table 123). Application of lowest level of N (200 kg) produced significantly higher net returns of Rs.45235.10 while the next higher levels recorded lower net returns of Rs.30985.10 and Rs.33850.10 respectively for l_2 and l_3 levels which did not differ each other.

Different ratios of substitution or frequencies of application had no influence on the net returns (Table 123).

Various interaction effects too could not affect the net monetary returns (Tables 124, 125 and 126).

Table - 123 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on economics of cultivation.

Factor	Gross Returns (Rs)		Net Returns (Rs)		Benefit/Cost ratio	
	Experiment I	Experiment II	Experiment I	Experiment II	Experiment I	Experiment II
<u>Nitrogen</u>						
l_1	96750.00	82480.00	45235.10	39690.10	1.89	1.95
l_2	86160.00	83210.00	30985.10	38951.77	1.58	1.89
l_3	92685.00	84370.00	33850.10	38633.02	1.59	1.85
$F_{2,22}$	2.02^{ns}	0.17^{ns}	4.03*	0.06^{ns}	6.82**	0.88^{ns}
<u>Ratios</u>						
r_1	90545.00	82355.00	35370.10	38086.35	1.65	1.88
r_2	90695.00	83515.00	40750.77	40841.60	1.83	1.97
r_3	94355.00	84190.00	33949.43	38346.93	1.59	1.84
$F_{2,22}$	0.33^{ns}	0.16^{ns}	0.91^{ns}	0.44^{ns}	3.46*	1.51^{ns}
<u>Frequencies</u>						
f_1	92880.00	90760.00	40712.00	49505.20	1.80	2.20
f_2	89665.00	75410.00	35993.55	32651.75	1.68	1.77
f_3	93050.00	83890.00	33364.75	35117.95	1.57	1.72
$F_{2,22}$	0.26^{ns}	11.25**	0.98^{ns}	15.76**	2.90^{ns}	25.86**
SEd	11263.88	6877.81	11263.89	6877.92	0.2	0.16
CD	-	6724.39	11012.63	6724.49	0.2	0.15

ns - Not Significant

* - Significant at 5% level ** - Significant at 1% level

Table - 124 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on economics of cultivation.

Factor	Gross Returns (Rs)		Net Returns (Rs)		Benefit/Cost ratio	
	Experiment I	Experiment II	Experiment I	Experiment II	Experiment I	Experiment II
$l_1 r_1$	96795.00	83115.00	45280.10	40325.10	1.89	1.98
$l_1 r_2$	91920.00	86055.00	44545.10	44510.85	1.95	2.07
$l_1 r_3$	101535.00	78270.00	45880.10	34234.35	1.83	1.80
$l_2 r_1$	82110.00	85455.00	26931.10	41182.35	1.48	1.94
$l_2 r_2$	85605.00	84075.00	35706.10	41432.85	1.72	1.99
$l_2 r_3$	90765.00	80100.00	30318.10	34240.10	1.52	1.75
$l_3 r_1$	92730.00	78495.00	33899.10	32751.60	1.58	1.72
$l_3 r_2$	94560.00	80415.00	42001.10	36581.10	1.81	1.85
$l_3 r_3$	90765.00	94200.00	25650.10	46566.35	1.39	1.99
$F_{4,22}$	0.37^{ns}	2.98*	0.57^{ns}	2.77^{ns}	0.56^{ns}	2.58^{ns}
SEd	11263.88	-	11263.89	6877.92	0.20	0.16
CD	-	6877.81	-	-	-	-

ns - Not Significant

* - Significant at 5% level

Table - 125 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on economics of cultivation.

Factor	Gross Returns (Rs)		Net Returns (Rs)		Benefit/Cost ratio	
	Experiment I	Experiment II	Experiment I	Experiment II	Experiment I	Experiment II
$l_1 f_1$	102405.00	87510.00	53897.00	47727.00	2.12	2.20
$l_1 f_2$	92385.00	81450.00	42373.55	40163.55	1.84	1.98
$l_1 f_3$	95460.00	78480.00	39434.75	31179.75	1.71	1.67
$l_2 f_1$	83070.00	91785.00	30902.00	50533.67	1.59	2.23
$l_2 f_2$	88065.00	70125.00	34393.55	27370.22	1.65	1.65
$l_2 f_3$	87345.00	87720.00	27659.75	38951.42	1.47	1.80
$l_3 f_1$	93165.00	92985.00	37337.00	50254.92	1.70	2.18
$l_3 f_2$	88545.00	74655.00	31213.55	30421.47	1.55	1.68
$l_3 f_3$	96345.00	85470.00	32999.75	35222.67	1.53	1.69
$F_{4,22}$	0.45^{ns}	1.94^{ns}	0.45^{ns}	1.94^{ns}	0.74^{ns}	1.89^{ns}
SEd	11263.88	6877.81	11263.89	6877.92	0.20	0.16

ns - Not Significant

Table - 126 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on economics of cultivation.

Factor	Gross Returns (Rs)		Net Returns (Rs)		Benefit/Cost ratio	
	Experiment I	Experiment II	Experiment I	Experiment II	Experiment I	Experiment II
$r_1 f_1$	92340.00	93435.00	40172.00	52173.25	1.78	2.27
$r_1 f_2$	83175.00	73710.00	29503.55	30944.80	1.56	1.73
$r_1 f_3$	96120.00	79920.00	36434.75	31141.00	1.61	1.64
$r_2 f_1$	92505.00	85110.00	45567.67	45443.50	1.98	2.14
$r_2 f_2$	87390.00	78255.00	38949.22	37085.05	1.81	1.91
$r_2 f_3$	92190.00	87180.00	37735.42	39996.25	1.69	1.85
$r_3 f_1$	93795.00	93735.00	36396.33	50898.83	1.65	2.19
$r_3 f_2$	98430.00	74265.00	39527.88	29925.39	1.68	1.67
$r_3 f_3$	90840.00	84570.00	25924.09	34216.58	1.41	1.67
$F_{4,22}$	0.67^{ns}	1.30^{ns}	0.67^{ns}	1.30^{ns}	0.57^{ns}	1.24^{ns}
SEd	11263.88	6877.81	11263.89	6877.92	0.20	0.16

ns - Not Significant

4.1.14.3 Benefit-Cost (B/C) Ratio

Main effects of the treatment on B/C ratio are depicted in Table 123.

Increasing the N level from l_1 (200 kg) to l_2 (250 kg) or l_3 (300 kg) significantly lowered the B/C ratio from 1.89 to 1.58 and 1.59 respectively although the l_2 and l_3 levels were on a par.

Nitrogen nutrition through 1:2 ratio of substitution (r_2) recorded the highest B/C ratio of 1.83 which was significantly higher than that recorded with r_1 or 1:1 ratio (1.65) which inturn was superior to r_3 (2:1 ratio) recording a B/C ratio of 1.59 (Table 123).

Different frequencies of application had not influenced the B/C ratio of Experiment I (Table 123).

The interaction effects (Tables 124, 125 and 126) too did not have any influence on B/C ratio.

4.2 Experiment II

4.2.1 Sex ratio

When organic source of N was poultry manure, effect of levels of N application, its ratios of substitution and frequencies of application on sex ratio at 40 DAS, 60 DAS and 90 DAS are depicted in Table 7. Sex ratio at 40 DAS and 60 DAS were not influenced by the application of various levels of nitrogen during 1995-96 and 1996-97. Either the levels of N or the ratios of N substitution

Table 7: Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on sex ratio.

Experiment - II

Factor	Sex ratio 40 DAS (No. of male flowers per female flower)		Sex ratio 60 DAS (No. of male flowers per female flower)		Sex ratio 90 DAS (No. of male flowers per female flower)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen						
l_1	3.16	0.96	4.50	4.02	13.19	10.40
l_2	4.19	1.50	4.51	4.95	12.69	10.34
l_3	3.38	1.35	4.18	4.91	11.97	9.19
$F_{2,22}$	1.01^{ns}	1.99^{ns}	0.22^{ns}	1.14^{ns}	3.86^{*}	0.71^{ns}
Ratios						
r_1	4.28	1.44	4.60	4.96	13.47	9.43
r_2	2.78	1.22	4.41	4.24	13.14	10.98
r_3	3.66	1.16	4.17	4.67	12.25	9.51
$F_{2,22}$	1.97^{ns}	0.56^{ns}	0.28^{ns}	0.55^{ns}	1.96^{ns}	1.16^{ns}
Frequencies						
f_1	2.61	1.10	4.04	5.12	12.14	10.00
f_2	4.39	1.30	4.66	4.79	13.17	9.21
f_3	3.72	1.42	4.48	3.96	13.56	10.71
$F_{2,22}$	2.79^{ns}	0.66^{ns}	0.63^{ns}	1.47^{ns}	2.64^{ns}	0.85^{ns}
SEd	1.62	0.59	1.22	1.48	1.35	2.44
CD	-	-	-	-	1.32	-

ns - Not Significant

* - Significant at 5% level

Table 8 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on sex ratio.

Experiment - II

Factor	Sex ratio 40 DAS (No. of male flowers per female flower)		Sex ratio 60 DAS (No. of male flowers per female flower)		Sex ratio 90 DAS (No. of male flowers per female flower)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	3.50	1.03	4.45	4.00	12.50	8.93
$l_1 r_2$	3.29	0.89	4.97	3.98	13.75	12.92
$l_1 r_3$	2.68	0.98	4.07	4.06	13.33	9.35
$l_2 r_1$	4.35	1.29	5.17	5.80	13.75	10.82
$l_2 r_2$	2.71	1.47	4.50	4.41	13.33	10.92
$l_2 r_3$	5.50	1.75	3.86	4.63	14.00	9.28
$l_3 r_1$	5.00	2.00	4.20	5.08	14.17	8.53
$l_3 r_2$	2.34	1.31	3.75	4.33	12.33	9.11
$l_3 r_3$	2.81	0.75	4.58	5.30	9.42	9.92
$F_{4,22}$	1.41^{ns}	1.65^{ns}	0.67^{ns}	1.47^{ns}	4.15^{*}	0.97^{ns}
SEd	1.62	0.59	1.22	1.48	-	2.44
CD	-	-	-	-	2.29	-

ns - Not Significant

* Significant at 5% level

Table 9 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on sex ratio.

Experiment - II

Factor	Sex ratio 40 DAS (No. of male flowers per female flower)		Sex ratio 60 DAS (No. of male flowers per female flower)		Sex ratio 90 DAS (No. of male flowers per female flower)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	2.56	0.59	4.03	4.36	12.83	9.60
$l_1 f_2$	3.40	0.92	4.46	3.89	12.83	9.90
$l_1 f_3$	3.51	1.39	5.00	3.80	13.92	11.69
$l_2 f_1$	2.95	1.54	4.42	5.92	12.75	10.65
$l_2 f_2$	6.00	1.22	5.03	4.56	14.17	8.78
$l_2 f_3$	3.62	1.75	4.08	4.36	14.17	11.58
$l_3 f_1$	2.34	1.18	3.67	5.08	10.83	9.75
$l_3 f_2$	3.78	1.75	4.50	5.92	12.50	8.96
$l_3 f_3$	4.04	1.13	4.36	3.72	12.58	8.85
$F_{4,22}$	0.73^{ns}	1.18^{ns}	0.36^{ns}	0.67^{ns}	0.35^{ns}	0.48^{ns}
SEd	1.62	0.59	1.22	1.48	1.35	2.44

ns - Not Significant

Table 10 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on sex ratio.

Experiment - II

Factor	Sex ratio 40 DAS (No. of male flowers per female flower)		Sex ratio 60 DAS (No. of male flowers per female flower)		Sex ratio 90 DAS (No. of male flowers per female flower)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	2.82	1.29	3.58	6.91	12.42	9.36
$r_1 f_2$	4.61	1.36	4.70	4.46	13.83	9.00
$r_1 f_3$	5.42	1.67	5.53	3.52	14.17	9.93
$r_2 f_1$	1.95	1.14	4.08	3.78	12.42	10.25
$r_2 f_2$	3.01	1.22	4.64	4.60	12.58	9.89
$r_2 f_3$	3.38	1.31	4.50	4.34	14.42	12.81
$r_3 f_1$	3.07	0.88	4.45	4.67	11.58	10.40
$r_3 f_2$	3.56	1.31	4.65	5.31	13.08	8.75
$r_3 f_3$	2.37	1.29	3.42	4.02	12.08	9.39
$F_{4,22}$	1.55^{ns}	0.12^{ns}	1.18^{ns}	1.76^{ns}	0.88^{ns}	0.45^{ns}
SEd	1.62	0.59	1.22	1.48	1.35	2.44

ns - Not Significant

or the frequencies of application did not influence the sex ratio in both the years with an exception in 1995-96 for N. When the nitrogen level was raised from 200 to 300 kg ha^{-1}, sex ratio at later stage (90 DAS) was significantly decreased from 13.19 to 11.97 during 1995-96. Sex ratio at 200 kg level or l_1 (13.19) was on a par with 250 kg level or l_2 (12.69) while the l_2 and l_3 (300 kg) levels did not differ each other. However this effect was not apparent during 1996-97 (Table 7).

Ratios of nitrogen substitution or its frequencies of application could not influence the sex ratio at 40 DAS, 60 DAS or 90 DAS (Table 7).

The interaction effects did not significantly influence the sex ratio at 40 DAS and 60 DAS during first and second years (Tables 8, 9 and 10). Though the sex ratio at 90 DAS too was unaffected by levels of nitrogen nutrition and frequencies of application interaction (LxF) and ratios of nitrogen substitution and frequencies of application interaction (RxF), levels of nitrogen nutrition and ratios of nitrogen substitution interaction (LxR) could significantly influence it during 1995-96 (Table 8). Application of highest level of nitrogen (300 kg ha^{-1}) in 2:1 organic-chemical N proportion produced the lowest sex ratio of 9.42 compared to all other combinations of nitrogen levels and substitution ratios which did not differ each other (Table 8). However this effect became nonsignificant in the succeeding year.

4.2.2 Days taken to flower

When poultry manure was used as organic source of nitrogen in Experiment II, different levels of the nutrient or its ratios of substitution did not have any

Table 15 : Effect of levels of nitrogen, ratio of substitution of nitrogen and frequencies of application of nitrogen on days required for flowering and harvests

Experiment II

Factor	Days taken to flower		Days taken for the first harvest		Days taken for 50% harvest		Days taken for the final harvest	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
<u>Nitrogen</u>								
l_1	32.83	32.78	47.56	47.44	74.33	72.56	98.56	107.00
l_2	33.22	31.94	48.67	48.33	75.00	72.67	99.89	107.00
l_3	33.44	32.11	47.56	47.44	74.67	72.17	99.89	107.00
$F_{2,22}$	1.24^{ns}	2.81^{ns}	0.75^{ns}	1.16^{ns}	1.03^{ns}	0.06^{ns}	0.56^{ns}	-
<u>Ratios</u>								
r_1	33.50	32.39	47.00	47.00	74.67	72.94	99.44	107.00
r_2	32.67	32.56	48.67	47.44	74.67	73.00	99.44	107.00
r_3	33.33	31.89	48.11	48.78	74.67	71.44	99.44	107.00
$F_{2,22}$	2.52^{ns}	1.74^{ns}	1.03^{ns}	0.76^{ns}	0.00^{ns}	0.69^{ns}	0.00^{ns}	-
<u>Frequencies</u>								
f_1	32.83	31.67	47.56	47.89	74.67	70.11	100.33	107.00
f_2	32.72	32.44	49.22	48.33	74.67	74.33	98.11	107.00
f_3	33.94	32.72	47.00	47.00	74.67	72.94	99.89	107.00
$F_{2,22}$	5.93^{**}	4.32^{*}	2.42^{ns}	2.03^{ns}	0.00^{ns}	3.07^{ns}	1.31^{ns}	-
SEd	0.83	0.79	2.23	1.43	0.98	3.20	3.08	-
CD	0.81	0.77	-	-	-	-	-	-

ns - Not Significant * Significant at 5% level ** Significant at 1% level

Table 16 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on days required for flowering and harvests

Experiment II

Factor	Days taken to flower		Days taken for the first harvest		Days taken for 50% harvest		Days taken for the final harvest	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	33.17	32.50	47.00	47.00	75.00	73.00	100.33	107.00
$l_1 r_2$	32.50	33.00	47.00	47.00	74.00	72.33	96.33	107.00
$l_1 r_3$	32.83	32.83	48.67	48.33	74.00	72.33	99.00	107.00
$l_2 r_1$	33.67	32.17	47.00	47.00	75.00	73.67	100.33	107.00
$l_2 r_2$	32.50	32.50	50.33	47.00	75.00	71.33	100.33	107.00
$l_2 r_3$	33.50	31.17	48.67	51.00	75.00	73.00	99.00	107.00
$l_3 r_1$	33.67	32.50	47.00	47.00	74.00	72.17	97.67	107.00
$l_3 r_2$	33.00	32.17	48.67	48.33	75.00	75.33	101.67	107.00
$l_3 r_3$	33.67	31.67	47.00	47.00	75.00	69.00	100.33	107.00
$F_{4,22}$	0.16^{ns}	0.87^{ns}	0.75^{ns}	1.09^{ns}	1.03^{ns}	1.36^{ns}	1.41^{ns}	-
SEd	0.83	0.79	2.23	1.43	0.98	3.20	3.08	-

ns - Not Significant

Table 17 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on days required for flowering and harvests

Experiment II

Factor	Days taken to flower		Days taken for the first harvest		Days taken for 50% harvest		Days taken for the final harvest	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	33.33	32.00	47.00	48.33	74.00	72.00	99.00	107.00
$l_1 f_2$	32.33	33.00	48.67	47.00	74.00	73.50	100.33	107.00
$l_1 f_3$	32.83	33.33	47.00	47.00	75.00	72.17	96.33	107.00
$l_2 f_1$	33.67	32.50	48.67	48.33	75.00	70.33	101.67	107.00
$l_2 f_2$	33.33	31.33	50.33	49.67	75.00	75.33	96.33	107.00
$l_2 f_3$	32.67	32.00	47.00	47.00	75.00	72.33	101.67	107.00
$l_3 f_1$	34.83	30.50	47.00	47.00	75.00	68.00	100.33	107.00
$l_3 f_2$	32.50	33.00	48.67	48.33	75.00	74.17	97.67	107.00
$l_3 f_3$	33.00	32.83	47.00	47.00	74.00	74.33	101.67	107.00
$F_{4,22}$	2.50^{ns}	4.53^{**}	0.19^{ns}	1.16^{ns}	1.03^{ns}	0.90^{ns}	2.16^{ns}	-
SEd	0.83	-	2.23	1.43	0.98	3.20	3.08	-
CD	-	1.34	-	-	-	-	-	-

ns - Not Significant

** Significant at 1% level

Table 18 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on days required for flowering and harvests

Experiment II

Factor	Days taken to flower		Days taken for the first harvest		Days taken for 50% harvest		Days taken for the final harvest	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	35.00	32.33	47.00	47.00	75.00	71.17	101.67	107.00
$r_1 f_2$	32.50	32.67	47.00	47.00	75.00	74.33	95.00	107.00
$r_1 f_3$	33.00	32.17	47.00	47.00	74.00	73.33	101.67	107.00
$r_2 f_1$	32.83	32.00	48.67	47.00	75.00	70.17	97.67	107.00
$r_2 f_2$	32.17	32.67	50.33	48.33	74.00	74.50	100.33	107.00
$r_2 f_3$	33.00	33.00	47.00	47.00	75.00	74.33	100.33	107.00
$r_3 f_1$	34.00	30.67	47.00	49.67	74.00	69.00	101.67	107.00
$r_3 f_2$	33.50	32.00	50.33	49.67	75.00	74.17	99.00	107.00
$r_3 f_3$	32.50	33.00	47.00	47.00	75.00	71.17	97.67	107.00
$F_{4,22}$	1.40^{ns}	1.92^{ns}	0.75^{ns}	1.16^{ns}	1.55^{ns}	0.22^{ns}	2.72^{ns}	-
SEd	0.83	0.79	2.23	1.43	0.98	3.20	3.08	-

ns - Not Significant

significant influence on days taken to flower in both first and second year (Table 15).

Different frequencies of application however, significantly influenced the flowering in first and second years. The f_1 and f_2 frequencies of application resulted in less number of days (32.83 and 32.72 respectively) for flowering in 1995-96 which did not vary each other while the f_1 frequency of application recorded minimum number of days for first flowering (31.67) in 1996-97 (Table 15).

Interaction effects are depicted in Table 16, 17 and 18.

None of the interactions were significant except for the LxF in 1996-97. Under l_1 and l_2, frequencies of N application did not produce any significant result but with l_3, f_1 treated plants recorded least number of days for flowering (30.50) than f_2 and f_3 which were on a par (Table 17).

4.2.3 Scoring of pest and diseases

4.2.3.1 Scoring of pests

4.2.3.1a Aphid - *Aphis malvae* (Koch)

When poultry manure was used as an organic source of N, aphid population was not observed at 30 DAS and 60 DAS and the aphid count was unaffected by levels of nitrogen, the ratios of substitution or its frequencies of application at 90 DAS during 1995-96. In 1996-97, aphid population was not

Table 23 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on aphid and jassid population

Experiment II

Factor	Number of Aphids						Number of Jassids					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen												
l_1	0	2.03(1.74)	0	0	0.37(1.17)	2.57(1.90)	0	0.17(1.09)	0	1.28(1.51)	0.35(1.17)	3.28(2.07)
l_2	0	2.35(1.83)	0	0	0.44(1.21)	2.88(1.98)	0	0.32(1.15)	0	1.69(1.64)	0.39(1.19)	3.75(2.19)
l_3	0	2.03(1.74)	0	0	0.28(1.13)	2.38(1.84)	0	0.21(1.11)	0	1.59(1.61)	0.30(1.14)	3.08(2.02)
$F_{2,22}$	-	0.09^{ns}	-	-	0.43^{ns}	0.46^{ns}	-	0.58^{ns}	-	0.17^{ns}	0.097^{ns}	0.66^{ns}
Ratios												
r_1	0	1.89(1.71)	0	0	0.35(1.16)	2.64(1.92)	0	0.17(1.09)	0	1.37(1.54)	0.37(1.18)	3.66(2.16)
r_2	0	2.00(1.73)	0	0	0.46(1.22)	2.38(1.84)	0	0.42(1.19)	0	2.03(1.74)	0.35(1.17)	3.28(2.08)
r_3	0	2.03(1.74)	0	0	0.28(1.13)	2.80(1.96)	0	0.12(1.07)	0	1.19(1.48)	0.35(1.17)	3.16(2.04)
$F_{2,22}$	-	0.29^{ns}	-	-	0.61^{ns}	0.34^{ns}	-	2.43^{ns}	-	0.66^{ns}	0.012^{ns}	0.38^{ns}
Frequencies												
f_1	0	1.53(1.60)	0	0	0.35(1.16)	2.42(1.85)	0	0.17(1.09)	0	1.37(1.54)	0.25(1.13)	3.00(2.00)
f_2	0	2.53(1.89)	0	0	0.59(1.27)	2.80(1.95)	0	0.42(1.19)	0	1.13(1.47)	0.54(1.24)	3.45(2.11)
f_3	0	2.35(1.83)	0	0	0.17(1.09)	2.64(1.92)	0	0.12(1.07)	0	2.06(1.76)	0.25(1.12)	3.67(2.17)
$F_{2,22}$	-	0.79^{ns}	-	-	2.50^{ns}	0.25^{ns}	-	2.43^{ns}	-	0.83^{ns}	0.85^{ns}	0.62^{ns}
SEd	-	0.53	-	-	0.17	0.30	-	0.13	-	-	0.22	0.31

ns - Not Significant

( ) Transformed mean

Table 24 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on aphid and jassid population

Experiment II

Factor	Number of Aphids						Number of Jassids					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	0	2.17(1.78)	0	0	0.28(1.14)	2.42(1.85)	0	0(1.00)	0	0.85(1.36)	0.12(1.07)	3.62(2.15)
$l_1 r_2$	0	2.39(1.84)	0	0	0.42(1.19)	2.39(1.84)	0	0.42(1.19)	0	3.20(2.06)	0.12(1.07)	3.71(2.17)
$l_1 r_3$	0	1.56(1.60)	0	0	0.42(1.19)	2.96(1.99)	0	0.12(1.07)	0	0.25(1.12)	0.82(1.36)	2.53(1.89)
$l_2 r_1$	0	1.31(1.52)	0	0	0.80(1.34)	3.24(2.06)	0	0.12(1.07)	0	1.65(1.63)	0.42(1.19)	4.15(2.28)
$l_2 r_2$	0	2.69(1.92)	0	0	0.80(1.34)	2.69(1.93)	0	0.72(1.31)	0	1.99(1.74)	0.51(1.24)	2.53(1.88)
$l_2 r_3$	0	3.20(2.05)	0	0	0.80(1.34)	2.76(1.94)	0	0.12(1.07)	0	1.43(1.56)	0.28(1.14)	4.71(2.39)
$l_3 r_1$	0	2.24(1.81)	0	0	0(1.00)	2.31(1.83)	0	0.42(1.19)	0	1.65(1.64)	0.59(1.26)	3.20(2.06)
$l_3 r_2$	0	1.02(1.43)	0	0	0.74(1.30)	2.10(1.76)	0	0.12(1.07)	0	1.02(1.43)	0.35(1.17)	3.70(2.17)
$l_3 r_3$	0	2.96(1.99)	0	0	0.12(1.07)	2.76(1.94)	0	0.12(1.07)	0	2.10(1.77)	0(1.00)	5.13(1.84)
$F_{4,22}$	0	0.79^{ns}	-	-	2.04^{ns}	0.19^{ns}	-	1.97^{ns}	-	1.35^{ns}	1.44^{ns}	1.74^{ns}
SEd	-	0.53	-	-	0.17	0.30	-	0.13	-	0.50	0.22	0.31

ns - Not Significant ( ) Transformed mean

Table 25 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on aphid and jassid population

Experiment II

Factor	Number of Aphids						Number of Jassids					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	0	1.96(1.73)	0	0	0.12(1.07)	2.72(1.93)	0	0.42(1.19)	0	0.85(1.37)	0(1.00)	2.80(1.96)
$l_1 f_2$	0	1.99(1.76)	0	0	0.74(1.33)	2.80(1.95)	0	0(1.00)	0	1.16(1.48)	0.59(1.26)	3.16(2.04)
$l_1 f_3$	0	2.13(1.77)	0	0	0.25(1.12)	2.24(1.81)	0	0.12(1.07)	0	1.86(1.69)	0.51(1.24)	3.84(2.21)
$l_2 f_1$	0	1.56(1.60)	0	0	0.80(1.34)	2.45(1.86)	0	0.12(1.07)	0	1.69(1.65)	0.42(1.19)	4.02(2.25)
$l_2 f_2$	0	2.49(1.87)	0	0	0.44(1.21)	3.33(2.09)	0	0.54(1.24)	0	0.85(1.36)	0.51(1.24)	3.32(2.09)
$l_2 f_3$	0	3.08(2.02)	0	0	0.12(1.07)	2.92(1.99)	0	0.28(1.44)	0	2.68(1.92)	0.28(1.14)	3.92(2.23)
$l_3 f_1$	0	1.13(1.47)	0	0	0.12(1.07)	2.09(1.76)	0	0(1.00)	0	1.59(1.61)	0.42(1.19)	2.24(1.81)
$l_3 f_2$	0	3.20(2.06)	0	0	0.59(1.26)	2.28(1.81)	0	0.74(1.33)	0	1.43(1.56)	0.51(1.24)	3.79(2.20)
$l_3 f_3$	0	1.89(1.70)	0	0	0.12(1.07)	2.80(1.96)	0	0(1.00)	0	1.72(1.66)	0(1.00)	3.24(1.81)
$F_{4,22}$	-	0.35^{ns}	-	-	1.34^{ns}	0.37^{ns}	-	0.74^{ns}	-	0.25^{ns}	0.76^{ns}	0.65^{ns}
SEd	-	0.53	-	-	0.17	0.30	-	0.20	-	0.50	0.22	0.31

ns - Not Significant ( ) Transformed mean

Table 26 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on aphid and jassid population

Experiment II

Factor	Number of Aphids						Number of Jassids					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	0	1.10(1.45)	0	0	0.80(1.34)	2.20(1.80)	0	0.12(1.07)	0	1.49(1.58)	0.72(1.31)	3.28(2.07)
$r_1 f_2$	0	3.04(2.02)	0	0	0.12(1.07)	2.61(1.91)	0	0.42(1.19)	0	0.93(1.40)	0.28(1.14)	4.29(2.30)
$r_1 f_3$	0	1.69(1.65)	0	0	0.12(1.07)	3.16(2.04)	0	0	0	1.68(1.65)	0.12(1.07)	3.45(2.11)
$r_2 f_1$	0	1.82(1.69)	0	0	0.12(1.07)	2.92(1.98)	0	0.25(1.12)	0	1.16(1.48)	0(1.00)	3.28(2.08)
$r_2 f_2$	0	2.53(1.88)	0	0	1.31(1.52)	2.80(1.95)	0	0.72(1.31)	0	2.38(1.84)	0.96(1.40)	2.84(1.97)
$r_2 f_3$	0	1.62(1.62)	0	0	0.12(1.07)	1.56(1.60)	0	0.28(1.14)	0	2.57(1.90)	0.12(1.07)	3.75(2.18)
$r_3 f_1$	0	1.72(1.66)	0	0	0.12(1.07)	2.13(1.78)	0	0.12(1.07)	0	1.43(1.56)	0.12(1.07)	2.46(1.86)
$r_3 f_2$	0	2.06(1.76)	0	0	0.44(1.21)	2.96(2.00)	0	0.12(1.07)	0	0.35(1.17)	0.42(1.19)	3.20(2.06)
$r_3 f_3$	0	3.92(2.23)	0	0	0.25(1.12)	3.41(2.11)	0	0.12(1.07)	0	1.96(1.72)	0.51(1.24)	3.84(2.20)
$F_{4,22}$	-	0.67^{ns}	-	-	0.83^{ns}	1.35^{ns}	-	0.70^{ns}	-	0.52^{ns}	1.70^{ns}	0.56^{ns}
SEd	-	0.53	-	-	0.29	0.30	-	0.13	-	0.50	0.22	0.31

ns - Not Significant ( ) Transformed mean * Significant at 5% level influenced by the direct effects of treatments at 30 and 90 DAS, while no infestation was observed at 60 DAS (Table 23).

Similar trend was observed in case of all the interactions which were not influenced by the treatment combinations (Tables 24, 25 and 26).

4.2.3.1b Jassid - *Hishimonas phycitis* (Dist.)

When nitrogen was substituted through poultry manure, its levels, ratios of substitution or frequencies of application did not have any effect on jassid count at any of the stages in first or second year (Table 23). None of the interaction effects was significant in both the years (Table 24, 25 and 26).

4.2.3.1c Fruit fly - *Bactrocera cucurbitae* (Coq.)

In Experiment II using poultry manure as an organic source of nitrogen substitution, similar observations were recorded as in Experiment I wherein neither the main effects nor their interactions could register any significant influence on percentage of fruit fly infestation in first and second years.

4.2.3.1d Epilachna beetle - *Henosepilachna septima* (Sab.)

No epilachna beetle infestation was noticed in Experiment II in first or second year of field experimentation.

4.2.3.1e Red pumpkin beetle - *Aulocophora foveicollis* (Lucas)

Red pumpkin beetle infestation was not observed in Experiment II in first and second year.

Table 31 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on fruit fly and leaf spot infestation

Experiment II

Factor	Fruit fly infestation (%)		Leaf spot infestation (%)					
			30 DAS		60 DAS		90 DAS	
	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97
Nitrogen								
l_1	5.86(2.63)	9.69(3.28)	0.39(1.19)	0	3.58(2.15)	3.71(2.15)	21.37(4.73)	50.55(7.19)
l_2	5.40(2.53)	11.18(3.50)	1.31(1.52)	0	6.73(2.79)	4.57(2.36)	23.50(4.95)	47.16(6.94)
l_3	6.12(2.67)	10.76(3.43)	0.58(1.26)	0	6.29(2.71)	2.88(1.97)	21.28(4.73)	39.58(6.37)
$F_{2,22}$	0.16^{ns}	0.92^{ns}	1.83^{ns}	-	1.48^{ns}	0.95^{ns}	0.18^{ns}	2.45^{ns}
Ratios								
r_1	5.55(2.56)	10.56(3.40)	0.74(1.32)	0	4.76(2.41)	3.62(2.15)	21.56(4.76)	47.86(7.00)
r_2	5.66(2.59)	10.42(3.39)	0.82(1.36)	0	7.18(2.86)	4.20(2.29)	26.77(5.28)	46.33(6.89)
r_3	6.18(2.69)	10.70(3.42)	0.66(1.29)	0	4.62(2.37)	3.28(2.08)	18.18(4.38)	42.69(6.61)
$F_{2,22}$	0.13^{ns}	0.02^{ns}	0.06^{ns}	-	0.91^{ns}	0.28^{ns}	2.17^{ns}	0.56^{ns}
Frequencies								
f_1	5.50(2.55)	10.22(3.35)	0.66(1.29)	0	3.62(2.16)	4.57(2.37)	20.62(4.65)	47.30(6.96)
f_2	6.18(2.68)	11.04(3.48)	0.90(1.39)	0	6.72(2.78)	3.67(2.17)	21.94(4.80)	46.89(6.93)
f_3	5.70(2.60)	10.42(3.38)	0.66(1.29)	0	6.29(2.70)	2.92(1.98)	23.60(4.96)	42.69(6.62)
$F_{2,22}$	0.13^{ns}	0.31^{ns}	0.18^{ns}	-	1.39^{ns}	0.94^{ns}	0.26^{ns}	0.50^{ns}
SEd	0.53	0.35	0.39	-	0.86	0.60	0.92	0.80

ns - Not Significant ( ) Transformed mean

Table 32 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on fruit fly and leaf spot infestation

Experiment II

Factor	Fruit fly infestation (%)		Leaf spot infestation (%)					
			30 DAS		60 DAS		90 DAS	
	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97
$l_1 r_1$	5.45(2.55)	9.96(3.32)	0.39(1.19)	0	2.92(1.98)	3.67(2.16)	19.52(4.54)	48.98(7.08)
$l_1 r_2$	5.66(2.58)	8.86(3.15)	0.87(1.38)	0	8.86(3.14)	3.88(2.21)	30.02(5.58)	48.98(7.08)
$l_1 r_3$	6.56(2.75)	10.36(3.38)	0(1.00)	0	6.69(1.31)	3.67(2.16)	15.65(4.08)	53.76(7.41)
$l_2 r_1$	5.10(2.47)	11.39(3.52)	0.87(1.38)	0	4.62(2.37)	4.62(2.38)	22.91(4.89)	49.98(7.14)
$l_2 r_2$	5.71(2.59)	11.25(3.50)	1.82(1.69)	0	8.99(3.17)	5.97(2.65)	30.02(5.58)	48.98(7.08)
$l_2 r_3$	5.40(2.54)	10.90(3.46)	1.22(1.50)	0	6.90(2.82)	3.24(2.07)	18.18(4.39)	42.56(6.60)
$l_3 r_1$	6.13(2.67)	10.29(3.36)	0.96(1.40)	0	7.12(2.86)	2.69(1.93)	22.33(4.84)	44.83(6.78)
$l_3 r_2$	5.66(2.58)	11.25(3.51)	0(1.00)	0	4.15(2.28)	2.96(2.00)	20.81(4.67)	41.38(6.51)
$l_3 r_3$	6.62(2.77)	10.76(3.43)	0.87(1.38)	0	7.94(2.99)	2.96(2.00)	20.81(4.67)	32.87(5.83)
$F_{4,22}$	0.06^{ns}	0.25^{ns}	1.08^{ns}	-	1.88^{ns}	0.22^{ns}	0.62^{ns}	0.58^{ns}
SEd	0.53	0.35	0.39	-	0.86	0.60	0.92	0.80

ns - Not Significant ( ) Transformed mean

Table 33 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on fruit fly and leaf spot infestation

Experiment II

Factor	Fruit fly infestation (%)		Leaf spot infestation (%)					
			30 DAS		60 DAS		90 DAS	
	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97
$l_1 f_1$	5.92(2.64)	9.50(3.25)	0.39(1.19)	0	4.24(2.29)	4.29(2.31)	23.21(4.93)	50.27(7.16)
$l_1 f_2$	6.29(2.70)	8.36(3.07)	0.39(1.19)	0	4.15(2.28)	3.67(2.16)	25.01(5.10)	57.52(7.65)
$l_1 f_3$	5.40(2.54)	11.39(3.52)	0.39(1.19)	0	2.46(1.86)	3.24(2.07)	16.31(4.16)	44.43(6.75)
$l_2 f_1$	4.66(2.38)	10.56(3.40)	1.22(1.50)	0	4.24(2.29)	6.18(2.69)	22.72(4.87)	49.41(7.10)
$l_2 f_2$	6.13(2.67)	12.99(3.75)	0.87(1.38)	0	5.97(2.64)	4.48(2.34)	18.18(4.39)	49.55(7.12)
$l_2 f_3$	5.45(2.55)	10.09(3.34)	1.82(1.69)	0	10.70(3.43)	3.24(2.07)	30.25(5.60)	42.56(6.61)
$l_3 f_1$	5.97(2.65)	10.56(3.40)	0.39(1.19)	0	2.53(1.89)	3.45(2.12)	16.31(4.16)	42.69(6.61)
$l_3 f_2$	6.08(2.67)	11.96(3.61)	1.52(1.59)	0	10.70(3.43)	2.96(2.00)	22.91(4.90)	35.00(6.01)
$l_3 f_3$	6.29(2.71)	9.96(3.29)	0(1.00)	0	6.90(2.82)	2.24(1.81)	25.21(5.13)	41.12(6.50)
$F_{4,22}$	0.09^{ns}	1.43^{ns}	1.07^{ns}	-	1.30^{ns}	0.09^{ns}	1.43^{ns}	0.67^{ns}
SEd	0.53	0.35	0.39	-	0.86	0.60	0.92	0.80

ns - Not Significant ( ) Transformed mean

Table 34 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on fruit fly and leat spot infestation

Experiment II

Factor	Fruit fly infestation (%)		Leaf spot infestation (%)					
			30 DAS		60 DAS		90 DAS	
	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97	1995-1996	1996-97
$r_1 f_1$	5.65(2.59)	10.22(3.35)	0(1.00)	0	2.20(1.79)	5.81(2.61)	18.45(4.42)	51.13(7.23)
$r_1 f_2$	4.90(2.43)	11.96(3.60)	2.88(1.97)	0	7.64(2.94)	2.88(1.97)	23.50(4.95)	45.24(6.81)
$r_1 f_3$	6.13(2.68)	9.50(3.24)	0(1.00)	0	5.15(2.48)	2.50(1.88)	22.91(4.89)	47.44(6.97)
$r_2 f_1$	5.92(2.63)	9.82(3.29)	1.82(1.69)	0	5.55(2.56)	3.88(2.21)	25.21(5.13)	50.27(7.16)
$r_2 f_2$	6.02(2.66)	10.97(3.46)	0(1.00)	0	9.50(3.25)	5.00(2.46)	30.02(5.58)	47.30(6.96)
$r_2 f_3$	5.05(2.47)	10.56(3.41)	0.87(1.38)	0	6.67(2.78)	3.75(2.19)	25.21(5.13)	41.77(6.55)
$r_3 f_1$	5.00(2.45)	10.56(3.41)	0.39(1.19)	0	3.45(2.12)	4.20(2.28)	18.45(4.42)	41.12(6.49)
$r_3 f_2$	7.70(2.95)	10.22(3.36)	0.39(1.19)	0	3.62(2.16)	3.24(2.07)	13.82(3.85)	48.14(7.01)
$r_3 f_3$	6.02(2.65)	11.18(3.49)	1.22(1.50)	0	7.07(2.84)	2.50(1.88)	22.72(4.87)	39.07(6.34)
$F_{4,22}$	0.41^{ns}	0.45^{ns}	0.57^{ns}	-	0.55^{ns}	0.46^{ns}	0.61^{ns}	0.38^{ns}
SEd	0.53	0.35	-	-	0.86	0.60	0.92	0.80

ns - Not Significant ( ) Transformed mean

4.2.3.2 Diseases

4.2.3.2a. Leaf spot (C.O. *Pseudoperonospora cubensis*)

When the organic source used for N substitution was poultry manure, neither the main effects (Table 31) or interaction effects (Tables 32,33 and 34) could significantly affect the leaf spot infestation at 30, 60 and 90 DAS during 1995-96 and 1996-97.

4.2.3.2b Mosaic

No viral mosaic infestation was observed in both the years.

4.2.4 Harvests and Yield

4.2.4.1 Harvests

4.2.4.1a Days to first harvest

Main effects (Table 15) or interaction effects of treatments (Tables 16, 17 and 18) did not significantly influence the days required for the first harvest in 1995-96 and 1996-97 when poultry manure was used as organic source for nitrogen substitution.

4.2.4.1b Days to 50 per cent harvest

When poultry manure was used as organic source, days required for 50 per cent harvest was not significantly influenced by the main effects (Table 15) or treatment interaction effects (Tables 16, 17 and 18) in first and second years.

4.2.4.1c Days to final harvest

As depicted in Tables 15, 16, 17 and 18, main effects or interaction effects of treatments could not significantly influence the days taken for the final harvest in first and second year of field experimentation.

4.2.4.1d Number of harvests

Main effects (Table 39) or interaction effects (Tables 40, 41 and 42) of treatments did not significantly influence the number of harvests in first and second year of experimentation.

4.1.4.2 Yield and yield attributes

4.2.4.2a Number of fruits plant^{-1}

When poultry manure was used as organic source for N substitution, number of fruits plant^{-1} was not influenced by levels of N application or its ratios of substitution (Table 39) during first and second year of experimentation.

However, different frequencies of application significantly influenced the number of fruits plant^{-1} during 1995-96 (Table 35). Maximum number of fruits plant^{-1} (37.78) was recorded with the application nitrogen at f_1 frequency which was significantly higher than the number of fruits obtained with f_2 frequency (31.83) although it did not differ from f_3 treatment (34.28). Moreover there was no significant variation between f_3 and f_2 frequency treatments. However the main effects of treatments had no impact on number of fruits plant^{-1} during 1996-97.

Table 39 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on number of harvests, yield and yield attributes

Experiment II

Factor	Number of harvests		Fruit yield ($t\ ha^{-1}$)		Fruit yield/plant(kg)		Number of fruits/ Plant	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen								
l_1	8.44	9.94	9.99	8.33	4.00	3.33	35.56	30.44
l_2	8.61	9.83	9.54	8.83	3.86	3.53	34.22	32.06
l_3	8.61	9.94	9.62	9.12	3.85	3.65	34.11	33.06
$F_{2,22}$	0.56^{ns}	1.16^{ns}	0.38^{ns}	0.70^{ns}	0.28^{ns}	0.69^{ns}	0.35^{ns}	0.73^{ns}
Ratios								
r_1	8.56	10.00	9.39	8.90	3.76	3.56	35.61	31.17
r_2	8.56	9.94	9.60	8.85	3.88	3.54	35.06	33.00
r_3	8.56	9.98	10.16	8.54	4.07	3.42	36.22	31.39
$F_{2,22}$	0.00^{ns}	0.16^{ns}	1.07^{ns}	0.16^{ns}	1.01^{ns}	0.16^{ns}	1.85^{ns}	0.42^{ns}
Frequencies								
f_1	8.67	9.89	10.50	9.67	4.20	3.87	37.78	34.33
f_2	8.39	9.83	8.95	7.80	3.58	3.12	31.83	29.44
f_3	8.61	10.00	9.71	8.82	3.93	3.53	34.28	31.78
$F_{2,22}$	1.31^{ns}	2.03^{ns}	4.01^{*}	3.78^{*}	4.09^{*}	3.78^{*}	4.87^{*}	2.50^{ns}
SEd	0.38	0.18	1.16	1.44	0.46	0.57	4.06	4.64
CD	-	-	1.13	1.41	0.45	0.55	3.97	-

ns - Not Significant

* Significant at 5% level

Table 40 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on number of harvests, yield and yield attributes

Experiment II

Factor	Number of harvests		Fruit yield (t ha^{-1})		Fruit yield/plant(kg)		Number of fruits/ Plant	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	8.67	10.00	10.13	8.34	4.05	3.33	36.17	29.67
$l_1 r_2$	8.17	10.00	9.84	9.28	3.94	3.71	35.33	34.50
$l_1 r_3$	8.50	9.83	10.00	7.38	4.00	2.95	35.17	27.17
$l_2 r_1$	8.67	10.00	9.47	9.52	3.79	3.81	32.50	33.17
$l_2 r_2$	8.67	10.00	8.89	9.45	3.69	3.78	33.17	36.33
$l_2 r_3$	8.50	9.50	10.22	7.53	4.11	3.01	37.00	26.67
$l_3 r_1$	8.33	10.00	8.59	8.85	3.44	3.54	29.17	30.67
$l_3 r_2$	8.83	9.83	10.06	7.81	4.02	3.12	36.67	28.17
$l_3 r_3$	8.67	10.00	10.22	10.71	4.09	4.28	36.50	40.33
$F_{4,22}$	1.41^{ns}	2.50^{ns}	0.93^{ns}	3.05^{*}	0.76^{ns}	3.05^{*}	1.30^{ns}	5.33^{**}
SEd	0.38	0.30	1.16	-	0.46	-	4.06	-
CD	-	-	-	2.44	-	0.97	-	7.85

ns - Not Significant   * Significant at 5% level   ** Significant at 1% level

Table 41 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on number of harvests, yield and yield attributes

Experiment II

Factor	Number of harvests		Fruit yield (t ha^{-1})		Fruit yield/plant(kg)		Number of fruits/ Plant	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	8.50	9.83	10.37	9.0	4.15	3.63	37.00	32.67
$l_1 f_2$	8.67	10.00	10.08	8.02	4.03	3.21	36.83	29.50
$l_1 f_3$	8.17	10.00	9.52	7.91	3.81	3.16	32.83	29.17
$l_2 f_1$	8.83	9.83	11.23	9.16	4.49	3.66	40.17	32.17
$l_2 f_2$	8.17	9.67	8.04	7.54	3.22	3.02	27.67	28.33
$l_2 f_3$	8.83	10.00	9.36	9.80	3.88	3.92	34.83	35.67
$l_3 f_1$	8.67	10.00	9.89	10.77	3.96	4.31	36.17	38.17
$l_3 f_2$	8.33	9.83	8.74	7.85	3.50	3.14	31.00	30.50
$l_3 f_3$	8.83	10.00	10.23	8.75	4.09	3.50	35.17	30.50
$F_{4,22}$	2.16^{ns}	1.16^{ns}	1.76^{ns}	1.00^{ns}	1.75^{ns}	1.00^{ns}	2.33^{ns}	1.31^{ns}
SEd	0.38	0.18	1.16	1.44	0.46	0.57	4.06	4.64

ns - Not Significant

Table 42 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on number of harvests, yield and yield attributes

Experiment II

Factor	Number of harvests		Fruit yield (t ha^{-1})		Fruit yield/plant(kg)		Number of fruits/ Plant	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	8.83	10.00	10.34	10.42	4.14	4.17	37.17	35.50
$r_1 f_2$	8.00	10.00	8.43	7.94	3.37	3.18	29.00	28.17
$r_1 f_3$	8.83	10.00	9.41	8.35	3.76	3.34	31.67	29.83
$r_2 f_1$	8.83	10.00	9.69	9.22	3.88	3.69	34.67	32.83
$r_2 f_2$	8.67	9.83	9.14	8.25	3.66	3.30	33.17	32.83
$r_2 f_3$	8.67	10.00	9.97	9.07	4.12	3.63	37.33	31.33
$r_3 f_1$	8.83	9.67	11.47	9.36	4.59	3.74	41.50	34.83
$r_3 f_2$	8.50	9.67	9.28	7.22	3.71	2.89	33.33	34.67
$r_3 f_3$	8.33	10.00	9.74	9.05	3.90	3.62	33.83	28.83
$F_{4,22}$	2.72^{ns}	1.16^{ns}	0.69^{ns}	0.55^{ns}	0.87^{ns}	0.55^{ns}	1.45^{ns}	0.62^{ns}
SEd	0.38	0.18	1.16	1.44	0.46	0.57	4.06	4.64

ns - Not Significant

The LxR interaction could significantly influence the number of fruits plant^{-1} only during 1996-97 wherein the maximum number of fruits plant^{-1} (40.33) was produced by l_3r_3 in which highest level of nitrogen (300 kg) was applied through 2:1 organic-chemical N substitution ratio and minimum number of fruits plant^{-1} was produced (26.67) by l_2r_3 treatment when only 250 kg N was applied through the same ratio. However the l_3r_3 treatment did not significantly differ from l_1r_2, l_2r_1 or l_2r_2 in its effect on number of fruits plant^{-1} which also did not vary each other while it was superior to all other interactions (Table 40).

The LxF or RxF interactions did not have any significant effect on number of fruits plant^{-1} during both the years of experimentation (Tables 41 and 42).

4.2.4.2b Fruit yield plant^{-1}

In experiment II with poultry manure as organic source for nitrogen substitution, different levels of nitrogen or ratios of substitution did not influence the fruit yield plant^{-1} in both first and second year of experimentation as depicted in Table 39.

Different frequencies of application did have appreciable influence on plant^{-1} fruit yield. Maximum fruit yield plant^{-1} (4.20 kg) was recorded with f_1 treatment during 1995-96 wherein full quantity of poultry manure was applied as basal dose combined with fortnightly split application of fertiliser nitrogen in comparison with the f_2 treatment (3.58 kg) wherein total quantity of poultry manure was applied as basal and as equal splits at 40th and 70th DAS or f_3 treatment (3.93 kg) wherein both organic and chemical nitrogen sources were applied as fortnightly split doses. The f_1 and f_3 treatments did not differ each other while the

f_3 treatment did not vary from f_2. During 1996-97 also same trend was noticed in case of frequencies of application wherein maximum fruit yield plant^{-1} (3.87 kg) was recorded with f_1 treatment when compared with f_2 treatment (3.12 kg). Here also f_1 and f_3 treatments did not differ each other while the f_3 treatment (3.53 kg) did not vary from f_2.

Interaction effects are depicted in Tables 40, 41 and 42.

Among interaction effects, only LxR interaction could significantly influence the fruit yield plant^{-1} during the second year of experimentation (Table 40). Maximum fruit yield of 4.28 kg plant^{-1} was recorded with l_3r_3 treatment. wherein 300 kg of N was applied through 2:1 organic-chemical N ratio compared to the application of the lowest level of N through the same ratio ie. l_1r_3 (2.95 kg^{-1}).

4.2.4.2c Fruit yield (t ha^{-1})

It is shown in table 39 that when poultry manure was used as organic source in Experiment II, different levels of nitrogen or its ratios of substitution could not significantly influence the fruit yield (t ha^{-1}) during first or second year of field experimentation.

Different frequencies of application had marked influence on fruit yield in both the years (Table 39). During the first year maximum fruit yield of 10.50 t ha^{-1} was obtained when organic source was applied in full quantity as basal and fertiliser nitrogen at fortnightly split doses (f_1) which was significantly higher than the yield obtained with f_2 (8.95 t ha^{-1}) treatment. However the f_3 treatment

(9.71 t ha^{-1}) did not differ from f_1 and f_2 treatments in case of fruit yield (t ha^{-1}); Table 39. During 1996-97 also fruit yield t ha^{-1} was maximum (9.67) with f_1 followed by f_3 (8.82) and f_2 (7.80). Treatment f_1 was on a par with f_3 which in turn was on a par with f_2.

As depicted in Table 40, LxR interactions could not significantly influence the fruit yield (t ha^{-1}) in first year. However, during the second year, maximum yield (10.71 t ha^{-1}) was obtained with the l_3r_3 interaction wherein 300 kg^{-1} nitrogen was applied through 2:1 ratio of organic-fertiliser nitrogen sources and l_1r_3 interaction recorded the lowest yield of 7.38 t ha^{-1} wherein 200 kg of nitrogen was applied through 2:1 ratio of organic - chemical nitrogen sources.

The LxF and RxF interactions had no effect on fruit yield (t ha^{-1}) in both the years (Tables 41 and 42).

4.2.5 Total dry matter production (g plant^{-1})

As in case of Experiment I, levels of nitrogen or ratios of organic-chemical N substitution did not have any significant effect on total dry matter production plant^{-1} during 1995-96 and 1996-97 (Table 47).

Different frequencies of application did have marked influence on dry matter production (Table 47) during both the years. During the first year, maximum total dry matter production was recorded (489.63 g plant^{-1}) with the f_1 treatment wherein full quantity of poultry manure was applied as basal which was significantly superior to the f_2 treatment where total quantity of manure was applied as basal and as two split doses which registered the lowest dry matter production of 414.36

Table 47 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on total dry matter production of plant, depth of root penetration, root dry weight

Experiment - II

Factor	Total dry matter production(g plant^{-1})		Depth of root penetration(cm)		Root dry weight (g)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
<u>Nitrogen</u>						
l_1	464.71	451.07	32.61	40.14	3.75	3.37
l_2	446.95	477.64	35.25	38.47	3.56	4.46
l_3	454.03	479.54	32.72	37.06	3.92	3.73
$F_{2,22}$	0.36^{ns}	0.43^{ns}	1.08^{ns}	0.89^{ns}	0.50^{ns}	1.90^{ns}
<u>Ratios</u>						
r_1	447.47	485.53	32.81	40.47	3.72	4.14
r_2	449.23	457.95	33.47	38.47	3.95	3.59
r_3	469.99	464.77	34.31	36.72	3.56	3.83
$F_{2,22}$	0.80^{ns}	0.35^{ns}	0.27^{ns}	1.31^{ns}	0.58^{ns}	0.46^{ns}
<u>Frequencies</u>						
f_1	489.63	524.00	33.72	40.67	4.09	4.30
f_2	414.36	430.74	33.11	38.86	3.28	3.81
f_3	459.69	453.51	33.75	36.14	3.86	3.45
$F_{2,22}$	6.26^{**}	4.03^{*}	0.06^{ns}	1.94^{ns}	2.55^{ns}	1.11^{ns}
SEd	45.43	72.65	4.31	4.91	0.78	1.20
CD	44.42	71.03	-	-	-	-

ns - Not Significant   * Significant at 5% level   ** Significant at 1% level

Table 48 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on total dry matter production of plant, depth of root penetration and root dry weight

Experiment - II

Factor	Total dry matter production(g $plant^{-1}$)		Depth of root penetration(cm)		Root dry weight (g)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	489.09	447.72	33.33	43.50	3.62	3.56
$l_1 r_2$	437.27	473.82	32.42	38.08	4.19	3.32
$l_1 r_3$	467.77	431.68	32.08	38.83	3.44	3.25
$l_2 r_1$	433.08	534.52	31.92	41.67	3.75	5.23
$l_2 r_2$	432.55	490.21	35.00	39.17	3.76	4.28
$l_2 r_3$	475.22	408.20	38.83	34.58	3.17	3.85
$l_3 r_1$	411.24	474.35	33.17	36.25	3.79	3.62
$l_3 r_2$	477.89	409.81	33.00	38.17	3.91	3.18
$l_3 r_3$	466.97	554.44	32.00	36.75	4.07	4.40
$F_{4,22}$	1.45^{ns}	2.61^{ns}	0.90^{ns}	0.74^{ns}	0.42^{ns}	0.71^{ns}
SEd	45.43	72.65	4.31	4.91	0.78	1.20

ns - Not Significant

Table 49 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on total dry matter production of plant, depth of root penetration and root dry weight

Experiment - II

Factor	Total dry matter production(g plant^{-1})		Depth of root penetration(cm)		Root dry weight (g)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	490.93	489.08	33.50	43.67	4.50	3.66
$l_1 f_2$	463.99	459.04	32.67	41.17	3.31	3.74
$l_1 f_3$	439.21	405.11	31.67	35.58	3.44	2.72
$l_2 f_1$	518.99	505.91	34.08	38.92	3.56	4.61
$l_2 f_2$	375.96	417.86	34.33	37.33	3.12	3.97
$l_2 f_3$	445.89	509.16	37.33	39.17	4.00	4.78
$l_3 f_1$	458.98	577.03	33.58	39.42	4.20	4.62
$l_3 f_2$	403.13	415.33	32.33	38.08	3.42	3.72
$l_3 f_3$	493.98	446.25	32.25	33.67	4.14	2.86
$F_{4,22}$	2.60^{ns}	1.35^{ns}	0.35^{ns}	0.72^{ns}	0.73^{ns}	0.78^{ns}
SEd	45.43	72.65	4.31	4.91	0.78	1.20

ns - Not Significant

Table 50 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on total dry matter production of plant, depth of root penetration and root dry weight

Experiment - II

Factor	Total dry matter production(g plant^{-1})		Depth of root penetration(cm)		Root dry weight (g)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	495.56	555.44	33.00	40.25	4.21	3.77
$r_1 f_2$	392.37	457.08	33.92	45.00	3.43	4.54
$r_1 f_3$	445.48	444.07	31.50	36.17	3.52	4.09
$r_2 f_1$	446.95	464.86	33.50	39.42	3.93	3.40
$r_2 f_2$	426.43	444.63	33.50	37.42	3.93	3.96
$r_2 f_3$	474.33	464.35	33.42	38.58	3.99	3.40
$r_3 f_1$	526.40	551.71	34.67	42.33	4.12	5.17
$r_3 f_2$	424.29	390.52	31.92	34.17	2.49	2.92
$r_3 f_3$	459.27	452.09	36.33	33.67	4.07	2.87
$F_{4,22}$	1.18^{ns}	0.96^{ns}	0.49^{ns}	1.78^{ns}	1.31^{ns}	2.47^{ns}
SEd	45.43	72.65	4.31	4.91	0.78	1.20

ns - Not Significant

g plant^{-1}. The f_3 treatment in which the total quantity of poultry manure was applied as basal and fortnightly splits recorded a total dry matter production of 459.69 g plant^{-1} which did not significantly differ from that obtained with f_1 treatment. During the second year of experimentation also similar trend was observed wherein the highest total dry matter production was recorded (524.00 g plant^{-1}) with f_1 frequency which was significantly superior to f_2 frequency (430.74 g plant^{-1}). However the f_3 frequency which produced a drymatter content of 453.51 g plant^{-1} did not vary from f_1 or f_2 frequencies.

The LxR, LxF or RxF interactions could not significantly influence the total dry matter production (g plant^{-1}) during both the years of field trial (Tables 48, 49 and 50).

4.2.6 Root studies

4.2.6.1 Depth of root penetration (cm)

As in the case of Experiment I, different N levels, its ratios of substitution or frequencies of application did not have significant influence on depth of root penetration during 1995-96 or 1996-97 (Table 47). None of the interaction effects was significant in affecting root penetration, during both the years of field experimentation (Tables 48, 49 and 50).

4.2.6.2 Root dry weight (g)

In case of Experiment II also, treatment main effects or interaction effects did not significantly influence the root dry weight during 1995-96 and 1996-97 (Tables 47, 48, 49 and 50).

4.2.7 Keeping quality and shelf life studies

4.2.7.1 Shelf life of fruits at room temperature (days)

As indicated by Table 55, different levels of N did not have any influence on shelf life of fruits at room temperature during 1995-96 or 1996-97.

Different substitution ratios significantly influenced the shelf life of fruits during 1995-96, although it had no effect during 1996-97 (Table 55). Shelf life of fruits at room temperature was maximum with r_3 (4.00 days) wherein N was applied through 2:1 organic-chemical N substitution ratio and was significantly higher than r_1 (3.33 days). The r_2 ratio with 1:2 substitution ratio (3.67 days) however did not differ from r_1 or r_3.

Different frequencies of application significantly influenced the shelf life of fruits at room temperature during 1995-96, although it did not exert any influence during 1996-97. Shelf life was maximum in f_3 frequency (4.28 days) which was significantly higher than the shelf life at f_2 frequency (3.00 days) or f_1 frequency (3.72 days); Table 55.

The LxR interaction is depicted in Table 56. During 1995-96, Shelf life of fruits was highest (4.88 days) with l_1r_3 or l_2r_3 combination where in 200 or 250 kg N ha^{-1} was applied through 2:1 substitution ratio. However further increment in N level to 300 kg ha^{-1} significantly reduced the shelf life of fruits (3.83 days) even though it was supplied through 2:1 ratio in which the organic source dominates. During 1996-97 shelf life of fruits was not under the influence of LxR interaction.

Plate 6. Shelf life of fruits on 7[th] day of room temperature storage (Expt.I)
(FT_{22} - $l_3r_2f_1$, FT_{25} - $l_3r_3f_1$)

Plate 7. Shelf life of fruits on 7[th] day of room temperature storage (Expt.II)
(PT_{24} - $l_3r_2f_3$, PT_9 - $l_1r_3f_3$)

Table 55 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on shelf life of fruits and the Physiological loss in weight during storage

Experiment II

Factor	Shelf life of fruits (days)				Physiological loss in weight (%)			
	At room temperature		Under refrigeration		At room temperature		Under refrigeration	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen								
l_1	3.94	5.17	14.56	13.11	16.38	23.97	22.62	23.07
l_2	3.56	4.50	11.94	14.11	14.60	22.44	20.73	25.21
l_3	3.50	4.39	10.61	14.44	15.47	23.26	22.59	25.58
$F_{2,22}$	2.46^{ns}	1.77^{ns}	3.67*	2.69^{ns}	0.75^{ns}	0.13^{ns}	1.78^{ns}	1.27^{ns}
Ratios								
r_1	3.33	4.61	13.78	12.94	13.57	22.11	23.56	23.11
r_2	3.67	4.67	12.61	13.11	15.32	23.82	21.34	24.39
r_3	4.00	4.78	14.72	15.11	14.56	23.75	23.03	24.35
$F_{2,22}$	4.66*	0.07^{ns}	1.76^{ns}	6.89**	2.61^{ns}	0.21^{ns}	1.70^{ns}	1.59^{ns}
Frequencies								
f_1	3.72	4.22	14.22	13.72	14.93	21.47	22.08	26.71
f_2	3.00	5.06	13.50	13.94	12.12	23.80	22.41	25.07
f_3	4.28	4.78	13.39	14.00	12.41	24.41	23.44	23.07
$F_{2,22}$	17.21**	1.80^{ns}	0.32^{ns}	0.12^{ns}	1.94^{ns}	0.54^{ns}	0.63^{ns}	1.87^{ns}
SEd	0.46	0.95	2.39	1.26	3.07	6.36	2.67	2.19
CD	0.45	-	2.34	1.24	-	-	-	-

ns - Not Significant   * Significant at 5% level   ** Significant at 1% level

Table 56 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on shelf life of fruits and thePhysiological loss in weight during storage

Experiment II

Factor	Shelf life of fruits (days)				Physiological loss in weight (%)			
	At room temperature		Under refrigeration		At room temperature		Under refrigeration	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	3.67	5.33	16.50	12.83	12.92	23.69	26.54	24.44
$l_1 r_2$	3.83	5.33	12.67	11.67	18.03	24.94	23.97	26.19
$l_1 r_3$	4.88	4.83	14.50	14.83	18.19	23.29	23.35	17.58
$l_2 r_1$	3.17	4.50	11.67	12.33	14.21	21.52	19.14	24.55
$l_2 r_2$	3.17	4.50	12.50	14.33	11.40	24.56	18.80	24.59
$l_2 r_3$	4.88	4.50	11.67	15.67	18.19	21.25	24.24	26.50
$l_3 r_1$	3.17	4.00	13.17	13.67	13.58	21.12	25.00	23.37
$l_3 r_2$	3.63	4.17	12.67	14.83	16.54	21.96	21.25	28.37
$l_3 r_3$	3.83	5.00	18.00	14.83	16.30	26.71	21.50	28.99
$F_{4,22}$	3.04^{*}	0.58^{ns}	2.42^{ns}	1.99^{ns}	1.80^{ns}	0.39^{ns}	2.63^{ns}	1.87^{ns}
SEd	-	0.95	2.39	1.26	3.07	6.36	2.67	2.22
CD	0.78	-	-	-	-	-	-	-

ns - Not Significant * Significant at 5% level

Table 57 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on shelf life of fruits and the Physiological loss in weight during storage

Experiment II

Factor	Shelf life of fruits (days)				Physiological loss in weight (%)			
	At room temperature		Under refrigeration		At room temperature		Under refrigeration	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	4.17	4.50	17.17	13.00	15.37	21.47	23.37	25.43
$l_1 f_2$	3.68	5.33	14.83	13.17	20.14	24.22	24.90	21.64
$l_1 f_3$	5.00	5.67	12.17	13.17	19.62	26.23	25.60	22.14
$l_2 f_1$	3.83	3.67	12.17	13.67	16.50	19.73	20.83	27.79
$l_2 f_2$	3.50	5.17	12.00	14.50	18.39	24.75	19.62	25.99
$l_2 f_3$	3.33	4.67	11.67	14.17	18.91	22.85	21.73	21.86
$l_3 f_1$	3.17	4.50	13.33	14.50	18.92	23.20	22.06	29.93
$l_3 f_2$	3.33	4.67	14.17	14.17	19.82	22.43	22.71	27.59
$l_3 f_3$	3.00	4.00	16.33	14.67	16.69	24.16	22.99	25.22
$F_{4,22}$	5.31^{**}	0.88^{ns}	2.14^{ns}	0.17^{ns}	1.73^{ns}	0.21^{ns}	0.24^{ns}	0.83^{ns}
SEd	-	0.95	2.39	1.26	3.07	6.36	2.67	2.22
CD	0.78	-	-	-	-	-	-	-

ns - Not Significant ** Significant at 1% level

Table 58 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on shelf life of fruits and Physiological loss in weight during storage

Experiment II

Factor	Shelf life of fruits (days)				Physiological loss in weight (%)			
	At room temperature		Under refrigeration		At room temperature		Under refrigeration	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	3.67	4.00	14.67	12.83	16.60	18.37	23.69	23.50
$r_1 f_2$	3.67	4.67	13.33	12.67	15.96	23.20	23.22	25.03
$r_1 f_3$	2.67	5.17	13.33	13.33	16.15	24.76	23.78	20.83
$r_2 f_1$	3.17	4.67	12.50	13.83	16.52	24.28	22.68	27.73
$r_2 f_2$	3.50	4.83	12.17	13.67	18.41	21.50	21.04	22.49
$r_2 f_3$	3.33	4.50	13.17	13.33	15.02	25.68	20.30	22.93
$r_3 f_1$	4.33	4.00	15.50	14.50	19.66	21.76	19.89	31.90
$r_3 f_2$	4.67	5.67	15.00	15.50	20.98	26.70	22.98	27.70
$r_3 f_3$	5.33	4.67	13.67	15.33	18.04	22.79	26.23	25.46
$F_{4,22}$	2.85*	0.89^{ns}	0.30^{ns}	0.38^{ns}	2.08^{ns}	0.56^{ns}	2.13^{ns}	2.25^{ns}
SEd	-	0.95	2.39	1.26	3.07	6.36	2.67	2.22
CD	0.78	-	-	-	-	-	-	-

ns - Not Significant   * Significant at 5% level

The LxF interaction affecting the shelf life of fruits is depicted in Table 57. During 1995-96, shelf life at room temperature storage was highest (5.00 days) when lowest level of nitrogen was applied with its organic and chemical N sources as basal and at fortnightly split doses in l_1f_3 treatment combination. However, further increase in the level of nitrogen to 250 or 300 kg N ha^{-1} lowered the shelf life of fruits, irrespective of frequencies and was lowest with l_3f_3 treatment combination (3.00 days). The LxF interaction however was not significant in the succeeding year (1996-97) of experimentation.

As depicted in Table 58, RxF interaction significantly influenced the shelf life of fruits at room temperature. During 1995-96, shelf life of fruits was highest (5.33 days) when nutrient N was applied through 2:1 organic- chemical N substitution ratio with organic + chemical N sources as basal + fortnightly intervals in r_3f_3 which was significantly superior to the shelf life recorded with r_1f_3 (2.67 days) and r_2f_3 (3.33 days) treatment combinations wherein 1:1 or 1:2 substitution ratios were followed. Shelf life of fruits was not affected by RxF interaction during 1996-97.

4.2.7.2 Shelf life of fruits under refrigeration (days)

Effects of levels of N, ratios of substitution and frequencies of application on shelf life of fruits under refrigeration when poultry manure was used as an organic source of N substitution are depicted in Table 55.

Different levels of N nutrition significantly influenced the shelf life of fruits during 1995-96 although it did not show any effect during 1996-97. When level of N nutrition was raised from 200 (l_1) to 250 and 300 kg N ha^{-1} (l_2 and l_3) the shelf life of fruits under refrigeration significantly reduced from 14.56 days to 11.94 and 10.61 days respectively. However the higher levels of N application (l_2 and l_3) did not differ each other in this respect (Table 55).

Different ratios of N substitution did not have any influence on shelf life of fruits under refrigeration during 1995-96. However during the succeeding year of 1996-97 shelf life was maximum when N was supplied through 2:1 organic-chemical N ratio (15.11 days) in r_3 as compared to 1:2 ratio (r_2) and 1:1 ratio (r_1) which recorded shelf life of 13.11 and 12.94 days respectively.

Different frequencies of N nutrition could not influence the shelf life of fruits during 1995-96 and 1996-97.

Various interaction effects did not have any influence on shelf life of fruits under refrigeration (Tables 56, 57 and 58) during 1995-96 or 1996-97.

4.2.7.3 Physiological loss in weight at room temperature storage (%)

As indicated by Table 55, main effects of treatments (L, R or F) did not influence the physiological loss in weight during storage at room temperature during 1995-96 and 1996-97. None of the interaction effects had any influence of physiological loss in weight during storage at room temperature during both the years (Tables 56, 57 and 58).

4.2.7.4 Physiological loss in weight under refrigeratory storage (%)

When poultry manure was used as organic source for N substitution neither the main effects (Table 55) or their interactions (Tables 56, 57 and 58) had any significant influence on physiological loss in weight during storage of fruits under refrigeration during 1995-96 or 1996-97.

4.2.8 Plant analysis

4.2.8.1 Total N content in plant (%)

When poultry manure was used as organic source for N substitution, neither the main effects (Table 63) or various interaction effects viz. LxR (Table 64), LxF (Table 65) or RxF (Table 66) had any significant influence on total N content in plant during 1995-96 and 1996-97.

4.2.8.2 Total P content in plant (%)

During 1995-96, different levels of N did not influence the total P content of plants (Table 63). However during the succeeding year, highest level of application of nitrogen (l_3) recorded the maximum P content of 0.33 per cent in plants which was significantly superior to l_2 which registered a total P content of 0.29 per cent in plants. However the lowest level of N application (200 kg N ha^{-1}) which registered a P content of 0.32 per cent did not significantly differ from l_3 treatment.

Different ratios of substitution had significant influence on total plant P content only during 1996-97 and was highest (0.33 per cent) with r_3 (2:1 organic - chemical N) ratio which was significantly superior to r_1 (0.30 per cent) or r_2 (0.30 per cent) which in turn were similar in effect.

Table 63 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on total N,P and K contents of plant.

Experiment - II

Factor	Total Plant N (%)		Total Plant P (%)		Total Plant K (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen						
l_1	1.89	2.10	0.31	0.32	3.11	2.95
l_2	1.79	2.11	0.32	0.29	3.37	3.19
l_3	1.65	2.26	0.30	0.33	3.58	3.55
$F_{2,22}$	1.84^{ns}	0.95^{ns}	1.05^{ns}	6.94^{**}	21.96^{**}	16.49^{**}
Ratios						
r_1	1.84	2.09	0.31	0.30	3.27	3.11
r_2	1.66	2.20	0.31	0.30	3.34	3.30
r_3	1.82	2.18	0.31	0.33	3.45	3.29
$F_{2,22}$	1.30^{ns}	0.43^{ns}	0.25^{ns}	5.86^{*}	3.30^{ns}	2.11^{ns}
Frequencies						
f_1	1.79	2.23	0.31	0.32	3.40	3.26
f_2	1.82	2.14	0.31	0.31	3.27	3.24
f_3	1.71	2.10	0.31	0.31	3.38	3.19
$F_{2,22}$	0.44^{ns}	0.58^{ns}	0.18^{ns}	0.53^{ns}	2.22^{ns}	0.27^{ns}
SEd	0.26	0.27	0.02	0.02	0.02	0.22
CD	-	-	-	0.02	0.15	0.22

ns - Not Significant ** Significant at 1% level * Significant at 5% level

Table 64 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on total N, P and K contents of plant

Experiment - II

Factor	Total Plant N (%)		Total Plant P (%)		Total Plant K (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	1.97	2.01	0.32	0.31	3.30	2.89
$l_1 r_2$	1.90	2.19	0.31	0.31	3.19	3.14
$l_1 r_3$	1.79	2.09	0.31	0.34	3.15	2.84
$l_2 r_1$	1.83	1.99	0.31	0.27	3.32	3.08
$l_2 r_2$	1.63	2.19	0.33	0.31	3.44	3.14
$l_2 r_3$	1.91	2.14	0.31	0.30	3.35	3.36
$l_3 r_1$	1.73	2.26	0.31	0.32	3.49	3.36
$l_3 r_2$	1.45	2.22	0.30	0.32	3.40	3.61
$l_3 r_3$	1.77	2.31	0.31	0.35	3.85	3.68
$F_{4,22}$	0.62^{ns}	0.21^{ns}	1.04^{ns}	0.94^{ns}	1.11^{ns}	1.24^{ns}
SEd	0.26	0.27	0.02	0.02	0.02	0.22

ns - Not Significant

Table 65 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on total N, P and K contents of plant

Experiment - II

Factor	Total Plant N (%)		Total Plant P (%)		Total Plant K (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	1.83	2.14	0.31	0.33	3.14	3.05
$l_1 f_2$	1.99	2.11	0.31	0.32	3.01	2.85
$l_1 f_3$	1.86	2.05	0.32	0.30	3.18	2.96
$l_2 f_1$	1.79	2.20	0.32	0.31	3.48	3.18
$l_2 f_2$	1.90	2.05	0.32	0.29	3.29	3.27
$l_2 f_3$	1.67	2.08	0.31	0.29	3.35	3.13
$l_3 f_1$	1.75	2.36	0.31	0.32	3.61	3.57
$l_3 f_2$	1.59	2.26	0.31	0.33	3.51	3.61
$l_3 f_3$	1.61	2.16	0.30	0.33	3.62	3.47
$F_{4,22}$	0.39^{ns}	0.08^{ns}	0.36^{ns}	0.94^{ns}	0.30^{ns}	1.25^{ns}
SEd	0.26	0.27	0.02	0.02	0.02	0.22

ns - Not Significant

Table 66 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on total N, P and K contents of plant

Experiment - II

Factor	Total Plant N (%)		Total Plant P (%)		Total Plant K (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	1.94	2.16	0.32	0.29	3.37	2.93
$r_1 f_2$	1.84	2.04	0.32	0.30	3.18	3.25
$r_1 f_3$	1.75	2.07	0.30	0.29	3.26	3.15
$r_2 f_1$	1.58	2.32	0.32	0.32	3.30	3.42
$r_2 f_2$	1.81	2.16	0.31	0.31	3.24	3.21
$r_2 f_3$	1.59	2.12	0.32	0.30	3.49	3.27
$r_3 f_1$	1.86	2.23	0.30	0.33	3.56	3.45
$r_3 f_2$	1.82	2.21	0.31	0.32	3.40	3.27
$r_3 f_3$	1.79	2.10	0.31	0.33	3.40	3.15
$F_{4,22}$	0.34^{ns}	0.01^{ns}	0.56^{ns}	0.75^{ns}	1.25^{ns}	1.72^{ns}
SEd	0.26	0.27	0.02	0.02	0.02	0.22

ns - Not Significant

Different frequencies of application did not influence the total plant P content during 1995-96 or 1996-97 (Table 63).

The LxR interaction (Table 64), LxF interaction (Table 65) or RxF interaction (Table 66) could not significantly influence the total P content in plant during 1995-96 or 1996-97.

4.2.8.3 Total K content in plant (%)

Different levels of N application significantly influenced the total K content in plants during 1995-96 (Table 63). Increase in levels of N significantly increased the total K content in plants and was maximum (3.58 per cent) with the application of 300 kg N (l_3) ha^{-1} which was significantly superior to l_2 (3.37 per cent) which inturn was significantly higher than l_1 (3.11 per cent). Similar trend was noticed during 1996-97 too wherein total K content was maximum (3.55 per cent) with the application of 300 kg N ha^{-1} (l_3) which was significantly superior to the total K content of 3.19 per cent recorded with the application of 250 kg (l_2) and 2.95 per cent with 200 kg nitrogen (l_1).

Different ratios of substitution or frequencies of application did not have any influence on total K content of plant during 1995-96 or 1996-97 (Table 63).

Interaction effects depicted in Tables 64, 65 and 66 showed that these effects could not significantly influence the total K content in plant during 1995-96 or 1996-97.

4.2.9 Fruit analysis

4.2.9.1 Crude protein content of fruits (%)

Different levels of application of nutrient N significantly influenced the crude protein content of fruits during 1995-96 as well as 1996-97 (Table 71) wherein increasing levels of N increased the crude protein content. During 1995-96, highest crude protein content of 21.77 per cent was recorded with the application of highest level or 300 kg of N (l_3) which was significantly higher than the crude protein content obtained with the application of 250 kg N (20.04 per cent) or 200 kg N (19.87 per cent) which were on a par. During 1996-97 also same trend was noticed wherein highest crude protein content of 21.93 per cent was recorded with l_3 (300 kg N) which was superior to l_2 (250 kg N) or l_1 (200 kg N) which recorded crude protein contents of 20.19 and 19.90 per cent respectively which did not differ each other.

Different ratios of N substitution or frequencies of application did not have any influence on the crude protein contents of fruits in Experiment II during 1995-96 or 1996-97 (Table 71). The LxR interaction or LxF interaction or RxF interaction did not have any influence on crude protein content of fruits (Tables 72, 73 and 74) during first and second years of experimentation.

4.2.9.2 Total P content of fruits (%)

Different levels of nitrogen application significantly influenced the total P content of fruits during 1995-96 as well as 1996-97 (Table 71). During 1995-

Table 71 : Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on crude protein, total P, total K, iron and ascorbic acid contents of fruit

Experiment - II

Factor	Crude protein content of fruit(%)		Total P content of fruit (%)		Total K content of fruit (%)		Iron content of fruit (%)		Ascorbic acid content of fruit (mg 100ml^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen										
l_1	19.87	19.90	1.00	1.02	7.57	7.19	0.08	0.09	101.72	120.36
l_2	20.04	20.19	1.05	1.07	7.49	7.21	0.10	0.10	100.04	114.80
l_3	21.77	21.93	1.08	1.11	7.83	7.30	0.10	0.10	90.04	108.35
$F_{2,22}$	27.21**	14.68**	4.66*	6.83**	4.75*	0.57^{ns}	8.29**	0.03^{ns}	16.10**	3.21^{ns}
Ratios										
r_1	20.01	20.26	1.04	1.07	7.63	7.20	0.09	0.11	95.08	108.57
r_2	19.97	20.66	1.02	1.05	7.53	7.16	0.09	0.09	98.44	118.66
r_3	20.70	21.10	1.08	1.07	7.74	7.34	0.10	0.09	98.27	116.28
$F_{2,22}$	2.13^{ns}	2.15^{ns}	2.75^{ns}	0.68^{ns}	1.74^{ns}	1.40^{ns}	0.79^{ns}	1.49^{ns}	1.45^{ns}	2.47^{ns}
Frequencies										
f_1	19.83	20.40	1.04	1.05	7.73	7.23	0.10	0.09	98.13	120.49
f_2	20.16	20.70	1.03	1.08	7.61	7.23	0.09	0.10	99.74	109.91
f_3	20.69	20.92	1.07	1.06	7.55	7.25	0.09	0.10	96.93	113.12
$F_{2,22}$	2.33^{ns}	0.82^{ns}	0.97^{ns}	1.03^{ns}	1.21^{ns}	0.018^{ns}	1.44^{ns}	0.06^{ns}	2.20^{ns}	2.61^{ns}
SEd	0.84	0.86	0.06	0.05	0.24	0.24	0.01	0.02	4.72	10.07
CD	0.82	0.84	0.06	0.05	0.24	-	0.01	-	4.69	-

ns - Not Significant ** Significant at 1% level *Significant at 5% level

Table 72 : Interaction effect of levels of nitrogen and its ratios of substitution (L x R) on crude protein, total P, total K, iron and ascorbic acid contents of fruits

Experiment - II

Factor	Crude protein content of fruit(%)		Total P content of fruit (%)		Total K content of fruit (%)		Iron content of fruit (%)		Ascorbic acid content of fruit (mg $100ml^{-1}$)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	18.20	19.63	0.99	1.02	7.53	7.09	0.07	0.10	103.99	127.10
$l_1 r_2$	19.04	20.34	0.99	1.01	7.51	7.17	0.09	0.09	108.00	135.46
$l_1 r_3$	19.36	19.73	1.03	1.03	7.68	7.31	0.09	0.10	103.17	128.53
$l_2 r_1$	19.73	20.32	1.05	1.11	7.49	7.13	0.08	0.11	110.65	114.28
$l_2 r_2$	19.94	19.65	1.01	1.04	7.32	7.17	0.10	0.09	106.17	123.39
$l_2 r_3$	20.45	20.60	1.10	1.05	7.66	7.32	0.12	0.09	103.30	126.74
$l_3 r_1$	22.10	20.83	1.07	1.08	7.86	7.38	0.12	0.11	99.60	124.34
$l_3 r_2$	20.93	21.99	1.06	1.09	7.75	7.14	0.09	0.09	101.16	127.13
$l_3 r_3$	22.29	22.96	1.12	1.14	7.86	7.40	0.19	0.09	108.35	123.58
$F_{4,22}$	1.14^{ns}	2.03^{ns}	0.12^{ns}	1.35^{ns}	0.20^{ns}	0.40^{ns}	15.10**	0.09^{ns}	2.60^{ns}	2.42^{ns}
SEd	0.84	0.86	0.06	0.05	0.24	0.24	-	0.02	6.30	10.07
CD	-	-	-	-	-	-	0.02	-	-	-

ns - Not Significant **Significant at 1% level

Table 73 : Interaction effect of levels of nitrogen and its frequencies of application (L x F) on crude protein, total P, total K, iron and ascorbic acid contents of fruits

Experiment - II

Factor	Crude protein content of fruit(%)		Total P content of fruit (%)		Total K content of fruit (%)		Iron content of fruit (%)		Ascorbic acid content of fruit (mg 100ml ¹)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	18.02	19.37	1.00	1.00	7.59	7.21	0.08	0.10	121.49	134.55
$l_1 f_2$	19.70	19.97	0.95	1.04	7.61	7.31	0.08	0.09	125.27	110.47
$l_1 f_3$	18.88	20.36	1.05	1.02	7.52	7.24	0.09	0.10	98.41	116.06
$l_2 f_1$	19.85	19.79	1.04	1.05	7.78	7.15	0.11	0.09	116.79	121.32
$l_2 f_2$	19.33	20.29	1.04	1.08	7.46	7.20	0.09	0.11	128.96	104.65
$l_2 f_3$	20.94	20.47	1.08	1.07	7.22	7.27	0.10	0.09	104.37	118.44
$l_3 f_1$	21.65	22.03	1.09	1.10	7.82	7.33	0.10	0.10	126.11	105.59
$l_3 f_2$	21.44	21.82	1.10	1.13	7.75	7.35	0.10	0.09	127.99	114.61
$l_3 f_3$	22.24	21.92	1.07	1.10	7.93	7.24	0.10	0.10	106.01	104.85
$F_{4,22}$	2.11^{ns}	0.37^{ns}	0.99^{ns}	0.07^{ns}	1.63^{ns}	0.24^{ns}	1.14^{ns}	0.74^{ns}	2.79^{ns}	2.66^{ns}
SEd	0.84	0.86	0.06	0.05	0.24	0.24	0.01	0.02	6.30	10.07

ns - Not Significant

Table 74 : Interaction effect of ratios of substitution and frequencies of application of nitrogen (R x F) on crude protein, total P, total K, iron and ascorbic acid contents of fruit

Experiment - II

Factor	Crude protein content of fruit(%)		Total P content of fruit (%)		Total K content of fruit (%)		Iron content of fruit (%)		Ascorbic acid content of fruit (mg 100ml⁻¹)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	19.38	19.60	1.01	1.08	7.64	7.25	0.09	0.09	113.85	123.35
$r_1 f_2$	19.86	20.43	1.03	1.11	7.59	7.19	0.09	0.11	93.04	111.57
$r_1 f_3$	20.79	20.74	1.07	1.03	7.65	7.16	0.09	0.12	108.36	120.79
$r_2 f_1$	20.18	20.42	1.03	1.01	7.75	7.09	0.10	0.09	110.11	125.11
$r_2 f_2$	19.43	20.68	1.02	1.08	7.47	7.13	0.09	0.08	105.59	129.40
$r_2 f_3$	20.30	20.88	1.01	1.06	7.36	7.25	0.10	0.09	99.63	121.48
$r_3 f_1$	19.96	21.18	1.08	1.06	7.80	7.34	0.10	0.10	100.43	113.00
$r_3 f_2$	21.18	20.98	1.04	1.06	7.77	7.35	0.09	0.09	93.60	128.76
$r_3 f_3$	20.96	21.13	1.12	1.11	7.65	7.33	0.09	0.09	100.80	127.08
$F_{4,22}$	1.30^{ns}	0.43^{ns}	0.84^{ns}	2.02^{ns}	0.57^{ns}	0.23^{ns}	0.27^{ns}	0.72^{ns}	2.57^{ns}	2.08^{ns}
SEd	0.84	0.86	0.06	0.05	0.24	0.24	0.01	0.02	6.30	10.07

ns - Not Significant

96, total P content of fruits was higher (1.08 per cent) when 300 kg N ha^{-1} (l_3) was given compared to the application of 250 kg N ha^{-1} (l_2) or 200 kg N ha^{-1} (l_1) which recorded total P contents of 1.05 and 1.00 per cent respectively. However there was no variation between the two higher levels (l_2 and l_3) in respect of total P content. During 1996-97 also similar trend was noticed wherein the total P content of fruits was maximum (1.11 per cent) with l_3 (300 kg N ha^{-1}) treatment when compared to l_2 (250 kg N ha^{-1}) or l_1 (200 kg N ha^{-1}) which recorded total P contents of 1.07 and 1.02 per cent respectively although l_3 and l_2 treatments were on a par.

Different ratios of substitution or frequencies of application had no effect on total P content of fruits during 1995-96 and 1996-97 (Table 71).

None of the interaction effects (Tables 72, 73 and 74) had any significant influence on total P content of fruits during 1995-96 or 1996-97.

4.2.9.3 Total K content of fruits (%)

The total K content of bitter gourd fruits was significantly influenced by different levels of N only during 1995-96 (Table 71) and maximum total K content of 7.83 per cent was recorded with the application 300 kg N (l_3) which was significantly higher than the total K content recorded with 250 kg N(l_2) or 200 kg N ha^{-1} (l_1) treatments which produced 7.49 and 7.57 per cent total K contents respectively. However the l_2 and l_1 treatments did not vary each other in respect of total K content in fruits. During 1996-97, different N levels had no influence on total K content of fruits.

Ratios of N substitution or frequencies of N application did not influence the total K content in fruits during 1995-96 or 1996-97 (Table 71).

Different interaction effects too (Tables 72, 73 and 74) did not affect the total K content in fruits during both the years of field experimentation.

4.2.9.4 Iron content of fruits (%)

When poultry manure was used as an organic source of N substitution, higher levels of N application enhanced the iron content of fruits (Table 71) during 1995-96. Higher fruit iron content was recorded with the application of either 300 kg N (0.10 per cent) or 250 kg N (0.10 per cent) which was significantly higher than the iron content recorded with the application of lowest level (200 kg) of N (0.08 per cent). However this influence was nonsignificant during 1996-97.

Different ratios of substitution or frequencies of application however could not influence the iron content of fruits during 1995-96 or 1996-97 (Table 71).

The LxR interaction significantly influenced the iron content of fruits during 1995-96 (Table 72). Maximum iron content in fruits was recorded (0.19 per cent) when 300 kg of N was supplied through 2:1 organic-chemical N substitution ratio in l_3r_3 treatment combination which was significantly higher than the iron content recorded with l_1r_3 (0.09 per cent) or l_2r_3 (0.12 per cent). Fruit iron content was lower (0.07 per cent) when lowest level of N was supplied through 1:1 ratio of N substitution in l_1r_1 treatment combination. The LxR interaction could not significantly influence the iron content of fruits during 1996-97.

The LxF interaction (Table 73) or RxF interaction (Table 74) did not have any impact on iron content of bitter gourd fruits during 1995-96 and 1996-97.

4.2.9.5 Ascorbic acid content of fruits (mg 100 ml^{-1})

Different levels of N application significantly influenced the ascorbic acid content of fruits only during 1995-96 (Table 71) when poultry manure was used as organic source of N substitution. As the N level was raised from 200 kg (l_1) or 250 kg (l_2) to 300 kg (l_3), ascorbic acid content of fruits was lowered to 90.04 mg 100 ml^{-1} (l_3) from 100.04 (l_2) and 101.72 mg 100 ml^{-1} (l_1) respectively although the l_2 and l_1 treatments did not differ each other.

Different substitution ratios or frequencies of application had no influence on ascorbic acid content of fruits during 1995-96 or 1996-97 (Table 71).

The LxR or LxF or RxF interactions too did not have any influence on ascorbic acid content of fruits (Tables 72, 73 and 74).

4.2.10 Soil Biological properties

4.2.10.1 Soil Bacterial Population (1x10^8 g^{-1})

Different levels of N significantly influenced the soil bacterial population during 1995-96 (Table 79) wherein a general reduction in count was noticed when compared to the initial population of 13.1 (1x10^8 g^{-1}). As nitrogen level was enhanced from l_1 (200 kg) to l_2 (250 kg) or l_3 (300 kg) the soil bacterial population count also increased from 10.76 to 11.96 and 11.91 (1x10^8 g^{-1}) respectively

Table - 79 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on soil microbial population

Experiment II

Factor	Soil bacterial population (1×10^8 g^{-1})		Soil fungal population (1×10^4 g^{-1})		Soil actinomycetes population (1×10^6 g^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen						
l_1	10.76 (4.23)	9.82 (3.29)	81.81 (9.10)	76.96 (8.83)	0.54 (1.24)	0.61 (1.27)
l_2	11.96 (3.60)	10.02 (3.32)	80.90 (9.05)	78.21 (8.90)	0.56 (1.25)	0.62 (1.28)
l_3	11.91 (3.58)	9.63 (3.26)	85.67 (9.31)	83.45 (9.19)	0.36 (1.17)	0.72 (1.31)
$F_{2,22}$	19.62**	0.49^{ns}	4.87*	6.31**	2.38^{ns}	1.11^{ns}
Ratios						
r_1	11.88(3.59)	9.63 (3.26)	81.26 (9.07)	78.38 (8.91)	0.61 (1.27)	0.54 (1.23)
r_2	11.04 (3.47)	10.22 (3.35)	83.27 (9.18)	80.00 (9.00)	0.61 (1.27)	0.49 (1.22)
r_3	11.97 (3.66)	9.63 (3.26)	83.82 (9.21)	80.00 (9.00)	0.48 (1.22)	0.64 (1.28)
$F_{2,22}$	8.43**	1.65^{ns}	1.32^{ns}	0.43^{ns}	0.72^{ns}	1.01^{ns}
Frequencies						
f_1	11-39 (3.52)	10.42 (3.38)	83.45 (9.19)	80.00 (9.00)	0.48 (1.22)	0.69 (1.26)
f_2	11.67 (3.56)	9.82 (3.29)	82.35 (9.13)	82.17 (9.12)	0.63 (1.28)	0.51 (1.23)
f_3	11.53 (3.54)	9.24 (3.20)	82.53 (9.14)	80.44 (9.05)	0.56 (1.25)	0.56 (1.25)
$F_{2,22}$	1.00^{ns}	4.30*	0.18^{ns}	2.30^{ns}	0.60^{ns}	0.18^{ns}
SEd	0.06	0.13	0.19	0.22	0.10	0.10
CD	0.06	0.13	0.18	0.22	-	-

ns - Not Significant * - Significant at 5% level ( ) - Transformed mean

** - Significant at 1% level

Table - 80 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on soil microbial population.

Experiment II

Factor	Soil bacterial population (1×10^8 g^{-1})		Soil fungal population (1×10^4 g^{-1})		Soil actinomycetes population (1×10^6 g^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	11.96 (3.60)	10.29 (3.36)	80.36 (9.02)	78.38 (8.91)	1.64 (1.43)	0.85 (1.37)
$l_1 r_2$	11.81 (3.58)	9.76 (3.28)	80.72 (9.04)	78.74 (8.93)	0.63 (1.28)	0.39 (1.18
$l_1 r_3$	11.74 (3.57)	9.43 (3.23)	84.19 (9.23)	73.82 (8.65)	0.61 (1.27)	0.59 (1.26)
$l_2 r_1$	12.69 (3.70)	9.63 (3.26)	77.49 (8.86)	77.14 (8.84)	0.51 (1.23)	0.28 (1.13)
$l_2 r_2$	10.97 (3.46)	10.76 (3.43)	84.56 (9.25)	75.56 (8.75)	0.61 (1.27)	0.44 (1.20)
$l_2 r_3$	12.24 (3.64)	9.75 (3.28)	80.90 (9.05)	81.81 (9.11)	0.58 (1.26)	0.28 (1.13)
$l_3 r_1$	10.90 (3.46)	9.05 (3.17)	86.04 (9.33)	79.82 (8.99)	0.29 (1.14)	0.49 (1.22)
$l_3 r_2$	10.28 (3.36)	10.29 (3.36)	84.74 (9.26)	85.67 (9.31)	0.58 (1.27)	0.61 (1.27)
$l_3 r_3$	10.97 (3.46)	9.56 (3.25)	86.23 (9.34)	84.74 (9.26)	0.23 (1.11)	0.70 (1.30)
$F_{4,22}$	2.58^{ns}	1.15^{ns}	1.60^{ns}	2.36^{ns}	1.58^{ns}	2.31^{ns}
SEd	0.06	0.13	0.19	0.22	0.10	0.1

ns - Not Significant

( ) - Transformed mean

Table - 81 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on soil microbial population.

Experiment II

Factor	Soil bacterial population (1 x 10^8 g^{-1})		Soil fungal population (1 x 10^4 g^{-1})		Soil actinomycetes population (1 x 10^6 g^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	11.67 (3.56)	10.22 (3.35)	80.18 (9.01)	75.38 (8.74)	0.87 (1.37)	0.54 (1.24)
$l_1 f_2$	11.89 (3.59)	9.96 (3.31)	82.90 (9.16)	80.90 (9.05)	0.79 (1.34)	0.71 (1.32)
$l_1 f_3$	11.96 (3.60)	9.30 (3.21)	82.17 (9.12)	74.69 (8.70)	0.58 (1.26)	0.56 (1.25)
$l_2 f_1$	11.67 (3.56)	9.76 (3.43)	81.44 (9.08)	78.03 (8.89)	0.39 (1.18)	0.39 (1.18)
$l_2 f_2$	11.96 (3.60)	9.89 (3.30)	80.54 (9.03)	80.00 (9.00)	0.74 (1.32)	0.23 (1.11)
$l_2 f_3$	12.17 (3.63)	9.43 (3.24)	81.08 (9.06)	76.44 (8.80)	0.61 (1.27)	0.35 (1.16)
$l_3 f_1$	10.69 (3.42)	10.29 (3.36)	88.49 (9.46)	86.42 (9.35)	0.27 (1.13)	0.82 (1.35)
$l_3 f_2$	11.11 (3.48)	9.63 (3.26)	84.00 (9.22)	85.49 (9.30)	0.39 (1.18)	0.59 (1.26)
$l_3 f_3$	10.42 (3.38)	9.04 (3.17)	84.56 (9.25)	78.56 (8.92)	0.46 (1.21)	0.61 (1.33)
$F_{4,22}$	0.99^{ns}	0.08^{ns}	0.95^{ns}	0.83^{ns}	0.97^{ns}	0.66^{ns}
SEd	0.06	0.13	0.19	0.22	0.10	0.10

ns - Not Significant ( ) - Transformed mean

Table - 82 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on soil microbial population.

Experiment II

Factor	Soil bacterial population (1×10^8 g^{-1})		Soil fungal population (1×10^4 g^{-1})		Soil actinomycetes population (1×10^6 g^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	11.46 (3.53)	10.22 (3.36)	80.54 (9.03)	80.54 (9.03)	0.51 (1.23)	0.61 (1.27)
$r_1 f_2$	11.74 (3.57)	9.62 (3.26)	80.72 (9.04)	81.99 (9.11)	0.58 (1.26)	0.54 (1.24)
$r_1 f_3$	12.32 (3.65)	9.04 (3.17)	82.72 (9.15)	73.13 (8.61)	0.71 (1.31)	0.44 (1.20)
$r_2 f_1$	10.49 (3.39)	10.70 (3.42)	84.93 (9.28)	80.90 (9.05)	0.63 (1.28)	0.51 (1.23)
$r_2 f_2$	11.11 (3.48)	9.82 (3.29)	81.81 (9.10)	81.08 (9.06)	0.63 (1.28)	0.32 (1.15)
$r_2 f_3$	11.46 (3.53)	11.22 (3.35)	83.08 (9.17)	77.85 (8.88)	0.56 (1.25)	0.61 (1.27)
$r_3 f_1$	12.87 (3.73)	10.36 (3.37)	84.55 (9.25)	78.38 (8.91)	0.34 (1.17)	0.61 (1.27)
$r_3 f_2$	12.10 (3.62)	9.89 (3.30)	84.93 (9.27)	83.08 (9.18)	0.66 (1.29)	0.69 (1.30)
$r_3 f_3$	10.76 (3.43)	8.55 (3.09)	81.99 (9.11)	78.74 (8.93)	0.42 (1.19)	0.61 (1.27)
$F_{4,22}$	1.30^{ns}	0.93^{ns}	0.81^{ns}	0.92^{ns}	0.62^{ns}	0.66^{ns}
SEd	0.06	0.13	0.19	0.22	0.10	0.10

ns - Not Significant ( ) - Transformed mean although the l_2 and l_3 levels were on a par. Soil bacterial population was not influenced by N levels during 1996-97.

Soil bacterial population was significantly influenced by different ratios of N substitution during 1995-96 (Table 79) wherein it was significantly higher with 2:1 organic-chemical N ratio (r_3) which recorded a population count of 11.97 ($1x10^8 g^{-1}$) compared to r_1 (1:1 ratio) which registered a bacterial count of 11.88 ($1x10^8$ g^{-1}) or r_2 (1:2 ratio) which recorded the lowest bacterial count of 11.04 ($1x10^8 g^{-1}$). However during 1996-97 soil bacterial population was not influenced by ratios of N substitution.

Different frequencies of application did not affect the soil bacterial population during 1995-96. However it influenced the population count during 1996-97 and there was a general decline in bacterial population when compared to the initial value of 11.5 ($1x10^8$ g^{-1}). The population was maximum with f_1 frequency which produced a count of 10.42 ($1x10^8 g^{-1}$) which was significantly superior to f_2 frequency which recorded a soil bacterial count of 9.82 ($1x10^8 g^{-1}$) which in turn was superior to the population count of 9.24 ($1x10^8$) registered with the f_3 treatment (Table 79).

Soil bacterial population was not under the influence of LxR (Table 80) or LxF (Table 81) or RxF (Table 82) during 1995-96 and 1996-97.

4.2.10.2 Soil Fungal Population ($1x10^4$ g^{-1})

Main effects of treatments on soil fungal population are depicted in Table 79.

During 1995-96, different levels of N application significantly influenced the soil fungal population. As the N level was raised from 200 to 250 kg, there was a slight reduction in fungal population from 81.81 to 80.90 ($1x10^4$ g^{-1}) although the next higher dose of N (300 kg) significantly improved the population count to 85.67 ($1x10^4$ g^{-1}) and all the levels improved the fungal population as compared to the initial population count of 78.2 ($1x10^4$ g^{-1}). During 1996-97 also same trend was observed, wherein increasing levels of N from 200 to 250 and 300 kg ha^{-1} increased the fungal population from 76.96 to 78.21 and then to 83.45 (1×10^4 g^{-1}) respectively.

Different ratios of N substitution or frequencies of application did not influence the soil fungal population during 1995-96 or 1996-97 (Table 79).

None of the interaction effects were significant in affecting the soil fungal population (Tables 80, 81 and 82).

4.2.10.3 Soil Actinomycetes Population ($1x10^6$ g^{-1})

Main effects of treatments (L, R and F) shown in Table 79 or their interactions (Tables 80, 81 and 82) could not significantly influence the soil actinomycetes population during 1995-96 or 1996-97.

4.2.11 Soil physico-chemical properties

4.2.11.1 Soil Reaction (pH)

Main effects of L, R and F are depicted in Table 87.

Table - 87 Effect of levels of nitrogen, ratios of substitution of nitrogen, and frequencies of application of nitrogen on physico-chemical properties of soil.

Experiment II

Factor	Bulk density (g cc^{-1})		Water holding capacity (%)		Particle density (g cc^{-1})		Porosity (%)		Soil reaction (pH)		Organic carbon content (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
<u>Nitrogen</u>												
l_1	1.28	1.29	33.35	34.05	2.71	2.84	43.03	43.48	5.36	5.30	0.64	0.73
l_2	1.28	1.30	34.39	34.26	2.84	2.70	43.78	43.83	5.31	5.23	0.68	0.71
l_3	1.27	1.29	35.48	34.02	2.75	2.83	41.96	44.30	5.32	5.26	0.64	0.73
$F_{2,22}$	1.43^{ns}	2.81^{ns}	3.30^{ns}	0.09^{ns}	3.12^{ns}	1.25^{ns}	1.09^{ns}	0.66^{ns}	2.11^{ns}	1.04^{ns}	1.27^{ns}	1.55^{ns}
<u>Ratios</u>												
r_1	1.28	1.30	34.54	34.36	2.73	2.68	42.52	43.61	5.33	5.26	0.68	0.69
r_2	1.30	1.29	33.04	33.97	2.86	2.76	43.67	43.93	5.22	5.12	0.57	0.60
r_3	1.26	1.29	35.64	34.00	2.71	2.73	42.58	44.07	5.33	5.41	0.72	0.78
$F_{2,22}$	35.76**	2.70^{ns}	4.95*	0.23^{ns}	5.15*	2.05^{ns}	0.55^{ns}	0.21^{ns}	10.19**	15.77**	12.38**	46.75**
<u>Frequencies</u>												
f_1	1.28	1.30	33.89	34.10	2.79	2.70	42.82	44.42	5.31	5.31	0.69	0.74
f_2	1.28	1.29	34.71	34.30	2.77	2.74	43.07	43.24	5.27	5.22	0.67	0.68
f_3	1.28	1.29	34.72	33.94	2.74	2.73	42.89	43.95	5.31	5.26	0.70	0.75
$F_{2,22}$	0.84^{ns}	0.34^{ns}	0.58^{ns}	0.17^{ns}	0.50^{ns}	0.69^{ns}	0.02^{ns}	1.38^{ns}	1.08^{ns}	1.77^{ns}	3.27^{ns}	1.66^{ns}
SEd	0.01	0.01	1.76	1.31	0.11	0.09	2.63	1.52	0.06	0.11	0.07	0.04
CD	0.01	–	1.72	–	0.10	–	–	–	0.06	0.10	0.07	0.04

ns - Not Significant

* - Significant at 5% level

** - Significant at 1% level

Table - 88 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on physico - chemical properties of soil.

Experiment II

Factor	Bulk density (g cc^{-1})		Water holding capacity (%)		Particle density (g cc^{-1})		Porosity (%)		Soil reaction (pH)		Organic carbon content (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	1.25	1.31	31.22	33.88	2.58	2.57	40.88	42.85	5.52	5.43	0.71	0.68
$l_1 r_2$	1.28	1.31	32.80	33.89	2.79	2.66	44.85	44.36	5.25	5.22	0.64	0.62
$l_1 r_3$	1.28	1.30	36.02	34.38	2.77	2.68	43.36	43.23	5.32	5.35	0.59	0.68
$l_2 r_1$	1.29	1.30	36.00	34.66	2.83	2.66	42.67	43.61	5.30	5.20	0.72	0.76
$l_2 r_2$	1.32	1.30	32.11	34.52	2.96	2.80	44.07	43.63	5.27	5.27	0.56	0.56
$l_2 r_3$	1.27	1.30	35.05	33.61	2.71	2.65	44.61	44.25	5.35	5.32	0.67	0.60
$l_3 r_1$	1.29	1.28	36.41	34.52	2.79	2.80	44.00	44.38	5.28	5.23	0.61	0.62
$l_3 r_2$	1.29	1.27	34.20	33.50	2.82	2.81	42.10	43.80	5.25	5.28	0.51	0.61
$l_3 r_3$	1.23	1.26	38.85	34.03	2.64	2.88	39.78	44.72	5.33	5.55	0.69	0.87
$F_{4,22}$	11.18**	0.17^{ns}	3.04*	0.46^{ns}	2.42^{ns}	1.49^{ns}	1.79^{ns}	0.52^{ns}	1.55^{ns}	1.04^{ns}	1.85^{ns}	2.31^{ns}
SEd	–	0.01	–	1.31	0.11	0.09	2.63	1.52	0.06	0.11	0.07	0.05
CD	0.02	–	2.99	–	–	–	–	–	–	–	–	–

ns - Not Significant

* - Significant at 5% level

** - Significant at 1% level

Table - 89 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on physico - chemical properties of soil

Experiment II

Factor	Bulk density (g cc^{-1})		Water holding capacity (%)		Particle density (g cc^{-1})		Porosity (%)		Soil reaction (pH)		Organic carbon content (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	1.28	1.32	32.99	34.22	2.75	2.63	43.80	43.50	5.35	5.28	0.60	0.60
$l_1 f_2$	1.28	1.30	33.78	33.81	2.68	2.63	43.33	43.52	5.35	5.25	0.62	0.60
$l_1 f_3$	1.27	1.30	33.26	34.13	2.71	2.66	41.96	43.41	5.38	5.37	0.72	0.68
$l_2 f_1$	1.29	1.30	34.47	33.85	2.88	2.64	42.46	44.41	5.37	5.37	0.67	0.72
$l_2 f_2$	1.29	1.31	34.29	35.57	2.84	2.75	43.09	42.81	5.22	5.12	0.70	0.66
$l_2 f_3$	1.30	1.30	34.45	33.37	2.79	2.72	45.80	44.27	5.33	5.20	0.68	0.76
$l_3 f_1$	1.28	1.27	34.25	34.23	2.74	2.83	42.20	45.35	5.22	5.28	0.51	0.59
$l_3 f_2$	1.27	1.27	36.05	33.51	2.79	2.84	42.79	43.39	5.25	5.28	0.69	0.70
$l_3 f_3$	1.26	1.28	36.15	34.31	2.72	2.82	40.90	44.15	5.20	5.20	0.72	0.72
$F_{4,22}$	0.73^{ns}	1.77^{ns}	0.34^{ns}	1.28^{ns}	0.36^{ns}	0.46^{ns}	1.07^{ns}	0.46^{ns}	2.45^{ns}	2.02^{ns}	2.52^{ns}	2.37^{ns}
SEd	0.01	0.01	1.76	1.31	0.11	0.09	2.63	1.52	0.06	0.11	0.07	0.05

ns - Not Significant

Table - 90 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on physico-chemical properties of soil.

Experiment II

Factor	Bulk density (g cc^{-1})		Water holding capacity (%)		Particle density (g cc^{-1})		Porosity (%)		Soil reaction (pH)		Organic carbon content (%)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	127	1.29	34.19	33.98	2.75	2.64	41.47	43.58	5.38	5.30	0.62	0.62
$r_1 f_2$	1.28	1.30	34.39	34.88	2.76	2.69	41.99	44.14	5.30	5.27	0.75	0.78
$r_1 f_3$	1.27	1.30	35.05	34.21	2.69	2.70	44.10	43.11	5.32	5.20	0.62	0.66
$r_2 f_1$	1.30	1.30	32.70	34.01	2.86	2.72	44.81	45.21	5.22	5.20	0.49	0.51
$r_2 f_2$	1.31	1.29	32.52	34.49	2.91	2.79	44.47	43.02	5.22	5.07	0.55	0.59
$r_2 f_3$	1.30	1.29	33.89	33.40	2.81	2.77	41.75	43.55	5.23	5.10	0.66	0.67
$r_3 f_1$	1.28	1.29	34.79	34.31	2.76	2.73	42.18	44.47	5.33	5.43	0.67	0.76
$r_3 f_2$	1.24	1.28	37.22	33.52	2.64	2.75	42.75	42.56	5.30	5.32	0.70	0.68
$r_3 f_3$	1.24	1.28	34.91	34.20	2.72	2.73	42.81	45.17	5.37	5.47	0.78	0.91
$F_{4,22}$	4.67**	0.72^{ns}	0.98^{ns}	0.52^{ns}	0.80^{ns}	0.16^{ns}	1.05^{ns}	1.52^{ns}	0.77^{ns}	0.90^{ns}	1.63^{ns}	14.20**
SEd	–	0.01	1.76	1.31	0.11	0.09	2.63	1.52	0.06	0.11	0.07	–
CD	0.02	–	–	–	–	–	–	–	–	–	–	0.07

ns - Not Significant
** - Significant at 1 % level

During 1995-96 or 1996-97, different levels of N had no significant effect on soil reaction.

During 1995-96, the pH values after the experimentation were low in comparison with initial value of 5.5. Application of nutrient N through 1:1 or 2:1 organic-chemical N ratio produced higher soil pH of 5.33 which was significantly higher than the pH recorded with 1:2 ratio (5.22). During the succeeding year of 1996-97, soil pH was higher (5.41) with 2:1 ratio when compared to 1:1 (5.26) or 1:2 (5.12) treatment combinations, which were still lower than the initial value (5.40).

Different frequencies of N application had no influence on soil reaction during 1995-96 and 1996-97.

No interaction effect was significant in influencing the soil reaction during 1995-96 or 1996-97 (Tables 88, 89 and 90).

4.2.11.2 Organic carbon content of soil (%)

Main effects of treatments on organic carbon content of soil when poultry manure was used as organic source are given in Table 87. Different levels of N application did not influence the organic carbon content during 1995-96 or 1996-97.

Different ratios of substitution significantly influenced the organic carbon content during 1995-96 and 1996-97 wherein it was greater than the initial values of 0.31 and 0.44 per cent respectively. During the first year, maximum organic carbon content of 0.72 per cent was recorded with 2:1 (r_3) ratios of substitution which was on a par with 1:1 (r_1) ratio which produced an organic carbon content of 0.68 per cent. Organic carbon content was minimum (0.57 per cent) with 1:2 (r_2) ratio of N substitution. Similar trend was observed during 1996-97 (Table 87) too wherein maximum organic carbon content of 0.78 per cent was recorded with r_3 followed by r_1 (0.69 per cent) and r_2 (0.60 per cent).

Different frequencies of application had no influence on soil organic carbon content during 1995-96 or 1996-97 (Table 87).

The LxR interaction (Table 88) or LxF interaction (Table 89) could not influence the organic carbon content of soil during 1995-96 or 1996-97.

The RxF interaction (Table 90) significantly influenced the organic carbon content during 1996-97 although it had no influence during the previous year. Maximum organic carbon content of 0.91 per cent was recorded with the application of r_3f_3 and the minimum (0.51 per cent) with r_2f_1 treatment.

4.2.11.3 Soil Physical Properties

4.2.11.3a Bulk density (g cc^{-1})

Effect of levels of N, ratios of substitution or frequencies of application are given in Table 87.

Different levels of N had no influence on bulk density of soil during 1995-96 or 1996-97.

Different ratios of N substitution affected the soil bulk density during 1995-96 which was lower than the initial value of 1.43 eventhough it did not have any influence during the succeeding year. During 1995-96 bulk density was lowest (1.26) with r_3 (2:1 ratio) followed by r_1 (1:1) and r_2 (1:2) ratios which recorded the values 1.28 and 1.30 respectively (Table 87).

Different frequencies of application could not influence the bulk density during 1995-96 or 1996-97 (Table 87).

The LxR interaction (Table 88) significantly influenced the bulk density of soil only during 1995-96 wherein it was minimum (1.23) with the l_3r_3 treatment combination and maximum (1.32) with l_2r_2 combination.

The LxF interaction (Table 89) did not have any influence on bulk density during 1995-96 or 1996-97.

The RxF interaction (Table 90) did influence the bulk density only during 1995-96 wherein the value was lower (1.24) with r_3f_3 treatment combination which did not differ from that obtained with r_3f_2 (1.24) and higher bulk density (1.31) was noticed with the r_2f_2 combination.

4.2.11.3b Water holding capacity (%)

As shown in Table 87, different levels of N application had not influenced the water holding capacity of soil during 1995-96 or 1996-97.

Different ratios of N substitution significantly influenced the water holding capacity only during the first year (1995-96) wherein it was higher than the initial value of 28.83 per cent. Maximum water holding capacity (35.64 per cent) was recorded with 2:1 organic-chemical N substitution ratio (r_3) followed by r_1 or 1:1 ratio (34.54 per cent) and then r_2 or 1:2 ratio (33.04 per cent). However the r_3 and r_1 were on a par while the r_3 was on a par with r_2. During the succeeding year of 1996-97, these effects were not significant.

Different frequencies of application could not influence the water holding capacity of soil during 1995-96 or 1996-97.

The LxR interaction shown in Table 88 indicated its influence on water holding capacity of soil. During 1995-96 maximum water holding capacity of 38.85 per cent was recorded with the application of 300 kg N through 2:1 ratio of substitution in l_3r_3 which was on a par with l_3r_1 combination (36.41 per cent) or l_1r_3 combination (36.02 per cent). However these effects were not significant during the succeeding year of 1996-97.

The LxF interaction (Table 89) or RxF interaction (Table 90) did not influence the water holding capacity of soil during 1995-96 or 1996-97.

4.2.11.3c Particle Density (g cc^{-1})

Main effects of the treatment are depicted in Table 87.

Different levels of N application did not significantly influence the particle density of soil during 1995-96 or 1996-97.

Different ratios of substitution significantly influenced the soil particle density during 1995-96 wherein it was maximum (2.86) with N nutrition through

1:2 ratio of substitution, which was higher than the particle density recorded with r_3 (2.71) or r_1 (2.73) although r_3 and r_1 were on a par. All the substitution ratios produced lower particle densities as compared to the initial value of 2.98. During 1996-97 particle density was unaffected by different ratios of substitution (Table 87).

Different frequencies of application could not influence the particle density during 1995-96 or 1996-97 (Table 87).

The LxR interaction (Table 88) or LxF interaction (Table 89) or RxF interaction (Table 90) did not have any influence on particle density of soil during the first or second year of field experimentation.

4.2.11.3d Porosity (%)

Main effects (L, R or F) of the treatments did not significantly influence the soil porosity during 1995-96 and 1996-97 (Table 87).

None of the interaction effects significantly influenced the soil porosity during 1995-96 or 1996-97 (Tables 88, 89 and 90).

4.2.12 Nutrient Balance Studies

4.2.12.1 Nitrogen balance in soil

4.2.12.1a N-uptake (kg ha^{-1})

Effect of different levels of N, ratios of substitution or frequencies of application on N-uptake are depicted in Table 95.

Table - 95 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on N-balance in soil.

Experiment II

Factor	N - Uptake by crop ($kg\ ha^{-1}$)		Expected N Balance in Soil ($kg\ ha^{-1}$)		Actual N Balance/Available N-content in soil ($kg\ ha^{-1}$)		Net loss (-) or gain (+) of N ($kg\ ha^{-1}$)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
<u>Nitrogen</u>								
l_1	32.54	32.39	302.31	374.59	166.56	260.11	-135.75	-144.47
l_2	33.12	34.31	351.73	422.67	154.88	266.91	-196.89	-155.76
l_3	35.40	37.50	399.24	469.49	153.49	273.35	-245.75	-196.13
$F_{2,22}$	1.24^{ns}	2.04^{ns}	1210.00**	692.52**	11.89**	2.90^{ns}	381.89**	97.05**
<u>Ratios</u>								
r_1	32.44	34.86	352.41	422.12	162.03	269.52	-190.39	-152.10
r_2	32.83	33.76	352.02	423.22	151.92	258.02	-200.14	-165.20
r_3	35.80	35.59	348.84	421.39	160.98	272.83	-187.86	-148.56
$F_{2,22}$	1.82^{ns}	0.26^{ns}	1.99^{ns}	0.26^{ns}	7.13**	2.99*	5.29*	4.38*
<u>Frequencies</u>								
f_1	35.81	38.29	349.04	418.69	158.72	271.26	-190.33	-147.43
f_2	30.64	31.86	354.21	425.13	155.06	271.44	-199.15	-153.69
f_3	34.62	34.06	350.02	422.92	161.16	257.67	-188.91	-165.25
$F_{2,22}$	3.96*	3.27^{ns}	3.89*	3.29^{ns}	2.18^{ns}	4.12*	2.88^{ns}	2.76^{ns}
SEd	4.08	5.42	4.18	5.41	6.24	11.66	8.35	12.58
CD	3.99	–	4.09	5.29	6.10	11.41	8.27	12.16

ns - Not Significant

* - Significant at 5 % level

** - Significant at 1% level

Table - 96 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on N-balance in soil.

Experiment II

Factor	N - Uptake by crop (kg ha^{-1})		Expected N Balance in Soil (kg ha^{-1})		Actual N Balance/Available N-content in soil (kg ha^{-1})		Net loss (-) or gain (+) of N (kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	33.07	31.22	301.75	375.76	177.71	257.15	-124.08	-118.61
$l_1 r_2$	31.44	35.96	303.41	371.02	158.37	274.92	-145.05	-96.09
$l_1 r_3$	33.12	30.00	301.73	376.98	163.60	248.27	-138.14	-128.71
$l_2 r_1$	31.69	37.36	353.16	419.62	150.01	294.78	-203.16	-124.84
$l_2 r_2$	31.61	35.19	353.24	421.80	147.92	241.99	-205.46	-179.80
$l_2 r_3$	36.08	30.39	348.77	426.59	166.73	263.95	-182.04	-162.65
$l_3 r_1$	32.56	35.99	402.29	470.98	158.37	256.63	-243.92	-214.36
$l_3 r_2$	35.46	30.12	399.40	476.86	149.48	257.15	-249.91	-219.71
$l_3 r_3$	38.20	46.38	396.02	460.61	152.62	306.28	-243.40	-154.33
$F_{4,22}$	0.48^{ns}	4.49**	0.48^{ns}	4.50**	2.16^{ns}	1.75^{ns}	2.51^{ns}	1.97^{ns}
SEd	4.08	–	4.18	–	6.24	11.66	8.46	12.43
CD	–	9.18	–	9.16	–	–	–	–

ns - Not Significant

** - Significant at 1 % level

Table - 97 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on N-balance in soil.

Experiment II

Factor	N - Uptake by crop (kg ha^{-1})		Expected N Balance in Soil (kg ha^{-1})		Actual N Balance/Available N-content in soil (kg ha^{-1})		Net loss (-) or gain (+) of N (kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	3303	33.95	301.82	373.04	173.00	249.32	-128.82	-123.72
$l_1 f_2$	33.86	33.18	300.99	373.80	164.12	265.51	-136.88	-108.29
$l_1 f_3$	30.73	30.05	304.12	376.93	162.55	265.51	-141.57	-111.41
$l_2 f_1$	38.09	36.10	346.76	420.88	153.14	285.38	-193.62	-135.51
$l_2 f_2$	31.94	29.39	357.91	427.59	146.87	263.42	-211.04	-164.17
$l_2 f_3$	34.34	37.44	350.51	419.54	164.64	251.92	-186.00	-167.62
$l_3 f_1$	36.31	44.82	398.54	462.16	150.00	279.10	-248.54	-183.06
$l_3 f_2$	31.12	32.99	403.73	473.99	154.19	285.38	-249.55	-188.62
$l_3 f_3$	38.78	34.69	395.43	472.30	156.28	255.58	-239.16	-216.71
$F_{4,22}$	2.53^{ns}	1.62^{ns}	2.54^{ns}	1.63^{ns}	3.65*	4.81**	2.07^{ns}	2.44^{ns}
SEd	4.08	5.42	4.18	5.41	-	-	14.33	21.06
CD	-	-	-	-	10.57	19.75	-	-

ns - Not Significant

* - Significant at 5 % level

** - Significant at 1 % level

Table - 98 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on N-balance in soil.

Experiment II

Factor	N - Uptake by crop (kg ha^{-1})		Expected N Balance in Soil (kg ha^{-1})		Actual N Balance/Available N-content in soil (kg ha^{-1})		Net loss (-) or gain (+) of N (kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	35.23	39.72	349.63	417.26	168.30	274.92	-181.33	-142.34
$r_1 f_2$	28.58	32.20	356.27	424.78	157.85	278.58	-198.43	-146.20
$r_1 f_3$	33.51	32.66	351.34	424.33	159.94	255.06	-191.40	-169.27
$r_2 f_1$	32.88	33.45	351.97	423.53	149.48	257.15	-202.49	-166.38
$r_2 f_2$	30.43	33.08	354.42	423.90	147.39	255.06	-207.03	-168.84
$r_2 f_3$	35.19	34.73	349.66	422.25	158.89	261.86	-190.91	-160.40
$r_3 f_1$	39.32	41.69	345.53	415.29	158.37	281.72	-187.16	-133.57
$r_3 f_2$	32.91	30.28	351.94	426.71	159.94	280.67	-192.01	-146.04
$r_3 f_3$	30.16	34.80	349.06	422.19	164.64	256.11	-184.42	-166.08
$F_{4,22}$	0.56^{ns}	1.00^{ns}	0.44^{ns}	1.00^{ns}	1.94^{ns}	2.15^{ns}	1.37^{ns}	2.47^{ns}
SEd	4.08	5.42	4.18	5.41	6.24	11.66	8.46	12.43

ns - Not Significant

Different levels of N application had no influence on N-uptake by crop during 1995-96 or 1996-97.

Different ratios of substitution too could not influence the N-uptake during both the years of field experimentation.

Different frequencies of application significantly influenced the N-uptake during 1995-96 although it did not have any influence during the succeeding year. Uptake was maximum (35.81 kg N ha^{-1}) with f_1 frequency which was significantly higher than the uptake recorded at f_2 frequency (30.64 kg).

However the uptake recorded at f_3 (34.62 kg) was on a par with the uptake at f_1 (35.81 kg); Table 95.

N-uptake was not influenced by LxR interaction (Table 96) during 1995-96. During 1996-97 uptake was maximum (46.38 kg ha^{-1}) when 300 kg N was applied through 2:1 organic- chemical N substitution ratio in l_3r_3 which was significantly higher than all other treatment combinations except l_2r_1 recording an uptake of 37.36 kg N ha^{-1} which was on par with N-uptake at l_3r_3 combination. N-uptake was lowest (30.0 kg N ha^{-1}) with l_1r_3 combination.

The LxF (Table 97) or RxF (Table 98) interaction did not influence the N-uptake during 1995-96 and 1996-97.

4.2.12.1b Expected N balance in soil (kg ha^{-1})

Different levels of N application significantly influenced the expected N balance in soil (Table 95) which increased with increasing levels of N. Expected

N balance in soil was maximum (399.24 kg) with l_3 (300 kg N) when compared to l_2 (250 kg) or l_1 (200 kg) recording 351.73 kg and 302.31 kg N ha^{-1} respectively. Similar observations were made during 1996-97 too wherein the expected N content in soil was maximum (469.49 kg) with l_3 when compared to l_2 (422.67 kg) and l_1 (374.59 kg N ha^{-1}).

Different ratios of substitution had no influence on expected N balance in soil during first or second years of experimentation (Table 95).

During 1995-96, the expected N balance was higher (354.21 kg) with f_2 frequency than f_3 or f_1 recording 350.02 kg and 349.04 kg N ha^{-1} respectively although the f_3 and f_1 were on a par. The frequencies of application did not have any influence on expected N balance in soil during 1996-97 (Table 95).

The LxR interaction (Table 96) had no influence on expected N balance of soil during 1995-96. However during the succeeding year of 1996-97, expected soil N balance showed an increasing trend with increasing levels of N irrespective of its ratio of substitution. Application of 300 kg N (l_2) through r_2 (1:2) ratio of N substitution (l_3 r_2) recorded significantly higher expected N balance of 476.86 kg ha^{-1} in l_3r_2, which was superior to all other treatment combinations except l_3r_1 recording an expected N balance of 470.98 kg ha^{-1} which was on a par with the l_3r_2 combination and also did not differ from l_1r_3 (376.98 kg) or l_1r_1 (375.76 kg). The LxF (Table 97) or RxF (Table 98) interactions could not affect the expected N balance in soil during 1995-96 or 1996-97.

4.2.12.1c Actual N balance or Available N content of soil (kg ha^{-1})

Main effects of the treatments are depicted in Table 95.

Different levels of N application significantly influenced the actual N balance of soil during 1995-96 and the nutrient nitrogen status in general after the experimentation was higher than the initial value (134.85 kg ha^{-1}). Application of l_1 (200 kg) recorded the highest balance of 166.56 kg N ha^{-1} which was superior to l_2 or l_3 treatments producing 154.88 kg and 153.49 kg N ha^{-1} respectively which did not differ each other. However during 1996-97, levels of N application had no influence on actual N balance of soil.

Different ratios of N substitution significantly influenced the actual N balance of soil only during 1995-96 wherein maximum actual N balance of 162.03 kg was obtained with r_1 (1:1) ratio of N substitution which was on a par with r_3 (2:1) ratio producing 160.98 kg N ha^{-1}. The actual N balance of soil was lowest (151.92 kg) with r_2 (1:2) ratio of substitution (Table 95).

Different frequencies of application did not influence the actual N balance of soil during 1995-96 although N nutrition through f_1 or f_2 frequencies recorded significantly higher actual N balance of 271.26 kg and 271.44 kg N ha^{-1} respectively which did not vary each other during 1996-97. However, nitrogen nutrition through f_3 frequency recorded lowest actual N balance of 257.67 kg N ha^{-1}.

The LxR interaction (Table 96) did not influence the actual N balance in soil during 1995-96 or 1996-97.

Actual N balance of soil was significantly affected by LxF interaction (Table 97) during 1995-96. Application of lowest level of N dose (200 kg N) at f_1 frequency recorded the highest available N content or actual N balance of 173.00 kg in soil which was on a par with l_1f_2 and l_1f_3 recording 164.12 kg and 162.55 kg respectively which also did not vary each other. The lowest available N content of 150.00 kg N ha^{-1} was observed with l_3f_1 combination. During 1996-97, all the treatment combinations improved the actual N balance of soil when compared to the previous year and was maximum (285.38 kg N ha^{-1}) with l_3f_2 or l_2f_1 combination and was minimum (249.32 kg N ha^{-1}) with l_1f_1 combination.

The RxF interaction (Table 98) did not influence the actual N balance of soil during first or second year of experimentation.

4.2.12.1d The Net loss (-) or gain (+) of N (kg ha^{-1})

Different levels of N application, ratios of substitution and frequencies of application significantly influenced the net loss of nitrogen (Table 95).

During 1995-96, the net loss of nutrient N significantly increased with increasing levels of N application which was maximum (-245.75 kg) with l_3 (300 kg) and was significantly higher when compared to l_2 (250 kg) or l_1 (200 kg) recording a net N loss of -196.89 kg and -135.75 kg respectively. During 1996-97 also similar trend was observed wherein, increase in N level from l_1 (200 kg) to l_2 (250 kg) and l_3 (300 kg) significantly increased the net loss of N from -144.47 kg to -155.76 kg and -196.13 kg respectively.

Different ratios of N substitution significantly influenced the net loss of N during 1995-96 as well as 1996-97. During the first year of experimentation, net loss of N was highest (-200.14 kg N) with r_2 (1:2) ratio of organic- chemical N substitution which was significantly greater than the net N loss recorded at r_1 (-190.39 kg) or r_3 (-187.86 kg) which were on a par each other. During the second year of field experimentation also similar observations were noticed wherein the net loss of N was higher (-165.20 kg) in r_2 ratio compared to r_1 (-152.60 kg) or r_3 (-148.56 kg) which were on a par each other.

Different frequencies of application had no influence on net loss or gain of N during 1995-96 or 1996-97.

None of the interactions (Tables 96, 97 and 98) significantly influenced the net loss or gain of N during 1995-96 and 1996-97.

4.2.12.2 Phosphorus balance in Soil

4.2.12.2a P-Uptake (P_2O_5 kg ha^{-1})

Main effects of the treatment (L, R or F) on P-uptake by crop are depicted in Table 103.

Different levels of N application did not significantly influence the P-uptake during 1995-96 or 1996-97.

P-uptake was not influenced by different ratios of N substitution during both the years of field experimentation.

Different frequencies of N application however had profound influence on P-uptake by crop only during 1995-96, wherein maximum P-uptake of 25.75

Table - 103 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on P - balance in soil.

Experiment II

Factor	P - Uptake by crop (P_2O_5 kg ha^{-1})		Expected P Balance in Soil (P_2O_5 kg ha^{-1})		Actual P Balance/Available P content in soil (P_2O_5 kg ha^{-1})		Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen								
l_1	23.15	21.06	111.17	107.28	29.11	42.22	-82.05	-65.23
l_2	23.45	22.96	131.16	126.10	26.82	52.44	-104.56	-73.66
l_3	24.17	24.42	151.16	145.35	23.41	55.78	-127.76	-89.57
$F_{2,22}$	0.36^{ns}	1.66^{ns}	552.87^{**}	213.12^{**}	1.94^{ns}	12.92^{**}	104.01^{**}	28.24^{**}
Ratios								
r_1	22.50	23.33	132.33	125.72	21.15	47.63	-108.16	-78.27
r_2	22.96	22.26	97.69	92.28	25.29	49.81	-72.40	-42.48
r_3	25.31	22.84	163.47	160.72	29.89	53.01	-133.80	-107.71
$F_{2,22}$	2.99^{ns}	0.17^{ns}	1497.04^{**}	689.09^{**}	2.18^{ns}	1.90^{ns}	189.40^{**}	197.17^{**}
Frequencies								
f_1	25.75	25.07	129.56	128.98	28.18	52.23	-101.38	-71.75
f_2	24.18	20.84	133.28	128.21	21.60	48.22	-111.90	-80.15
f_3	21.22	22.52	130.64	126.53	21.52	49.99	-109.12	-76.54
$F_{2,22}$	5.46^{*}	2.67^{ns}	2.07^{ns}	2.67^{ns}	16.90^{**}	1.04^{ns}	19.96^{**}	3.28^{ns}
SEd	2.62	3.91	4.41	3.91	6.18	5.88	-	6.98
CD	2.56	-	4.30	3.82	6.04	5.76	6.57	6.82

ns - Not Significant * - Significant at 5 % level ** - Significant at 1% level

Table - 104 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on P - balance in soil.

Experiment II

Factor	P - Uptake by crop (P_2O_5 kg ha^{-1})		Expected P Balance in Soil (P_2O_5 kg ha^{-1})		Actual P Balance/Available P content in soil (P_2O_5 kg ha^{-1})		Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	23.39	21.01	110.93	107.35	25.64	38.56	-85.26	-69.28
$l_1 r_2$	22.20	22.68	85.05	78.34	33.17	40.66	-51.89	-37.68
$l_1 r_3$	23.86	19.50	137.53	136.17	28.53	47.45	-109.00	-88.71
$l_2 r_1$	22.28	25.79	132.45	123.26	27.27	52.58	-105.18	-70.67
$l_2 r_2$	21.95	23.59	98.42	90.68	24.22	49.59	-74.20	-41.09
$l_2 r_3$	26.01	19.48	162.60	164.36	28.97	55.15	-134.30	-109.21
$l_3 r_1$	21.73	23.18	153.60	146.57	19.55	51.73	-134.05	-94.84
$l_3 r_2$	24.72	18.52	109.60	107.83	18.50	59.17	-91.10	-48.66
$l_3 r_3$	26.07	29.55	190.29	181.65	32.17	56.43	-158.12	-125.20
$F_{4,22}$	0.83^{ns}	3.28^{*}	23.77^{**}	4.78^{**}	1.98^{ns}	0.93^{ns}	0.83^{ns}	3.52^{*}
SEd	2.62	-	-	-	6.18	5.89	6.72	-
CD	-	6.62	4.32	6.62	-	-	-	11.82

ns - Not Significant * - Significant at 5 % level ** - Significant at 1% level

Table - 105 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on P - balance in soil.

Experiment II

Factor	P - Uptake by crop (P_2O_5 kg ha^{-1})		Expected P Balance in Soil (P_2O_5 kg ha^{-1})		Actual P Balance/Available P content in soil (P_2O_5 kg ha^{-1})		Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	24.06	22.73	110.26	105.62	37.49	38.69	-72.78	-66.93
$l_1 f_2$	22.19	20.96	112.13	107.38	26.87	40.79	-85.25	-67.10
$l_1 f_3$	23.20	19.50	111.12	108.85	22.97	47.20	-88.12	-61.65
$l_2 f_1$	27.06	23.65	127.77	125.41	38.33	56.86	-89.43	-68.55
$l_2 f_2$	19.52	20.10	134.64	128.96	17.61	49.16	-117.69	-79.80
$l_2 f_3$	23.76	25.13	131.07	123.93	24.52	51.30	-106.55	-72.63
$l_3 f_1$	24.69	28.84	150.64	140.92	32.83	61.13	-117.81	-79.78
$l_3 f_2$	22.25	21.47	153.09	148.29	20.32	54.72	-132.77	-93.57
$l_3 f_3$	25.58	22.93	149.76	146.83	17.06	51.48	-132.70	-95.35
$F_{4,22}$	1.24^{ns}	1.07^{ns}	1.07^{ns}	1.07^{ns}	0.87^{ns}	2.05^{ns}	1.41^{ns}	1.89^{ns}
SEd	2.62	3.91	2.55	3.91	6.18	5.89	6.72	6.98

ns - Not Significant

Table - 106 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on P - balance in soil.

Experiment II

Factor	P - Uptake by crop (P_2O_5 kg ha^{-1})		Expected P Balance in Soil (P_2O_5 kg ha^{-1})		Actual P Balance/Available P content in soil (P_2O_5 kg ha^{-1})		Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	24.25	27.15	130.58	121.90	37.00	44.89	-93.57	-77.01
$r_1 f_2$	20.12	21.83	134.71	127.22	17.03	49.17	-117.68	-78.56
$r_1 f_3$	23.13	21.01	131.70	128.05	18.43	48.82	-113.24	-79.22
$r_2 f_1$	23.16	22.49	97.49	92.05	33.55	53.23	-63.94	-38.83
$r_2 f_2$	21.67	21.58	98.98	92.97	21.59	48.05	-77.39	-44.91
$r_2 f_3$	24.04	22.71	96.61	91.83	20.75	48.14	-75.86	-43.69
$r_3 f_1$	28.40	25.58	160.61	157.99	38.10	58.57	-122.51	-99.42
$r_3 f_2$	22.18	19.12	166.17	164.44	26.19	47.45	-140.64	-116.99
$r_3 f_3$	25.37	23.84	163.64	159.73	25.38	53.01	-138.26	-106.72
$F_{4,22}$	0.70^{ns}	0.89^{ns}	0.63^{ns}	0.89^{ns}	0.45^{ns}	1.44^{ns}	0.51^{ns}	1.12^{ns}
SEd	2.62	3.91	2.55	3.91	6.18	5.89	6.72	6.98

ns - Not Significant

kg P_2O_5 ha^{-1} was noticed with f_1 which was on a par with f_2 recording the P-uptake of 24.18 kg P_2O_5 ha^{-1}. Nitrogen nutrition at f_3 frequency resulted in lowest uptake of 21.22 kg P_2O_5 ha^{-1}.

The LxR interaction could not influence the P-uptake by crop during 1995-96, although during 1996-97 maximum uptake of 29.55 kg P_2O_5 ha^{-1} was recorded when highest level (300 kg) of N was applied through 2:1 ratio of N substitution in l_3r_3 combination which was on a par with l_2r_1 recording 25.79 kg P_2O_5 ha^{-1}. P-uptake was minimum (18.52 kg P_2O_5 ha^{-1}) with l_3r_2 combination.

The LxF (Table 105) or RxF (Table 106) interactions had no significant influence on P-uptake by crop.

4.2.12.2b Expected P balance in soil (P_2O_5 kg ha^{-1})

As shown in Table 103, different levels of N application significantly influenced the expected P balances of soil during both the years of field experimentation. During 1995-96, the expected P balance increased with increase in each level of N and was significantly higher (151.16 kg P_2O_5 ha^{-1}) with 300 kg N (l_3) than with l_2 (250 kg N) or l_1 (200 kg N) recording 131.16 and 111.17 kg P_2O_5 ha^{-1} respectively. This trend was repeatedly observed during the succeeding year of 1996-97 wherein maximum expected P balance of 145.35 kg P_2O_5 ha^{-1} was obtained with l_3 which was significantly superior to l_2 or l_1 recording 126.10 and 107.28 kg P_2O_5 ha^{-1} respectively.

Different ratios of N substitution significantly influenced the expected P balance of soil during 1995-96 and 1996-97. During 1995-96, nitrogen nutrition through 2:1 ratio of organic - chemical N substitution (r_3) resulted in significantly higher expected P balance of 163.47 kg P_2O_5 ha^{-1} when compared to r_1 or r_2 recording 132.33 and 97.69 kg P_2O_5 ha^{-1} respectively. During the succeeding year also similar result was obtained wherein r_3 ratio produced maximum expected P balance of 160.72 kg P_2O_5 ha^{-1} followed by r_1 (125.72 kg P_2O_5 ha^{-1}) and r_2 (92.28 kg P_2O_5 ha^{-1}).

The expected P balance during first or second year of field experimentation was not influenced by frequencies of application.

The LxR interaction significantly influenced the expected P balance of soil; Table 104. During 1995-96, application of 300 kg N through 2:1 ratio of substitution in l_3r_3 combination recorded the maximum expected P balance of 190.29 kg P_2O_5 ha^{-1} which was significantly higher than the balance obtained with all other combinations, while the minimum expected P balance (85.05 kg P_2O_5 ha^{-1}) was noticed with l_1r_2 combination. Similar trend was noticed during the succeeding year of 1996-97 too wherein maximum expected P balance of 181.65 kg P_2O_5 ha^{-1} was obtained with l_3r_3 combination and minimum (78.34 kg P_2O_5 ha^{-1}) with l_1r_2 combination.

The LxF interaction or RxF interaction could not significantly influence the expected P balance of soil during 1995-96 or 1996-97 (Tables 105 and 106).

4.2.12.2c Actual P balance or available P content of soil (P_2O_5 kg ha^{-1})

Main effects of treatments on actual P balance of soil in Experiment II are depicted in Table 103.

Different levels of N did not produce any variation in actual P balance of soil during 1995-96. During the succeeding year, increasing the level of N from 200 (l_1) to 250 (l_2) or 300 kg (l_3) N ha^{-1} significantly enhanced the actual P balance of soil from 42.22 kg to 52.44 kg and 55.78 kg P_2O_5 ha^{-1} although the two higher levels did not differ each other and all the levels recorded higher actual P balance in comparison with initial value of 20.52 kg P_2O_5 ha^{-1}.

Actual P balance of soil was not influenced by different ratios of N substitution during 1995-96 or 1996-97.

During 1995-96, nitrogen nutrition at f_1 frequency produced significantly higher actual P balance of soil (28.18 kg P_2O_5 ha^{-1}) compared to f_2 or f_3 frequencies recording 21.60 and 21.52 kg P_2O_5 ha^{-1} respectively wherein the f_2 and f_3 did not differ each other. However during 1996-97 the actual P balance of soil was unaffected by frequencies of application.

None of the interaction effects was significant to influence the actual P balance of soil during 1995-96 and 1996-97 (Tables 104, 105 and 106).

4.2.12.2d Net loss (-) or gain (+) of P (P_2O_5 kg ha^{-1})

Main effects of the treatments on net loss or gain of P are shown in Table 103.

Increase in levels of N application significantly increased the net loss of P during 1995-96 and the maximum loss of -127.76 kg P_2O_5 ha^{-1} was obtained with 300 kg N (l_3) level which was significantly more than the net loss occurred with l_2 (-104.56 kg P_2O_5 ha^{-1}) and l_1 (-82.05 kg P_2O_5 ha^{-1}). Similar trend was noticed during 1996-97 too wherein the highest net loss of P was observed with l_3 (300 kg N) level (-89.57 kg P_2O_5 ha^{-1}) which was significantly higher than the net loss of P occurred with the application of l_2 (-73.66 kg P_2O_5 ha^{-1}) which in turn was greater than the net loss of P occurred with the application of l_1 (-65.23 kg P_2O_5 ha^{-1}).

Different ratios of N substitution significantly influenced the net loss or gain of P during both the years of field experimentation. During 1995-96, maximum net loss of P occurred (-133.80 kg P_2O_5 ha^{-1}) when 2:1 substitution ratio was followed in r_3 which was significantly higher than the net loss occurred with r_1 (-108.16 kg P_2O_5 ha^{-1}) and the loss was minimum (-72.40 kg P_2O_5 ha^{-1}) with r_2 (1:2) ratio of N substitution. During the succeeding year also similar trend was observed wherein net loss of P was higher (-107.71 kg P_2O_5 ha^{-1}) with r_3 ratio of N substitution which was significantly higher than the loss recorded with r_1 ratio (-78.27 kg P_2O_5 ha^{-1}) which in turn was higher than the net loss of P with r_2 ratio of N substitution (-42.48 kg P_2O_5 ha^{-1}).

Different frequencies of application significantly influenced the net loss or gain of P only during 1995-96 wherein the f_2 ratio of N application resulted in maximum loss (-111.90 kg P_2O_5 ha^{-1}). However the net loss of P at f_2 ratio was on a par with net loss occurred with f_3 ratio (-109.12 kg P_2O_5 ha^{-1}) and the loss was minimum with f_1 ratio (-101.38 kg P_2O_5 ha^{-1}).

The LxR interaction significantly affected the net loss of P only during the second year of field experimentation (Table 104). When highest level of N (300 kg) was applied through 2:1 ratio of N substitution in l_3r_3 combination, net loss of

P was higher (-125.20 kg P_2O_5 ha^{-1}) compared to all other treatment combinations. Application of lowest dose of N (200 kg) through 1:2 ratio of N substitution in l_1r_2 combination caused the lowest net loss of P (-37.68 kg P_2O_5 ha^{-1}) although it was on a par with l_2r_2 or l_3r_2 combinations recording -41.09 kg and -48.66 kg P_2O_5 ha^{-1} net P losses respectively.

The LxF interaction (Table 105) or RxF interaction (Table 106) could not influence the net loss of P during 1995-96 or 1996-97.

4.2.12.3 K Balance in soil

4.2.12.3a K-Uptake by crop (K_2O kg ha^{-1})

Effect of levels of N application, ratios of substitution and frequencies of application on K-uptake by crop are depicted in Table 111.

Different levels of N application or its ratios of N substitution had no influence on K-uptake of crop during 1995-96 or 1996-97.

Various frequencies of N nutrition however significantly influenced the K-uptake by crop. During 1995-96, K-uptake was maximum with f_1 frequency (101.63 kg K_2O ha^{-1}) which was significantly higher than the K-uptakes recorded with f_3 (93.50 kg K_2O ha^{-1}) or f_2 (85.16 kg K_2O ha^{-1}) although the latter two were on a par in effect. During 1996-97 a slightly different trend was noticed wherein the K-uptake was significantly higher (94.98 kg K_2O ha^{-1}) with f_1 frequency when compared to f_2 frequency recording an uptake of 77.12 kg K_2O ha^{-1} although the f_1 treatment did not vary from f_3 treatment recording a K-uptake of 83.93 kg K_2O ha^{-1} which was also on a par with the f_2 treatment (Table 111).

Table - 111 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on K - balance in soil.

Experiment II

Factor	K - Uptake by crop (K_2O Kg ha^{-1})		Expected K Balance in Soil (K_2O Kg ha^{-1})		Actual K Balance/Available K content in Soil (K_2O Kg ha^{-1})		Net loss (-) or gain (+) of K (K_2O Kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Nitrogen								
l_1	93.98	80.07	95.44	144.30	122.45	154.56	+27.01	+10.26
l_2	90.94	85.80	113.55	151.45	119.47	165.76	+9.50	+14.31
l_3	95.36	90.15	123.36	159.98	136.64	148.59	+13.28	-11.39
$F_{2,22}$	0.47^{ns}	1.11^{ns}	18.49^{**}	2.66^{ns}	2.31^{ns}	3.32^{ns}	2.34^{ns}	5.94^{**}
Ratios								
r_1	90.43	86.66	114.05	150.59	135.15	153.07	+24.68	+2.48
r_2	91.47	83.99	88.19	131.79	107.52	158.29	+19.33	+26.50
r_3	98.39	85.38	130.10	173.34	135.89	157.55	+5.79	-15.79
$F_{2,22}$	1.70^{ns}	0.08^{ns}	41.22^{**}	18.70^{**}	13.40^{**}	0.35^{ns}	2.61^{ns}	13.99^{**}
Frequencies								
f_1	101.63	94.98	102.86	142.28	145.60	144.11	+42.74	+1.83
f_2	85.16	77.12	118.92	160.13	112.75	156.05	-2.59	-4.08
f_3	93.50	83.93	110.57	153.32	120.21	168.75	+9.64	+15.43
$F_{2,22}$	6.16^{**}	3.51^{*}	5.95^{**}	3.51^{*}	15.20^{**}	6.63^{**}	15.18^{**}	3.11^{ns}
SEd	9.96	14.43	-	14.43	12.66	14.35	18.06	17.01
CD	9.73	14.11	9.66	14.11	12.96	14.03	17.66	16.63

ns - Not Significant   * - Significant at 5 % level   ** - Significant at 1 % level

Table - 112 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on K- balance in soil

Experiment II

Factor	K - Uptake by crop (K_2O Kg ha^{-1})		Expected K Balance in Soil (K_2O Kg ha^{-1})		Actual K Balance/Available K content in Soil (K_2O Kg ha^{-1})		Net loss (-) or gain (+) of K (K_2O Kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 r_1$	96.08	78.61	93.34	145.76	127.68	150.08	+36.38	+4.32
$l_1 r_2$	89.94	86.98	80.15	120.38	116.48	172.48	+36.33	+52.09
$l_1 r_3$	95.93	74.61	112.83	166.76	123.20	141.12	+10.37	-25.64
$l_2 r_1$	88.32	92.91	116.99	144.34	138.88	170.24	+32.63	+25.90
$l_2 r_2$	85.74	89.60	93.72	126.01	91.84	154.56	-1.88	+28.55
$l_2 r_3$	98.76	74.90	129.92	183.99	127.68	172.48	-2.24	-11.52
$l_3 r_1$	86.90	88.46	131.83	161.67	138.88	138.88	+7.06	-22.79
$l_3 r_2$	98.72	75.38	90.70	148.99	114.24	147.84	+23.54	-1.16
$l_3 r_3$	100.48	106.63	147.55	139.27	156.80	159.04	+17.25	-10.23
$F_{4,22}$	0.88^{ns}	2.69^{ns}	1.95^{ns}	1.62^{ns}	2.63^{ns}	2.16^{ns}	1.87^{ns}	2.19^{ns}
SEd	9.96	14.43	9.88	14.43	13.25	23.35	18.06	14.81

ns - Not Significant

Table - 113 Interaction effect of levels of nitrogen and its frequencies of application (LxF) on K - balance in soil

Experiment II

Factor	K - Uptake by crop (K_2O Kg ha^{-1})		Expected K Balance in Soil (K_2O Kg ha^{-1})		Actual K Balance/Available K content in Soil (K_2O Kg ha^{-1})		Net loss (-) or gain (+) of K (K_2O Kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$l_1 f_1$	98.53	87.64	90.89	136.73	129.92	138.88	+39.03	+2.15
$l_1 f_2$	94.74	78.23	94.68	146.14	114.24	154.56	+19.56	+8.42
$l_1 f_3$	88.68	74.34	100.75	150.03	123.20	170.24	+22.45	+20.21
$l_2 f_1$	109.57	89.04	95.74	148.21	145.60	163.52	+49.86	+15.31
$l_2 f_2$	75.30	74.52	128.77	162.74	96.32	143.36	-21.71	-19.38
$l_2 f_3$	87.95	93.86	116.13	143.39	116.48	190.40	+0.36	+47.00
$l_3 f_1$	96.79	108.25	121.94	141.89	161.28	129.92	+39.34	-11.97
$l_3 f_2$	85.43	78.61	133.30	171.52	127.68	170.24	-5.62	-1.28
$l_3 f_3$	103.88	83.61	114.85	166.53	120.96	145.60	+6.12	-20.93
$F_{4,22}$	3.15^{*}	1.13^{ns}	2.00^{ns}	1.13^{ns}	2.16^{ns}	2.24^{ns}	1.60^{ns}	5.09^{**}
SEd	-	14.43	9.88	14.43	13.25	24·31	18.06	-
CD	16.86	-	-	-	-	-	-	28.81

ns - Not Significant * - Significant at 5 % level ** - Significant at 1 % level

Table - 114 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on K - balance in soil.

Experiment II

Factor	K - Uptake by crop (K_2O Kg ha^{-1})		Expected K Balance in Soil (K_2O Kg ha^{-1})		Actual K Balance/Available K content in Soil (K_2O Kg ha^{-1})		Net loss (-) or gain (+) of K (K_2O Kg ha^{-1})	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
$r_1 f_1$	99.77	100.41	105.54	136.85	150.08	136.64	+44.54	-0.20
$r_1 f_2$	80.27	79.80	123.80	157.45	123.20	165.76	+10.14	+8.31
$r_1 f_3$	91.25	79.77	112.82	157.48	132.16	156.80	+19.34	-0.68
$r_2 f_1$	93.44	86.17	86.22	129.62	132.16	138.88	+45.95	+9.27
$r_2 f_2$	85.55	79.52	94.11	134.27	98.56	163.52	+4.45	+27.26
$r_2 f_3$	95.41	86.28	84.25	129.51	91.84	172.48	+7.60	+42.98
$r_3 f_1$	111.68	98.35	116.81	160.37	154.56	156.80	+37.75	-3.57
$r_3 f_2$	89.66	72.04	138.84	186.69	116.48	138.88	-22.36	-47.81
$r_3 f_3$	93.84	85.75	134.65	172.97	136.64	176.96	+1.99	+3.99
$F_{4,22}$	0.85^{ns}	0.62^{ns}	0.85^{ns}	0.62^{ns}	1.09^{ns}	2.15^{ns}	0.53^{ns}	2.11^{ns}
SEd	9.96	14.43	9.88	14.43	13.25	24.21	18.06	14.81

ns - Not Significant

The LxR interaction (Table 112) had no influence on K-uptake by crop during both 1995-96 and 1996-97.

The LxF interaction is depicted in Table 113 and it showed that the K-uptake was maximum (109.57 kg K_2O ha^{-1}) when 250 kg N was applied at f_1 frequency in l_2f_1 combination although it was on a par with l_1f_1 (98.53 kg), l_1f_2 (94.74 kg), l_3f_1 (96.79 kg) and l_3f_3 (103.88 kg) combinations during 1995-96. During 1996-97, the LxF interaction did not influence the K-uptake by crop.

The RxF interaction (Table 114) did not have any effect on K-uptake by crop during 1995-96 or 1996-97.

4.2.12.3b Expected K balance in soil (K_2O kg ha^{-1})

As depicted in Table 111, different levels of N application profoundly influenced the expected K balance of soil. During 1995-96, increase in levels of N to 300 kg ha^{-1} (l_3) significantly enhanced the expected K balance to 123.36 kg K_2O ha^{-1} which was significantly superior to l_2 (113.55 kg K_2O ha^{-1}) and l_1 (95.44 kg K_2O ha^{-1}) levels. During 1996-97 levels of N application could not influence the expected K balance.

Different ratios of N substitution had significant influence on expected K balance of soil during both the years of field experimentation. During 1995-96, maximum expected K balance of 130.10 kg K_2O ha^{-1} was obtained with r_3 ratio of N substitution which was significantly superior to r_1 ratio recording 114.05 kg K_2O ha^{-1} which inturn was higher than 88.19 kg expected K balance noted for r_2

ratio. During 1996-97 also similar observations were made wherein the expected K balance in soil was highest (173.34 kg K_2O ha^{-1}) for r_3 ratio compared to r_1 (150.59 kg K_2O ha^{-1}) which in turn was significantly superior to r_2 (131.79 kg K_2O ha^{-1}); Table 111.

Different frequencies of N nutrition could significantly influence the expected K balance of soil during 1995-96 as well as 1996-97. During the first year, the expected K balance was maximum (118.92 kg K_2O ha^{-1}) with f_2 frequency which was also on a par with f_3 frequency recording 110.57 kg K_2O ha^{-1}. The f_1 frequency produced low expected K balance of 102.86 kg K_2O ha^{-1} compared to other frequencies although it did not differ from f_3 frequency significantly. Similar observations were noted during 1996-97 also wherein maximum expected K balance of 160.13 kg K_2O ha^{-1} was recorded with f_2 frequency which was on a par with f_3 frequency registering an expected K balance of 153.32 kg K_2O ha^{-1} which inturn was on a par with f_1 frequency recording the lower expected balance of 142.28 kg K_2O ha^{-1}.

The LxR interaction (Table 112) or LxF interaction (Table 113) or RxF interaction (Table 114) could not influence the expected K balance in soil during 1995-96 or 1996-97.

4.2.12.3c Actual K balance or Available K content in soil (K_2O kg ha^{-1})

Main effects of the treatments on actual K balance or available K content of soil are depicted in Table 111.

Different levels of N application had not influenced the actual K balance of soil during 1995-96 and 1996-97. During the first year, actual K balance of soil was greater (135.89 kg K_2O ha^{-1}) when nutrient N was applied through 2:1 (r_3) organic-chemical N ratio in experiment II using poultry manure as organic source when compared to the 1:2 (r_2) ratio of N substitution recording 107.52 kg K_2O ha^{-1} although the former was on a par with r_1 (1:1) ratio registering an actual K balance of 135.15 kg K_2O ha^{-1}. However all the ratios increased the actual K balances as compared to the initial K status (105.83 kg K_2O ha^{-1}). During the succeeding year of 1996-97 ratios of N substitution had no effect on actual K balance of soil.

During 1995-96, nitrogen nutrition at f_1 (full basal organic source application) frequency recorded significantly higher actual K balance in soil (145.60 kg K_2O ha^{-1}) compared to f_2 and f_3 frequencies recording 112.75 kg and 120.21 kg actual K balances respectively which did not differ each other in effect. However during 1996-97 actual K balance of soil was maximum (168.75 kg K_2O ha^{-1}) with f_3 frequency which did not vary from f_2 frequency producing 156.05 kg K_2O ha^{-1}. The lowest value (144.11 kg K_2O ha^{-1}) was recorded with f_1 frequency which was on a par with f_2 frequency while the f_3 and f_2 frequencies enhanced the available K content in soil in comparison with initial content of 147.84 kg K_2O ha^{-1} (Table 111).

None of the interaction effects (Table 112, 113 and 114) could significantly influence the actual K content of soil during 1995-96 and 1996-97.

4.2. 12.3d Net loss (-) or gain of K in soil (K_2O kg ha^{-1})

As shown in Table 111, main effects of the treatment influenced the net loss or gain of K, when poultry manure was used as organic source of N.

During 1995-96, different levels of N application did not influence the net loss or gain of K although it did influence during the next year (1996-97). Application of highest level (300 kg) of N resulted in a net loss of -11.39 kg K_2O ha^{-1} while the lower levels resulted in net gains wherein 10.26 and 14.31 kg K_2O ha^{-1} were recorded with application of l_1 and l_2 levels respectively.

Different ratios of N substitution had no influence on net loss or gain of K during 1995-96. However during 1996-97, N substitution through 2:1 ratio of organic-chemical N substitution (r_3) resulted in a net loss of -15.79 kg K_2O ha^{-1}. Net gains were resulted when 1:1 (r_1) or 1:2 (r_2) ratios were followed which recorded 2.48 kg and 26.50 kg K_2O ha^{-1} respectively and the net gain was significantly higher with r_2 ratio of N substitution (Table 111).

During 1995-96, net gains of K occurred when N was given at f_1 and f_3 frequencies and was significantly higher (42.74 kg K_2O ha^{-1}) in case of full basal organic manure application in f_1 frequency compared to fortnightly split application of organic manure in f_3 frequency (9.64 kg K_2O ha^{-1}). Application of organic source as basal + 2 splits as in f_2 frequency recorded a net loss of -2.59 kg K_2O ha^{-1}. The frequencies of application had no influence on net loss or gain of K during 1996-97.

The LxR interaction (Table 112) did not influence the net loss or gain of K during 1995-96 or 1996-97.

The LxF interaction (Table 113) did not produce any effect on net loss or gain of K during 1995-96. However during 1996-97, significantly higher net gain of 47.00 kg K_2O ha^{-1} was noticed when 250 kg N was applied at f_3 frequency in l_2f_3 combination compared to other treatment combinations. However net losses of -1.28 kg, -11.97 kg, -19.38 kg and -20.93 which did not vary each other were resulted with l_3f_2, l_3f_1, l_2f_2 and l_3f_3 treatment combinations respectively.

The RxF interaction depicted in Table 114 showed that it could not influence the net loss or gain of K during 1995-96 or 1996-97.

4.2.13 Energy Budgeting

4.2.13.1 Total Energy Output (MJ ha^{-1})

Different levels of N application had no effect on total energy output during 1995-96 and 1996-97 (Table 119).

Different ratios of N substitution too did not show any influence on total energy output during both the years of field experimentation (Table 119).

Total energy output was maximum (10673.72 MJ ha^{-1}) when organic source of N was fully applied as basal (f_1) which was significantly superior to f_2 (basal + 2 split doses of organic source) recording a total energy output of 9015.69 MJ ha^{-1} during 1995-96. The f_1 frequency was however on a par with f_3 frequency registering total energy output of 10019.85 MJ ha^{-1}. During 1996-97 also similar trend was noticed wherein maximum total energy output was observed (11641.72 MJ ha^{-1}) with f_1 which was significantly higher than the energy output noticed with f_2 (9589.00 MJ ha^{-1}) and f_3 (9965.28 MJ ha^{-1}) although the f_2 and f_3 frequencies were on a par (Table 119).

Table - 119 Effect of levels of nitrogen, ratios of substitution of nitrogen and frequencies of application of nitrogen on energy budgeting.

Experiment II

Factor	Total energy output (MJ ha^{-1})		Net energy - returns (MJ ha^{-1})		Energy ratio	
	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97
Nitrogen						
l_1	10119.39	10019.50	-6016.97	-6116.86	-0.37	-0.38
l_2	9734.67	10607.89	-9431.69	-8558.47	-0.49	-0.45
l_3	9855.20	10568.61	-12341.16	-11627.75	-0.56	-0.52
$F_{2,22}$	0.37^{ns}	0.35^{ns}	96.64^{**}	24.89^{**}	27.35^{**}	7.00^{**}
Ratios						
r_1	9699.89	10794.50	-9466.47	-8371.86	-0.48	-0.43
r_2	9782.53	10069.50	-9383.83	-9096.86	-0.48	-0.46
r_3	10226.83	10332.00	-8939.53	-8834.36	-0.46	-0.46
$F_{2,22}$	0.77^{ns}	0.44^{ns}	0.77^{ns}	0.44^{ns}	0.70^{ns}	0.45^{ns}
Frequencies						
f_1	10673.72	11641.72	-8022.24	-7054.24	-0.42	-0.37
f_2	9015.69	9589.00	-9915.47	-9342.16	-0.51	-0.48
f_3	10019.85	9965.28	-9852.11	-9906.68	-0.49	-0.49
$F_{2,22}$	6.73^{**}	3.90^{*}	11.15^{**}	7.45^{**}	7.77^{**}	5.60^{*}
SEd	966.07	1660.47	966.02	1660.42	0.05	0.08
CD	944.52	1623.43	944.47	1623.38	0.05	0.08

ns - Not Significant   * - Significant at 5% level   ** - Significant at 1% level

Table - 120 Interaction effect of levels of nitrogen and its ratios of substitution (LxR) on energy budgeting.

Experiment II

Factor	Total energy output (MJ ha^{-1})		Net energy - returns (MJ ha^{-1})		Energy ratio	
	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97
$l_1 r_1$	10707.15	9938.83	-5429.21	-6197.53	-0.33	-0.38
$l_1 r_2$	9455.40	10662.17	-6680.96	-5694.19	-0.42	-0.35
$l_1 r_3$	10195.63	9677.50	-5940.73	-6458.86	-0.37	-0.40
$l_2 r_1$	9405.72	11924.50	-9760.64	-7241.86	-0.51	-0.38
$l_2 r_2$	9455.10	10833.50	-9711.26	-8332.86	-0.51	-0.44
$l_2 r_3$	10343.18	9065.67	-8823.18	-10100.69	-0.46	-0.53
$l_3 r_1$	8986.82	10520.17	-13209.54	-11676.19	-0.60	-0.53
$l_3 r_2$	10437.10	8932.83	-11759.26	-13263.53	-0.53	-0.60
$l_3 r_3$	10141.68	12252.83	-12054.68	-9943.53	-0.54	-0.45
$F_{4,22}$	1.64^{ns}	2.49^{ns}	1.64^{ns}	2.49^{ns}	1.56^{ns}	2.40^{ns}
SEd	966.07	1660.47	966.02	1660.42	0.05	0.08

ns - Not Significant

Table - 121 Interaction effect of levels of nitrogen and its frequencies of applications (L x F) on energy budgeting.

Experiment II

Factor	Total energy output (MJ ha^{-1})		Net energy - returns (MJ ha^{-1})		Energy ratio	
	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97
$l_1 f_1$	10718.02	10860.17	-4947.94	-4805.79	-0.47	-0.31
$l_1 f_2$	10087.45	10266.17	-5813.71	-5634.99	-0.37	-0.35
$l_1 f_3$	9552.72	8932.17	-7289.24	-7909.79	-0.43	-0.47
$l_2 f_1$	11318.98	11265.50	-7376.98	-7430.46	-0.39	-0.40
$l_2 f_2$	8192.72	9305.50	-10738.44	-9625.66	-0.57	-0.51
$l_2 f_3$	9692.30	11252.67	-10179.66	-8619.29	-0.51	-0.43
$l_3 f_1$	9984.17	12799.50	11741.79	-8926.46	-0.54	-0.41
$l_3 f_2$	8766.90	9195.33	-13194.26	-12765.83	-0.60	-0.58
$l_3 f_3$	10814.53	9791.00	-12087.43	-13190.96	-0.53	-0.58
$F_{4,22}$	2.82*	1.34^{ns}	2.82*	1.34^{ns}	2.82*	1.37^{ns}
SEd	966.07	1660.47	966.02	1660.42	0.05	0.08
CD	1635.96	-	1635.87	-	0.09	-

ns - Not Significant
* - Significant at 5% level

Table - 122 Interaction effect of ratios of substitution and frequencies of application of nitrogen (RxF) on energy budgeting.

Experiment II

Factor	Total energy output (MJ ha^{-1})		Net energy - returns (MJ ha^{-1})		Energy ratio	
	1995 - 96	1996 - 97	1995 - 96	1996 - 97	1995 - 96	1996 - 97
$r_1 f_1$	10830.88	12313.83	-7865.08	-6382.13	-0.39	-0.33
$r_1 f_2$	8544.35	10227.00	-10386.81	-8704.16	-0.53	-0.44
$r_1 f_3$	9724.45	9842.67	-10147.51	-10029.29	-0.51	-0.51
$r_2 f_1$	9748.98	10230.17	-8946.98	-8465.79	-0.47	-0.45
$r_2 f_2$	9285.40	9869.50	-9645.76	-9061.66	-0.50	-0.46
$r_2 f_3$	10313.22	10108.83	-9558.74	-9763.13	-0.48	-0.48
$r_3 f_1$	11441.30	12381.17	-7254.66	-6314.79	-0.38	-0.33
$r_3 f_2$	9217.32	8670.50	-9713.84	-10260.66	-0.50	-0.55
$r_3 f_3$	10021.88	9944.33	-9850.08	-9927.63	-0.49	-0.50
$F_{4,22}$	1.20^{ns}	0.97^{ns}	1.20^{ns}	0.97^{ns}	1.15^{ns}	1.63^{ns}
SEd	966.07	1660.47	966.02	1660.42	0.05	0.08

ns - Not Significant

The LxR interaction (Table 120) did not influence the total energy output during 1995-96 or 1996-97.

The LxF interaction (Table 121) significantly influenced the total energy output of the crop only during 1995-96. The energy output was maximum (11318.98 MJ ha^{-1}) when 250 kg N was applied at f_1 (full organic source at basal) frequency in l_2f_1 which did not significantly vary from l_1f_2 (10087.45 MJ ha^{-1}) or l_1f_1 (10718.02 MJ ha^{-1}) or l_2f_3 (9692.30 MJ ha^{-1}) or l_3f_1 (9984.17 MJ ha^{-1}) or l_3f_3 (10814.53 MJ ha^{-1}) combinations.

The RxF interaction (Tables 122) did not affect the total energy output during both the years of field experimentation.

4.2.13.2 Net Energy Returns (MJ ha^{-1})

Main effects of the treatment on net energy returns when poultry manure was used as organic source of N substitution are depicted in Table 119.

As seen before in case of Experiment I, net energy loss (negative returns) was observed with different levels of N application. During 1995-96, the net energy loss increased with increasing levels of N application and was maximum (-12341.16 MJ ha^{-1}) with 300 kg N (l_3) level which significantly higher than l_2 or l_1 recording -9431.69 and -6016.97 MJ ha^{-1} net energy losses respectively. During 1996-97 also, net energy loss was significantly higher (-11627.75 MJ ha^{-1}) with l_3 as compared to l_2 (-8558.47 MJ ha^{-1}) or l_1 (-6116.86 MJ ha^{-1}).

Different ratios of N substitution did not influence the net energy returns during 1995-96 or 1996-97 (Table 119).

During 1995-96, net energy loss observed was maximum with f_2 (basal + 2 split doses of organic source) which was recorded a value of -9915.47 MJ ha^{-1} although it was on a par with f_3 (basal + fortnightly split doses of organic source) frequency which produced a net energy loss of -9852.11 MJ ha^{-1}. The f_1 frequency wherein organic source was completely applied at basal recorded a lower energy loss of -8022.24 MJ ha^{-1}. This trend was repeated during the succeeding year also wherein net energy loss was maximum (-9906.68 MJ ha^{-1}) with f_3 which did not differ from f_2 recording -9342.16 MJ ha^{-1} net energy loss although the energy losses with f_2 and f_3 were significantly higher than that obtained with f_1 frequency (-7054.24 MJ ha^{-1}) ;Table 119.

The LxR interaction shown in Table 120 indicated that the net energy returns were unaffected by the interaction effect.

The LxF interaction (Table 121) significantly influenced the net energy returns (or loss) during 1995-96 although it did not have any effect during 1996-97. The net energy loss obtained was maximum (-13194.26 MJ ha^{-1}) when highest level of N (300 kg) was applied at f_2 frequency in l_3f_2 which was on a par with l_3f_3 (-12087.43 MJ ha^{-1}) which also did not differ each other.

The RxF interaction (Table 122) could not influence the net energy returns during 1995-96 or 1996-97.

4.2.13.3 Energy ratio

Main effects of the treatment on energy ratio when poultry manure was used as an organic source are given in Table 119.

During 1995-96, increasing levels of N from 200 to 250 and 300 kg ha^{-1} recorded energy ratio values -0.37, -0.49 and -0.56 respectively for l_1, l_2 and l_3 which indicated higher energy losses at higher levels of N application. During 1996-97, application of 300 kg N (l_3) recorded an energy ratio of -0.52 which was on a par with l_2 registering a net ratio of -0.45 which in turn did not differ from the energy ratio produced with the application of l_1 (-0.38).

The net energy ratios during 1995-96 and 1996-97 were not under the influence of different ratios of N substitution (Table 119).

Different frequencies of application significantly influenced the net energy ratios. During 1995-96, nitrogen nutrition at f_2 (basal + 2 split doses of organic source) or f_3 (fortnightly split dose of organic source) recorded energy ratios -0.51 and -0.49 respectively which were on a par and suggested higher losses of energy while the f_1 (full basal application of organic source) frequency recorded an energy ratio of -0.42 which indicated low energy losses. During 1996-97 the trend was repeated wherein energy ratio of -0.37 was recorded with f_1 frequency which indicated moderate energy loss when compared to f_2 or f_3 registering -0.48 and -0.49 energy ratios respectively (Table 119).

The LxR interaction depicted in Table 120 showed that it could not influence the energy ratio during 1995-96 or 1996-97.

The LxF interaction (Table 121) markedly influenced the energy ratio only during 1995-96 wherein application of lowest level of N (200 kg) at f_2 frequency (l_1f_2) recorded an energy ratio of -0.37 indicating lowest energy loss which was on a par with l_2f_1 (-0.39) and l_1f_3 (-0.43) combinations. Application of highest (300 kg) level of N at f_1, f_2 or f_3 frequencies recorded energy ratios of -0.54, -0.60 and -0.53 respectively for l_3f_1, l_3f_2 and l_3f_3 combinations which did not differ each other and suggested higher energy losses.

The R x F interaction had no influence on energy ratio during 1995-96 or 1996-97 (Table 122).

4.2.14 Economics of Cultivation

4.2.14.1 Gross returns (Rs. ha^{-1})

Different levels of N application or ratios of substitution had no influence on gross returns when poultry manure was used as an organic source of N substitution (Table 123).

Different frequencies of application had significant influence on gross returns, wherein higher gross returns was obtained (Rs.90760.00) with f_1 frequency which was significantly greater than the gross returns of Rs.83890.00 obtained with f_3 frequency which inturn was significantly superior to f_2 producing a gross returns of Rs.75410.00 (Table 123).

The LxR interaction significantly influenced the gross returns which was maximum (Rs.94200.00) when 300 kg N (l_3) was supplied through 2:1 ratio of N substitution in $l_3 r_3$ combination when compared to all other combinations (Table 124).

The LxF interaction or RxF interaction had no influence on gross returns (Tables 125 and 126).

4.2.14.2 Net returns (Rs. ha^{-1})

As depicted in Table 123, different levels of N or its ratios of substitution did not influence the net returns.

Different frequencies of application had conspicuous effect on net returns wherein it was maximum (Rs.49505.20) with f_1 frequency which was significantly higher than the net returns recorded with f_2 frequency (Rs.32651.75) and f_3 frequency (Rs.35117.95) although f_2 and f_3 treatments were on a par (Table 123).

Different interaction effects (Tables 124, 125 and 126) could not influence the net returns obtained in Experiment II.

4.2.14.3 Benefit-Cost (B/C) Ratio

Different levels of N application or its ratios of substitution could not influence the B/C ratio (Table 123).

The B/C ratio was however maximum when nutrient N was supplied at f_1 frequency (2.20) which was significantly higher than the ratio at f_2 (1.77) or f_3 (1.72) although the latter two were on a par each other (Table 123).

The LxR interaction (Table 124) or LxF interaction (Table 125) or RxF interaction (Table 126) could not influence the B/C ratio of Experiment II.

DISCUSSION

DISCUSSION

An investigation was conducted at Instructional Farm, College of Agriculture, Vellayani with the objective of studying the effect of different levels of nitrogen, substitution ratios of organic and chemical nitrogen and their frequencies of application on the yield and keeping quality along with the possibility of enhancing the N levels for commercial bitter gourd production. Two experiments (Experiment I using farm yard manure as organic source and Experiment II using poultry manure as organic source) were laid out simultaneously. Significant results of Experiment I and Experiment II conducted during 1995-96 and 1996-97 are discussed together in this chapter.

5.1 Sex ratio

Varying levels of N nutrition had no influence on sex ratio of plants in Experiment I. When the organic source of N used was poultry manure (Experiment II), enhancing the nitrogen level from 200 to 300 kg N ha^{-1} significantly reduced the sex ratio from 13.19 to 11.97 at 90 DAS during the first year of the trial (Table 7). The sex ratio narrowed down consequent to the increase in the level of nitrogen application which appears to be a common observation especially at the later stages of the plant growth. In the present study also higher rate of vegetative growth was resulted as indicated by the trend in the dry matter production (DMP) consequent to higher doses of nitrogen (Table 47). At the late growth phase, as the vegetative growth slowed down, the incoming nitrogen which was to be utilised for vegetative growth would have been translocated to reproductive organs resulting in higher female flower production and thereby lowering the sex ratio (Singh *et al.*, 1982). Similar results were reported by Matlop and Basher (1985) in summer squash, Maurya (1987) in cucumber and Ali *et al.* (1995) in bitter gourd.

Ratios of substitution or frequencies of application did not influence the sex ratio in Experiment I and II.

The interaction effect of LxR significantly influenced the sex ratio at 90 DAS during first year in Experiment II, wherein application of 300 kg N through 2:1 N substitution ratio using poultry manure recorded the lowest sex ratio (Table 8). As discussed earlier, N available at the late growth phase must have been utilised for producing female flowers thereby narrowing the sex ratio. The release of N during the post vegetative stage is more apparent when it is mostly supplied through an organic source (poultry manure) than as chemical fertiliser. This might be the reason for recording lowest sex ratio under the combination of 300 kg N + 2:1 organic- chemical N ratio. According to Smith (1950), when compared to other forms of organic manures like farm yard manure, recovery of nitrogen from poultry manure is quicker. Uric acid, which constitutes 60 per cent of N in poultry manure changes to ammoniacal form which is utilised by plants which would have resulted in the release of substantial amount of N during the later growth stages of the plant instead of causing a residual effet and this process in general might have produced a narrow sex ratio.

The LxF or RxF interactions were not significant in Experiment I or II.

5.2 Days taken to flower

As shown in Table 11, when nitrogen level was raised from 200 to 250 and 300 kg ha^{-1} in Experiment I using farm yard manure as organic source, days taken for the appearance of first flower were reduced from 33.67 to 32.61 and 32.67 respectively while these effects were not significant in Experiment II. Enhancing the N levels in general advances the physiological maturity of crops and also results in greater seedling vigour which would have resulted in early flower bud differentiation thereby reducing the days required for flowering. Similar observation was made by Saito *et al.* (1963) in tomato.

Different ratios of N substitution could not influence the days to flower in Experiment I or II.

The frequencies of N nutrition significantly influenced the days taken to flower in both the experiments (Tables 11 and 15). The f_3 treatment wherein both organic and chemical N were applied in equal splits as basal and fortnightly split doses required relatively more number of days for flowering. When a portion of the required dose of nitrogen is supplied through an organic source in several splits, the proportion of nitrogen supplied which becomes available during the early vegetative phase of the plant is limited which in turn may slow down the initial growth and delay the flowering. Application of nitrogen in more than 3 splits prolonging the days required for flowering was observed previously by Dod *et al.* (1992).

As given in Table 12, when 300 kg N was supplied through 2:1 organic-chemical N ratio as farm yard manure in Experiment I, it took less number of days for flowering during the second year. This could be due to the early flower bud differentiation on account of greater seedling vigour resulting from nitrogen nutrition as suggested by Saito *et al.* (1963). The LxR interaction did not influence the days taken to flower in Experiment II.

The LxF interaction was not influential on days taken to flower in Experiment I. But when 200 kg N was supplied through f_3 frequency wherein both poultry manure and chemical N fertiliser were applied as basal and in fortnightly split doses, more days were required for flowering (Table 17) in Experiment II. As discussed earlier in case of main effects of levels of N nutrition and its frequencies of application, when low level of N was applied with the organic portion in several split doses, the nutrient N which would have been available during the early growth phase might have been limited resulting in reduced initial growth and delayed flowering.

Days taken to flower were unaffected by RxF interaction in Experiment I and II.

5.3 Scoring of pests and diseases

5.3.1 Scoring of pests

5.3.1a Aphid - *Aphis malvae* (Koch)

Aphid infestation was not influenced by main effects or interaction effects of treatments during both the years in Experiment I and II.

5.3.1b Jassid - *Hishimonas phycitis* (Dist.)

Different levels of N nutrition, ratios of substitution or frequencies of application could not influence the jassid population in both the experiments.

The LxR interaction, as indicated in Table 20 significantly influenced the jassid population during 1996-97 at 60 DAS in Experiment I, while it had no influence in Experiment II. Jassid count was higher when highest level of nitrogen (300 kg) was applied through 2:1 ratio of N substitution. The effects of application of dung and organic matter on pests seems to be obscure. According to Jones (1976), the claims made that the dung and organic matter application suppress pests are probably over-rated. He had also pointed out that in experiments conducted at Rothamstead where fertilisers, mineral and organic were applied to the same plots for more than 100 years or to the plots in trials repeated on different sites in several seasons, organic matter had little effect on pest incidence and resistance seems to be a property within plant cells and of the whole plant rather than of the substances translocatable from tops to roots. In this connection, Singh (1970) remarked that the composition of cell sap is affected by the nutrients applied to soil as N, P and K and may sometimes enhance or reduce the real resistance of the crop to particular pests by modifying non-preference or antibiosis.

The LxF or RxF interactions were not significant to influence the jassid population in both the experiments.

5.3.1c Fruit fly - *Bactrocera cucurbitae* (Coq.)

Main effects or treatment interactions did not influence the fruit fly population in Experiment I or II.

5.3.1d Epilachna beetle - *Henosepilachna septima* (Sab.)

No epilachna beetle attack was noticed in both the experiments.

5.3.1e Red pumpkin beetle - *Aulocophora foveicollis* (Lucas)

No red pumpkin beetle attack was noticed in both the experiments.

5.3.2 Diseases

5.3.2a Leaf spot - (C.O. *Pseudoperonospora cubensis*)

As presented in Table 27, leaf spot infestation was influenced by nitrogen levels at 90 DAS during 1996-97 in Experiment I using farm yard manure. Percentage infestation was maximum at lower levels of N (200 kg ha^{-1}) compared to higher levels. This observation however need be taken as a result of the direct effect of increasing N levels on growth and biomass production. Raising the level of N nutrition beyond 200 kg ha^{-1} appeared to have a limiting effect on dry matter production (Table 43). Consequently dry matter production was maximum with treatment l_1 which also registered maximum leaf spot infestation. The dense crop resulted from increased biomass production might have caused a humid microclimate around these plants which could have favoured the fungal pathogen as reported by Jenkyn (1976). Various levels of N nutrition had no influence on leaf spot infestation in Experiment II.

Different ratios of N substitution had not influenced the fungal leaf spot infestaton in Experiment I or II.

Maximum leaf spot infestation was noticed with f_3 treatment at 30 DAS when both farm yard manure and chemical N source were applied as basal dose and in several fortnightly split doses in Experiment I (Table 27). Frequent split applications of farm yard manure and chemical N source in f_3 seemed to create a more humid environment around the plants compared to other treatments, which may be important especially for the fungal pathogen whose infestation is favoured by the presence of free water. Split application of N favouring the leaf spot infestation was previously reported by Salt (1952) and Widdowson *et al.* (1976) in wheat. Similar observation was made by Batal *et al.* (1994) in the case of onion rot. Frequencies of N nutrition could not however influence the leaf spot infestation in Experiment II.

The LxR interaction depicted in Table 28 showed significant influence on the leaf spot infestation at 90 DAS during 1996-97 in Experiment I although it had no effect in Experiment II. In the former case, leaf spot infestation was maximum when 200 kg N was applied through 2:1 farm yard manure - chemical N ratio. As discussed earlier, this can be inferred as the direct effect of N on biomass and dry matter production (Table 44) wherein the dry matter production did not show positive response beyond 200 kg N level and the higher biomass production with lower level of N when applied through a higher proportion of organic source as farm yard manure would have indirectly favoured the leaf spot infestation.

The LxF and RxF interactions were not significant to influence the leaf spot infestation in Experiment I or II.

5.3.2b Mosaic

No viral mosaic incidence was noticed in Experiment I or II.

5.4 Harvests and Yield

5.4.1 Harvests

Days to first harvest, days to 50 per cent harvest, days to final harvest and number of harvests in Experiment I and II were not significantly influenced by main effects or interaction effects of treatments.

5.4.2 Yield

5.4.2a Number of fruits plant^{-1}

Various levels of application of N or its ratios of substitution did not influence the number of fruits plant^{-1} in Experiment I and Experiment II.

Although various frequencies of N nutrition did not produce any variation in the number of fruits plant^{-1} in Experiment I, more number of fruits was produced with f_1 frequency (full basal application of organic source + basal and fortnightly split doses of chemical N source) in Experiment II (Table 39). Number of fruits plant^{-1} was more with full basal application of poultry manure (f_1) compared to the split applications probably due to the better nitrogen use efficiency (NUE) consequent to the former treatment. As discussed earlier in case of sex ratio (5.1), the N present in poultry manure is quickly available to the plants. When full quantity of poultry manure was applied as basal dose and well incorporated with the soil in pit, possibility of volatalisation loss of NH_4-N which is the major constituent of poultry manure can be expected to be less since NH_4^+ ions get adsorbed to the soil particles under deep placement (Tisdale *et al.*, 1995). This is more conducive for better uptake by young seedlings compared to the split applications wherein top dressing of manure was done. Increased possibility of volatalisation loss of NH_4-N in poultry manure in split application was previously suggested by Liebhardt *et al.* (1979), Hadas *et al.* (1983) and Cooper *et al.* (1984).

The LxR interaction could not significantly influence the number of fruits plant^{-1} in Experiment I. In Experiment II, when highest level of N (300 kg) was applied through 2:1 ratio of poultry manure - chemical N ratio (l_3r_3), higher number of fruits plant^{-1} was produced (Table 40). As explained before, application of highest level of nitrogen through a higher proportion of poultry manure which contains more nitrogen in a utilisable form would have resulted in better utilisation of this nutrient and improvement in soil properties which might have contributed to the higher number of fruits plant^{-1}. Superiority of poultry manure in producing higher number of fruits was previously reported by Mina (1986) in muskmelon.

The LxF or RxF interactions did not influence the number of fruits plant^{-1} in Experiment I and II.

5.4.2b Fruit yield plant^{-1}

Different levels of nitrogen or its ratios of substitution could not influence the fruit yield plant^{-1} in Experiment I and II.

Fruit yield plant^{-1} in Experiment I was unaffected by various frequencies of nitrogen nutrition. However Table 39 showed that in Experiment II, higher fruit yield plant^{-1} was obtained with f_1 frequency wherein full quantity of poultry manure was applied as basal along with basal + fortnightly split doses of chemical N source. As explained earlier full basal application of poultry manure, major portion of which consists of easily utilisable nitrogen would have contributed to the better NUE compared to the split applications thereby resulting in maximum fruit yield plant^{-1}.

The LxR interaction was not significant in Experiment I to influence the fruit yield plant^{-1}. As depicted in Table 40, the LxR interaction affected the fruit yield plant^{-1} during the second year wherein maximum yield was noticed when 300 kg N was applied through 2:1 ratio of poultry manure and chemical N source in l_3r_3 combination. As explained before, when poultry manure was applied in 2:1 ratio, the easily available form of nitrogen present in the manure would have contributed to the yield obtained with that treatment combination.

The LxF or RxF interactions did not have any significant influence on fruit yield plant^{-1} in Experiment I or II.

5.4.2c Fruit yield (t ha^{-1})

Different levels of N nutrition or its ratios of substitution could not influence the fruit yield (t ha^{-1}) in Experiment I or II.

Different frequencies of N nutrition did not produce any significant influence on fruit yield (t ha^{-1}) in the first experiment. However as depicted in Table 39, when full quantity of poultry manure was applied as basal dose along with basal + fortnightly split doses of chemical N source (f_1) in the second experiment, higher fruit yield in t ha^{-1} was obtained. As discussed earlier, recovery of nitrogen from poultry manure is quick when compared to other organic sources like farm yard manure. More than 60 per cent of nitrogen in poultry manure is constituted by uric acid which rapidly gets converted to ammoniacal form and is easily utilised by the plant (Smith, 1950). As the entire quantity of poultry manure was applied fully as basal dose well mixed with soil in pits, it could be presumed that major portion of nitrogen would have been thus recovered by the plant which increases the seedling vigour as compared to other frequencies of applications where same quantity was applied through basal dressing and two or more top dressings. The respective N-uptake pattern (Table 95) also justifies this point wherein higher uptake was noticed with f_1 treatment. Such increased utilisation of nitrogen which has reflected in growth would have ultimately resulted in higher yield.

The LxR interaction did not influence the fruit yield in t ha^{-1} in Experiment I. However, maximum yield was noticed in Experiment II (Table 40), when 300 kg N was applied through 2:1 ratio of poultry manure and chemical N source in l_3r_3 combination during the second year. Higher levels of nitrogen favourably influencing the fruit yield in cucurbitaceous crops was reported by Wilcox (1973) in muskmelon, Shukla and Gupta (1980) in squash and Ravikrishnan (1989) in bitter gourd. When poultry manure was used in higher proportion (2:1 ratio of substitution), the easily utilisable form of nitrogen present in it would have contributed to the higher yield obtained with that treatment combination as compared to other ratios. Mina (1986) reported that when nutrient nitrogen was supplied through poultry manure, fruit yield per plot was increased in muskmelon.

The LxF or RxF interactions did not influence the fruit yield in t ha^{-1} in Experiment I and II.

5.5 Total dry matter production (g $plant^{-1}$)

Different levels of N application or ratios of N substitution could not significantly influence the total dry matter production $plant^{-1}$ in Experiment I and II.

In case of Experiment I, various frequencies of N nutrition did not have any influence on total dry matter production $plant^{-1}$. However it showed marked influence in Experiment II as shown in Table 47. Maximum total dry matter production $plant^{-1}$ was recorded with f_1 treatment wherein full quantity of poultry manure was applied as basal and chemical N source as basal + fortnightly split doses. The influence of frequencies of N nutrition on total dry matter production $plant^{-1}$ is further illustrated by Fig. 3. As discussed earlier, when entire quantity of poultry manure was applied as basal, more than 60 per cent of its N present as uric acid rapidly changes to ammoniacal form. Besides this, of the nitrogen mineralised during the first 2 to 3 months of the application of organic source, 80 per cent is converted to NO^-_3 at the end of first 3 weeks as suggested by Tisdale *et al.* (1995). Therefore it could be presumed that these plant available forms of N released during the peak nitrogen requirement stages of the crop would have utilised for the dry matter accumulation. The N-uptake (Table 95) pattern at different frequencies of application further supports this view.

Interaction effects were not significant to influence the total drymatter production $plant^{-1}$ in Experiment I or II.

5.6 Root studies

5.6.1 Depth of root penetration (cm)

Main effects or treatment interactions could not significantly influence the depth of root penetration in Experiment I and II.

5.6.2 Root dry weight (g)

Root dry weight in Experiment I or II was not influenced by main effects and interaction effects of treatments.

5.7 Keeping quality and shelf life studies

5.7.1 Shelf life of fruits at room temperature

Different levels of N nutrition did not influence the shelf life of fruits under room temperature storage in Experiment I and II.

Different ratios of organic-chemical N substitution significantly influenced the shelf life of fruits at room temperature (Table 51) in Experiment I. Application of nitrogen through 2:1 ratio of substitution using farm yard manure resulted in higher shelf life of fruits as indicated by Fig. 4. Beneficial effect of organic sources of nitrogen on keeping quality and shelf life of fruits in storage is well known. Asano *et al.* (1981) reported that decreased hardening of fruit surface, decreased browning and discolouration in brinjal and cucumber consequent to the application of organic sources of nitrogen compared to the application of fertiliser nitrogen. This beneficial effect was assumed to be the result of slow or delayed activity of

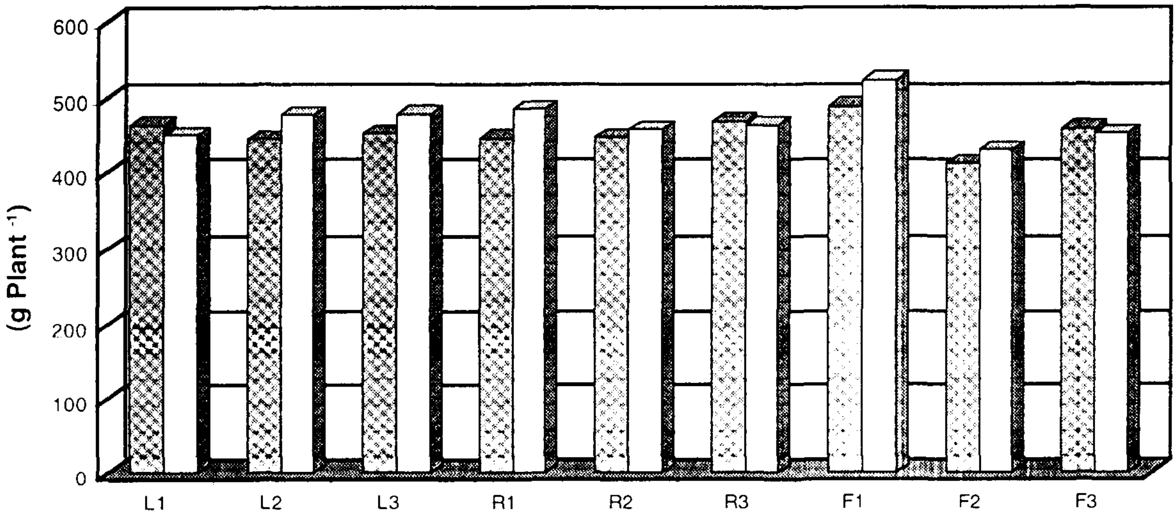


Fig. 3 Total dry matter production Expt - II

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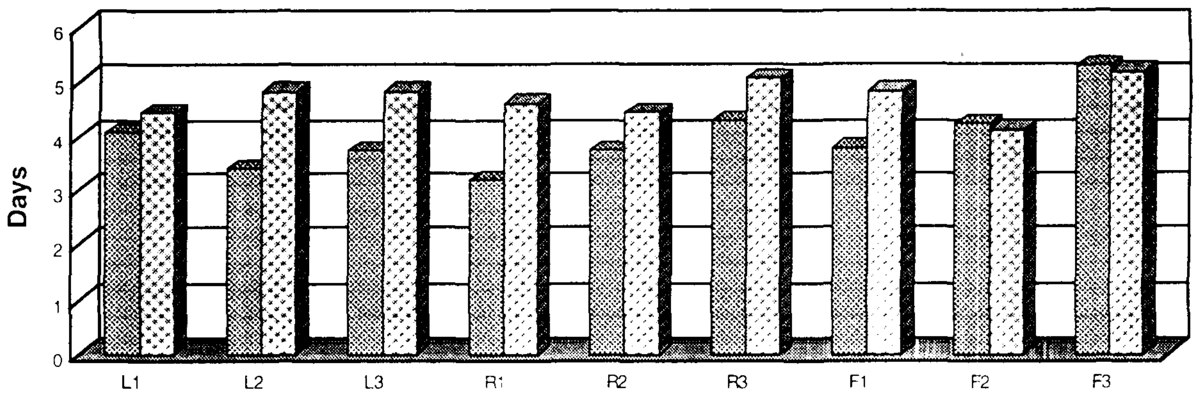

Fig. 4 Shelf life of fruits at room temperature Expt - I

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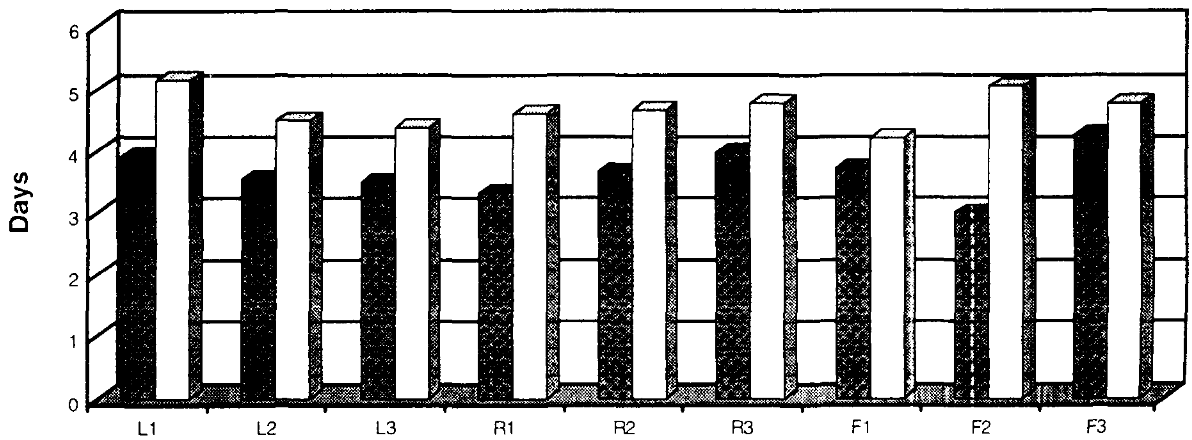

Fig. 5 Shelf life of fruits at room temperature - Expt - II

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organic nitrogen contained in the organic source. While considering the influence of farm yard manure as an organic source, its application in higher proportion has a profound influence on soil properties as it enriches the soil organic matter and release micronutrients, organic acids and other growth substances through chelation (Tisdale *et al.* 1995). The increased production of these organic constituents and availability of micronutrients would have indirectly contributed to the higher shelf life of fruits at storage when farm yard manures was applied in greater proportion. In case of Experiment II also similar trend was noticed (Table 55) wherein application of poultry manure in 2:1 ratio with chemical N source enhanced the shelf life of fruits at room temperature (Fig. 5). Like any other organic manure, application of poultry manure in higher proportion had favourable influence on soil properties through the increased supply of micronutrients and other growth substances. According to Bitzer and Sims (1988), when poultry manure is applied, long term increases in soil levels of nutrients like B, Ca, Mg, Cu and Zn can be expected. Importance of micronutrients like boron in keeping quality of fruits and tubers was indicated by Tisdale *et al.* (1995) wherein it was pointed out that boron deficiency causes cracking or rotting of fruits and tubers thereby reducing the storage life. Therefore the application of poultry manure seemed to have a favourable influence on shelf life of fruits when compared to the application of fertiliser source in greater proportion.

In both Experiment I and II, application of farm yard manure/poultry manure and chemical N source as basal and in fortnightly split doses (f_3) improved the shelf life of fruits (Tables 51 and 55) at room temperature storage. As indicated by the mode of application, quantity of farm yard manure/poultry manure applied in pit as basal in f_3 frequency was limited since major quantity of the manure was applied as top dressings, wherein the chances of full decomposition was comparatively less which in turn reduced the N-uptake. Further more considering the mineralisation pattern of poultry manure as reported by Smith (1950), it can be assumed that when this manure was applied in several splits, the mineral N released consequent to the mineralisation would not have been utilised by the plants during peak growth stage to the extent of its full basal application resulting in lesser N-uptake. The respective N-uptake patterns in Experiment I and II (Table 91 and 95) further support this view. The negative influence of nitrogen on storage life was previously reported by Basu (1986) in potato and Ashcroft and Jones (1993) in tomato.

The LxR interaction significantly influenced the shelf life of fruits at room temperature in both Experiment I and II. In case of Experiment I (Table 52), when low level of N (200 kg ha^{-1}) was supplied through 2:1 ratio of substitution using farm yard manure as organic source, higher shelf life was noticed. The favourable influence of low levels of N nutrition on storage life of fruits is clearly indicated by the interaction, especially when major quantity of N was supplied through farm yard manure. When N level was enhanced, the shelf life slightly decreased even when it was predominantly supplied through an organic source although it was higher as compared to N nutrition through a major source of chemical nature. Beneficial influence of organic source of N on shelf life of fruits might be due to the delayed activity of organic N compounds present in the source as suggested by Asano *et al.* (1981). In this context, favourable influence of low levels of N combined with farm yard manure on marketable fruit yield in chilli after 10 days of storage from harvest was reported previously by Nair and Peter (1990). The Experiment II also showed similar trends with respect to LxR interaction wherein application of low (200 kg) or moderate (250 kg) levels of N through 2:1 ratio of N substitution using poultry manure as organic source recorded maximum shelf life (Table 56) and further increment in N level to 300 kg ha^{-1} reduced the shelf life even when it was supplied through 2:1 ratio. Application of low levels of nitrogen through poultry manure reducing the production of unmarketable tubers in potato was reported earlier by Singh *et al.* (1973).

The LxF interaction influenced the shelf life of fruits at room temperature in both Experiment I and II. In case of Experiment I, application of low level of N (200 kg) through f_3 frequency wherein both farm yard manure and chemical N sources were applied as basal and in fortnightly split doses recorded higher shelf life of fruits (Table 53). Similar trend was noticed in Experiment II also wherein supply of 200 or 250 kg N through f_3 frequency enhanced the shelf life of fruits (Table 57). However increasing the N doses reduced the shelf life of fruits irrespective of frequencies of application in both the experiments. As discussed earlier, application of lower levels of nitrogen as organic source in several split doses would have resulted in low N-uptake as shown in Tables 93 and 97 which in turn would have favourably influenced the shelf life of fruits. However with increase in the level of N, there occurred a corresponding increase in the N-uptake, which would have adversely affected the shelf life of fruits even when the major source of N was organic. Inverse relationship between N and shelf life of fruits was reported earlier by Ashcroft and Jones (1993).

The RxF interaction significantly influenced the shelf life of fruits in Experiment I and II (Tables 54 and 58). Nitrogen nutrition using 2:1 ratio of organic-chemical N substitution through f_3 frequency (r_3f_3) recorded higher shelf life when the organic source of substitution was farm yard manure or poultry manure. Application of N with its major source as organic in fortnightly split doses reduced the N-uptake (Tables 94 and 98) due to delayed mineralisation, which would have indirectly favoured the storage life of fruits as discussed before. Poultry manure application increasing the availability of micronutrients (Bitzer and Sims, 1988) coupled with incidental reduction in N-uptake could be attributed to be the reason behind better shelf life in Experiment II.

5.7.2 Shelf life of fruits under refrigeration

As depicted in Table 51, enhancing the N level from low to moderate or higher levels decreased the shelf life of fruits under refrigeration in 1995-96 (Fig. 6) in Experiment I. Similar trend was noticed in case of Experiment II also (Fig. 7). Low levels of N nutrition favourably influenced the shelf life of fruits under refrigeration on account of the well known inverse relationship between nitrogen and keeping quality as pointed out by workers like Singh *et al.* (1973) and Kadam *et al.* (1993).

Table 51 and 55 showed that nitrogen nutrition through 2:1 ratio of organic-chemical N source using farm yard manure/poultry manure as organic source was found to enhance the shelf life of fruits under refrigeratory storage. These effects are further illustrated by Fig.6 (Experiment I) and Fig.7 (Experiment II). As already discussed in case of room temperature storage, application of organic source in higher proportion would have enhanced the shelf life of fruits on account of delayed activity of N. The inverse relationship between N and storage life is well established according to Ashcroft and Jones (1993).

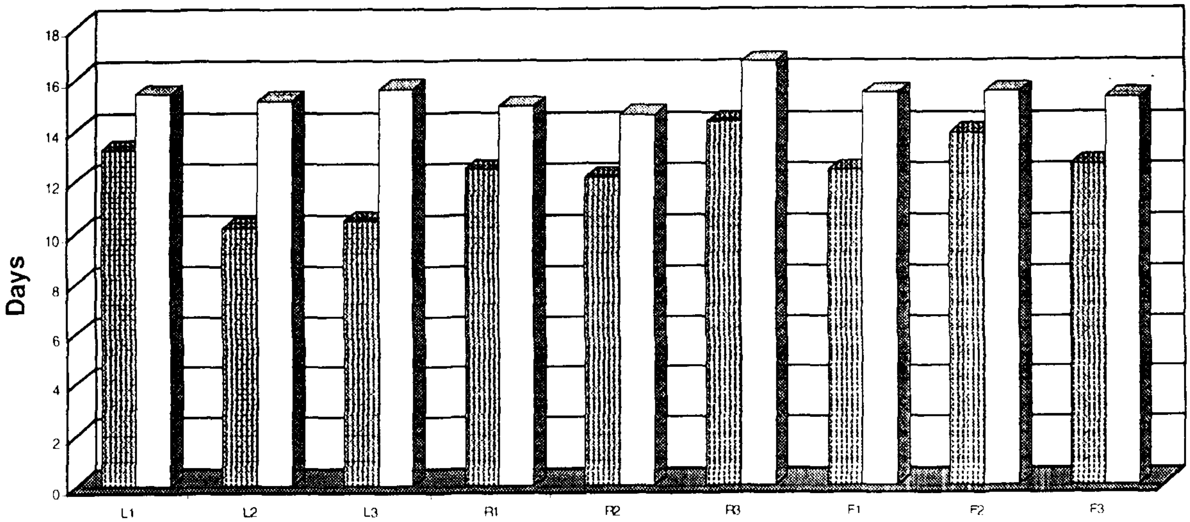

Fig. 6 Shelf life of fruits under refrigeration - Expt - I

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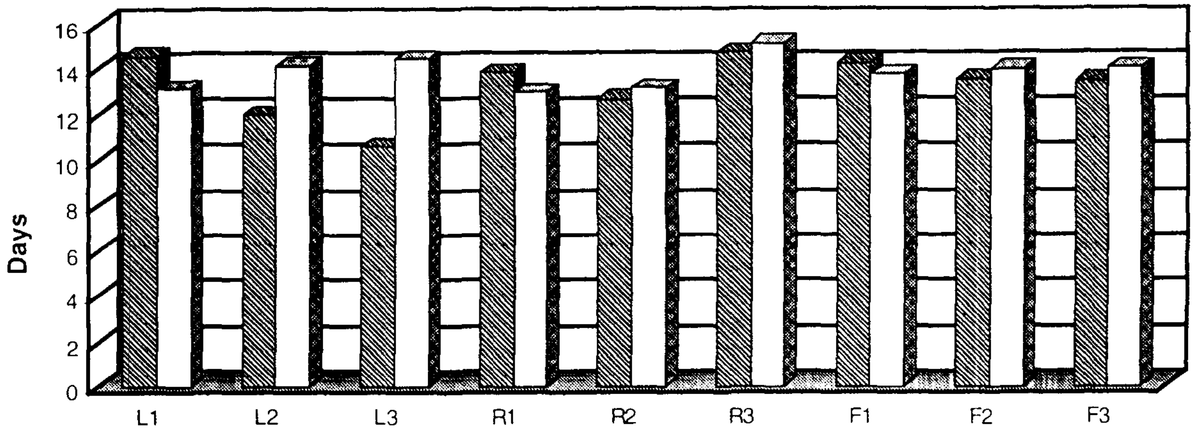

Fig. 7 Shelf life of fruits under refrigeration - Expt - II

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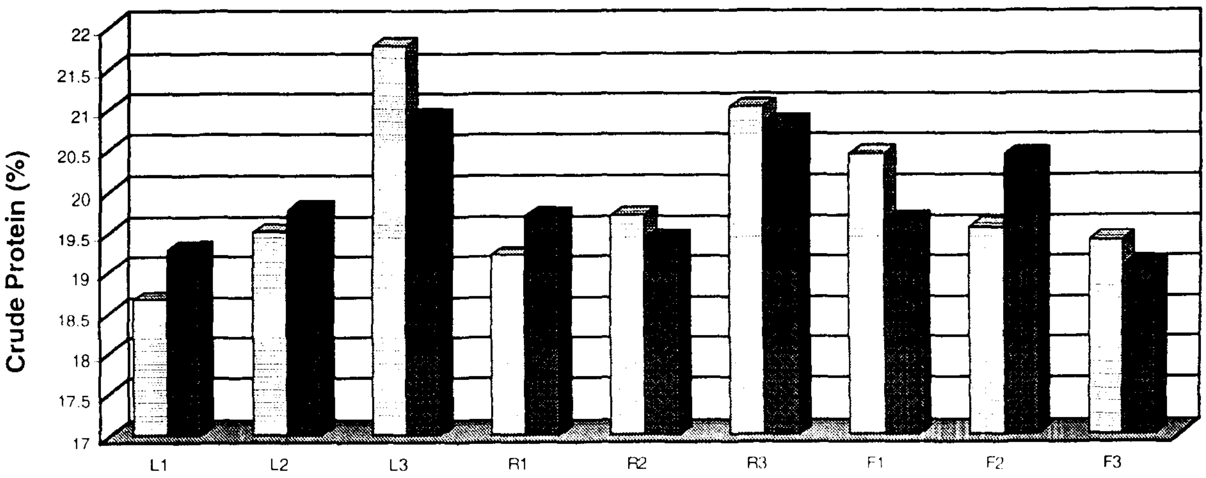

Fig. 8 Crude protein content of fruits - Expt - I

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Further more application of poultry manure brings about long term increases in micronutrients such as boron in soil (Bitzer and Sims, 1988) which might favourably influence the keeping quality of fruits and tubers as suggested by Tisdale *et al.* (1995).

Different frequencies of application did not influence the shelf life of fruits under refrigeration in Experiment I and II.

Interaction effects were not significant to influence the shelf life of fruits under refrigeration in Experiment I and II.

5.7.3 Physiological loss in weight at room temperature storage (%)

Main effects or interaction effects of the treatments could not significantly influence the physiological loss in weight during storage at room temperature in Experiment I and II.

5.7.4 Physiological loss in weight under refrigeratory storage (%)

Under refrigeratory condition, physiological loss in weight was not affected by main effects or interaction effects of treatments in both the experiments.

5.8 Plant analysis

5.8.1 Total N content in plant (%)

Increasing the N level from 200 or 250 kg to 300 kg significantly enhanced the total N content of plant in Experiment I (Table 59). These effects were however not significant in Experiment II. As evident from Table 91, application of higher level of N resulted in an increased uptake of N which naturally would have increased the plant nutrient status of nitrogen. According to Tisdale *et al.* (1995), plant analysis is based on the presumption that the amount of a given nutrient in a plant is directly related to the availability of the nutrient in the soil. Application of N fertilisers increasing the nitrogen content of plants was reported by earlier workers like Tayel *et al.* (1965) in cucumber.

Different ratios of substitution did not have any influence on total N content in plant in case of Experiment I and II.

Different frequencies of application affected the total N content of plant in Experiment I (Table 59) while it did not show any influence in Experiment II. Higher total N content was recorded in plants when full quantity of farm yard manure was applied as basal dose and chemical N source as basal + fortnightly split doses in f_1 frequency. The quick decomposition of farm yard manure would have been favoured in f_1 frequency since the manure was well mixed into the soil of the pit before planting when compared to other frequencies of application wherein top dressing of manure was followed. In this context it is worthwhile to consider the observation pointed out by Tisdale *et al.* (1995) that, of the N mineralised during the first 2 or 3 months of application of organic source, 80 per cent is converted to NO^-_3 at the end of first three months which is readily utilised by the plant. Therefore the chances of mineralisation of organic source and release of plant available forms of nitrogen and its utilisation are likely to be more with f_1 frequency which would have resulted in an enhanced uptake (Table 91) and higher total plant N content.

Different interaction effects did not have any influence on total plant N content in Experiment I and II.

5.8.2 Total P content in plant (%)

Higher total P content in plant was recorded with the application of highest level (300 kg) of N in both Experiment I and II (Tables 59 and 63). The biochemical pathway of nutrient N in plants narrated by Tisdale *et al.* (1995) indicated that the NO_3^- or NH_4^+ absorbed by the plants will be assimilated into numerous aminoacids after a series of reactions and are subsequently incorporated into proteins, nucleic acids and other biochemicals when the P supply is not limited. The element P is an important structural component of a wide variety of biochemicals including nucleic acids, co enzymes, nucleotides, phosphoproteins, phospholipids and sugarphosphates. Therefore it could be presumed that increased supply of nitrogen might result in increased production of P containing biochemicals under non limited conditions of P supply, which would have contributed to the improved total P content in plant. Synergetic influence of N nutrition on P content was previously reported by Singh *et al.* (1970) in cauliflower.

Different ratios of organic-chemical N source substitution could not influence the total plant P content in Experiment I. In case of Experiment II as indicated by Table 63, total P content in plant was higher when 2:1 ratio of substitution using poultry manure as organic source was followed. When nutrient N was supplied through 2:1 ratio using poultry manure as organic source, the manure with its higher P content (Table 2) would have contributed to the nutrient pool of P in soil. Besides this organic manure application in higher proportion would have resulted in vigorous root growth thereby increasing the P-uptake and P content in plant over and above the synergetic effect of nitrogen present in the manure.

Frequencies of N nutrition were not significant to influence the total plant P content in Experiment I and II.

None of the interaction effects was significant to affect the total plant P content in Experiment I and II.

5.8.3 Total K content in plant (%)

Increase in levels of N application significantly increased the total K content of plant in Experiment I and II (Tables 59 and 63). Highest total plant K content was obtained when highest level of N (300 kg ha^{-1}) was applied in both the experiments. As pointed out by Tisdale *et al.* (1995), uptake of K largely depends on the supply of other nutrients and therefore when nutrient nitrogen was supplied in higher levels, the requirement of K also would have increased which in turn resulted in increased K-uptake (Tables 107 and 111) and K accumulation in plants. Higher levels of nitrogen nutrition favouring the plant K content was previously reported by Singh *et al.* (1970) and Haris (1989).

Different ratios of substitution influenced the total K content in plants when farm yard manure was used as organic source in Experiment I and the content was higher with 2:1 ratio of substitution. Ratios of substitution did not show any influence on total K content of plants in Experiment II. When farm yard manure was applied in higher proportion in 2:1 ratio of substitution, it would have enhanced the moisture retention capacity of soil which being the general advantage of organic manure application. Increasing moisture content and retention in soil likely to have accelarated K^+ diffusion to roots as pointed out by Tisdale *et al.* (1995), which would have resulted in better uptake and higher K concentration in plants.

Frequencies of nitrogen nutrition could not influence the total plant K content in Experiment I or II.

Various interaction effects too did not influence the total K content of plant in Experiment I and II.

5.9 Fruit Analysis

5.9.1 Crude protein content of fruits (%)

It is depicted in Table 67 that enhancing the N level from low (200 kg) or moderate (250 kg) to higher level (300 kg) improved the crude protein content of fruit in Experiment I which is illustrated by Fig. 8. A similar trend was noticed in case of Experiment II (Table 71), wherein increase in levels of N application significantly increased the crude protein content of fruits (Fig. 9). The biochemical pathway of nutrient N in plants indicate that nitrogen in the form of NH_4^+ or NO_3^-, which after a series of reductions will be assimilated into numerous aminoacids that are subsequently incorporated into protein synthesis (Tisdale *et al.*, 1995). Therefore higher levels of N nutrition would have favourably influenced the crude protein content of fruits on account of increased N assimilation. N application promoting the crude protein content was previously reported by Fritz and Habben (1972) in spinach, Maurya (1987) in cucumber and Haris (1989) in snake gourd.

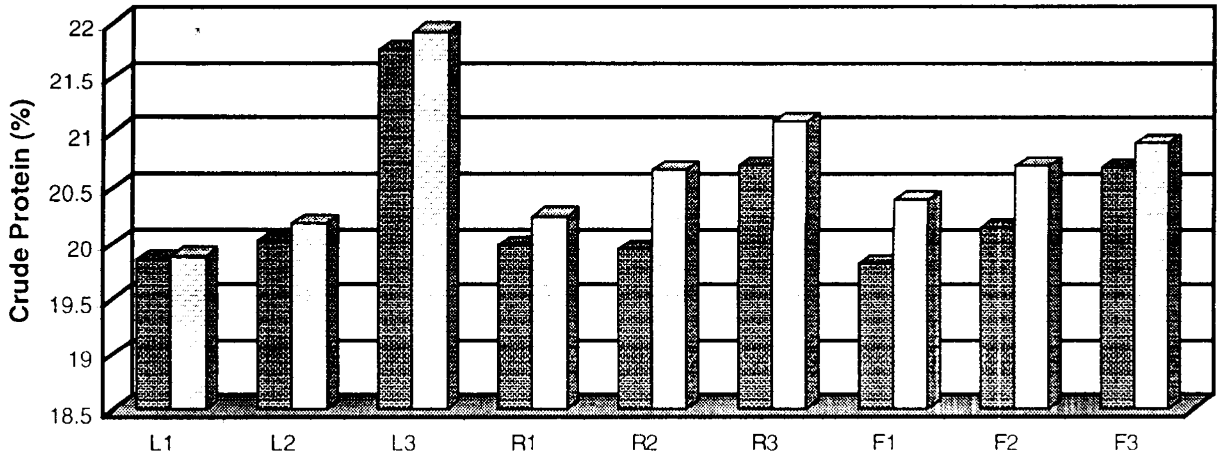

Fig. 9 Crude Protein in content of fruits - Expt - II

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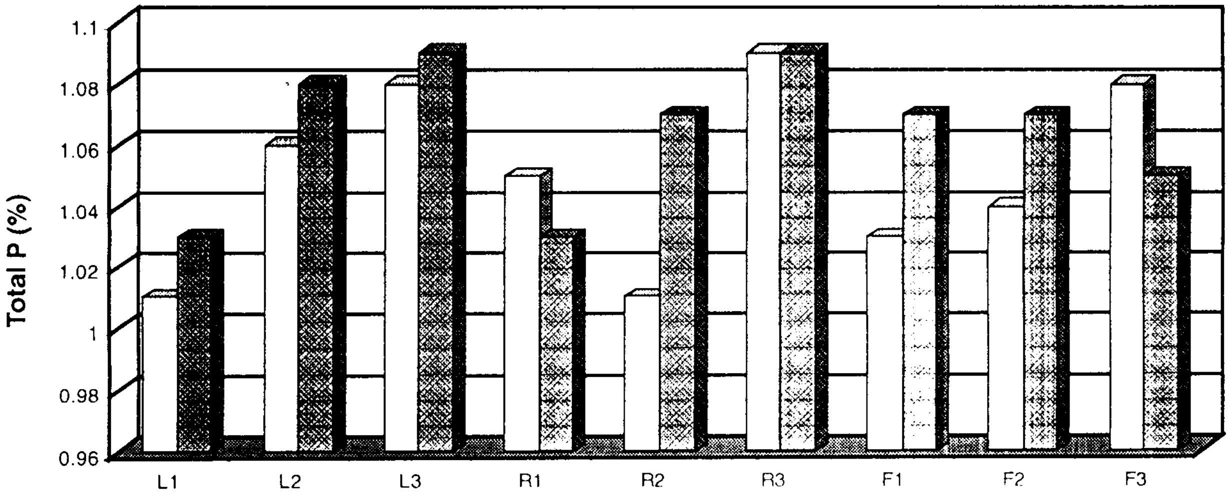

Fig. 10 Total P content of fruit - Expt - I

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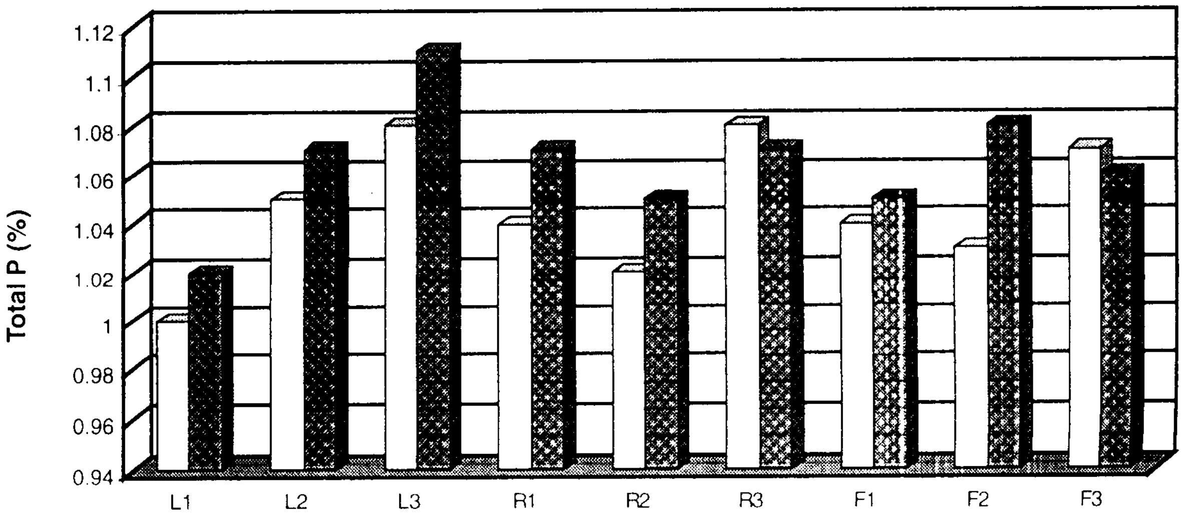

Fig. 11 Total P content of fruit - Expt - II

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Different ratios of N substitution significantly influenced the crude protein content of fruits in Experiment I (Table 67) although it did not show any influence in Experiment II. Highest crude protein content of fruits was recorded when farm yard manure and chemical N source were applied in 2:1 ratio of substitution in r_3 (Fig.8). Application of organic source in greater proportion through its favourable effect on soil properties would have resulted in better utilisation of major nutrients as well as micronutrients which in turn might have enhanced the quality aspects like crude protein content of fruits. Application of higher levels of organic source as farm yard manure improving the N content in economic plant parts was earlier reported by Singh *et al.* (1996).

Frequencies of N application did not influence the crude protein content of fruits in Experiment I and II.

The LxR interaction depicted in Table 68 indicated that the crude protein content of fruits in Experiment I was influenced by LxR interaction, although it was not significant in Experiment II. Higher crude protein content was observed when highest level of N (300 kg) was supplied through 2:1 organic-chemical N ratio using farm yard manure as organic source. As discussed in case of main effects, the higher levels of nutrient N when applied through a major source of organic nature, it improves the soil properties which increase the plant availability and uptake of nitrogen and other nutrients which might have assimilated into numerous aminoacids that are subsequently utilised for protein synthesis as pointed out by Tisdale *et al.* (1995).

The LxF and RxF interactions were not significant in Experiment I and II.

5.9.2 Total P content of fruits (%)

As shown in Tables 67 and 71, enhancing the levels of nitrogen from 200 to 250 or 300 kg ha^{-1} significantly increased the total P content of fruits in both Experiment I and II. These effects are further illustrated in Fig. 10 (Experiment I) and Fig. 11 (Experiment II). Nitrogen application stimulates the root growth and uptake of other nutrients like P and K (Brady, 1996), which would have resulted in better accumulation of P in fruits in addition to the increased biosynthesis of proteins, nucleic acids and other bio chemicals of which P is a structural constituent. Nitrogen nutrition favouring the P content in plants was previously reported by Singh *et al.* (1970), Patel and Chandravanshi (1996) and Paikaray *et al.* (1997).

Different ratios of N substitution or frequencies of N nutrition did not influence the total P content of fruits in Experiment I and II.

Various interaction effects too could not affect the total P content of bitter gourd fruits in both Experiment I and II.

5.9.3 Total K content of fruits (%)

Higher total K content was recorded in fruits when 300 kg N ha^{-1} (highest dose) was applied in both the experiments (Table 67 and 71). The beneficial influence of higher levels of N nutrition on total K content of fruits in both the years is evidenced in Fig. 12 (Experiment I) and Fig. 13 (Experiment II). The uptake and utilisation of element K greatly depend on the supply of other nutrients especially nitrogen (Tisdale *et al.*, 1995). When nutrient N was applied in higher

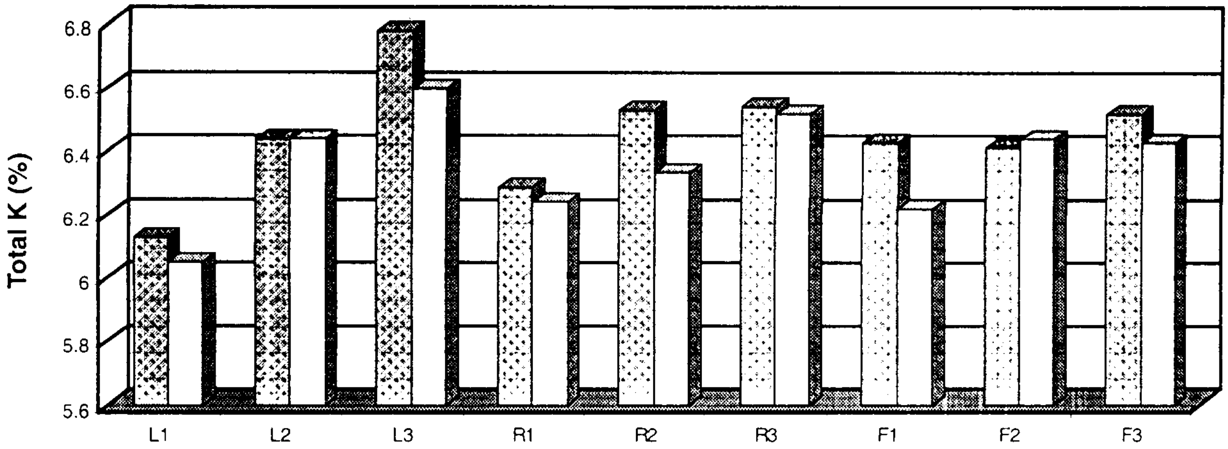

Fig. 12 Total K content of fruit - Expt - I

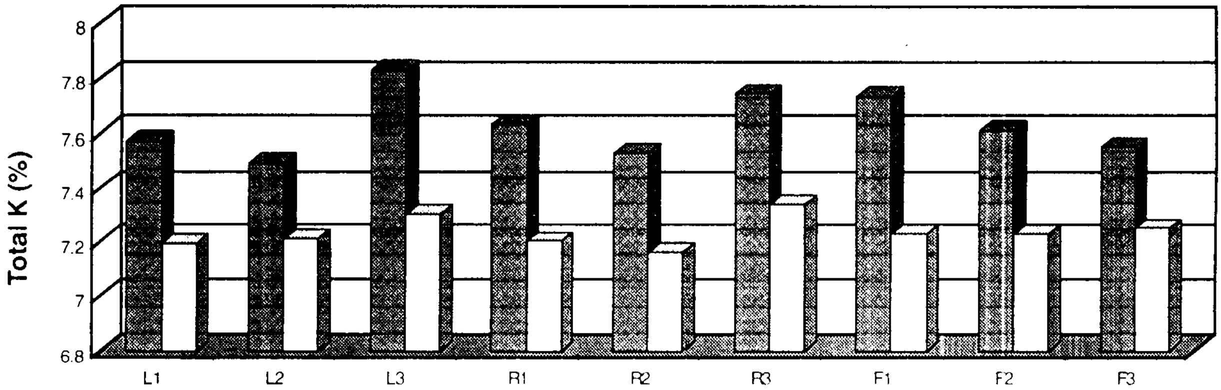

Fig. 13 Total K content of fruit - Expt - II

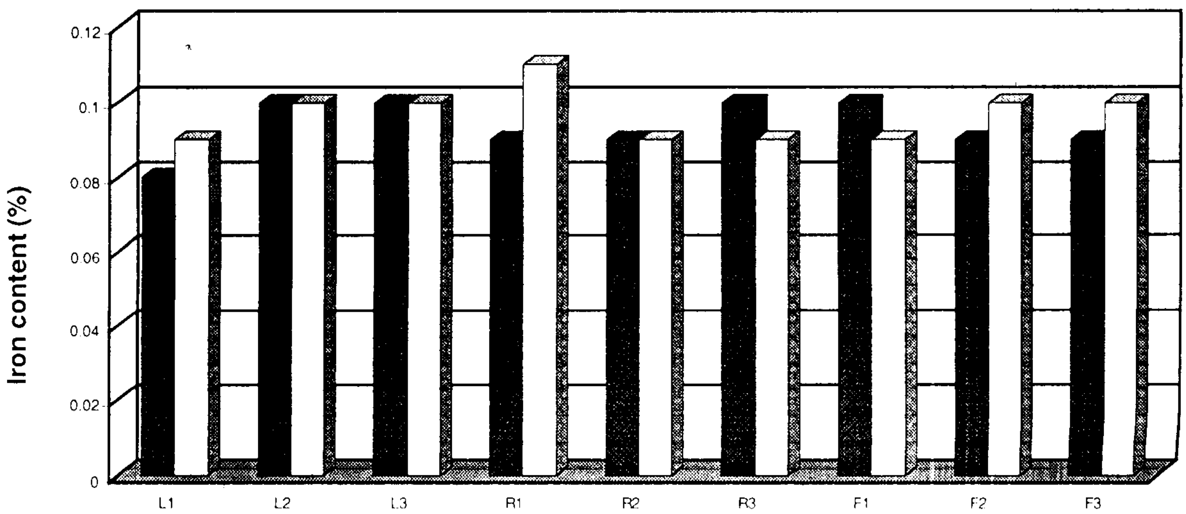

Fig. 14 Iron content of fruit - Expt - II

levels, the plant requirement and uptake of K also might have increased which would have ultimately resulted in better accumulation of K in fruits. The K-uptake depicted in Table 107 (Experiment I) and Table 111 (Experiment II) supports this opinion. Nitrogen nutrition promoting the total K content in cauliflower heads has been reported earlier by Singh *et al.* (1970).

Different ratios of substitution or frequencies of application of N did not have any influence on total K content of fruits in Experiment I and II.

Total K content of fruits was not affected by treatment interactions in Experiment I and II.

5.9.4 Iron content of fruits (%)

Different levels of N application did not influence the iron content of fruits in Experiment I. However when poultry manure was used in Experiment II, higher levels of N application enhanced the iron content of fruits (Table 71 and Fig. 14). Uptake of nutrient iron is closely related to the root development since the chelated Fe which diffuses to the root surface in "chelate-micronutrient cycling" (Tisdale *et al.*, 1995) greatly contributes to the plant available Fe and its uptake. However there is a direct favourable effect of N on root growth of plants in general which in turn would have promoted the uptake and accumulation of Fe. Favourable influence of nitrogen nutrition on Fe content has been reported earlier by Cheng (1982).

Different ratios of organic-chemical N substitution on frequencies of N nutrition did not have any effect on iron content of fruits in Experiment I and II.

Though the LxR interaction did not influence the iron content of fruits in Experiment I, it produced significant variation in Experiment II. When 300 kg N was applied through poultry manure in 2:1 ratio (l_3r_3), significantly higher iron content was noticed, (Table 72). Supply of highest dose of N through 2:1 organic-chemical N ratio necessitated highest quantity of poultry manure application on equivalent nitrogen basis. Chemical analysis of poultry manure revealed that it is primarily composed of NH_4-N (Bitzer and Sims, 1988). According to Tisdale *et al.* (1995), Fe solubility and availability are favoured by the acidity that develops when NH_4^+ is utilised by the plant. Hence it could be presumed that application of higher quantities of poultry manure to supply highest level of N would have increased the Fe availability, uptake and accumulation in plants.

The LxF or RxF interactions did not have any effect on iron content of fruits in Experiment I and II.

5.9.5 Ascorbic acid content of fruits (mg 100 ml^{-1})

As shown in Tables 67 and 71, higher levels of N significantly reduced the ascorbic acid content of fruits which is illustrated in Fig. 15 (Experiment I) and Fig. 16 (Experiment II). The inverse relationship between N and ascorbic acid content was suggested earlier by Mapson (1955). According to him, the higher rate of respiration usually induced by higher nitrogen supply may influence the concentration of ascorbic acid in the cell by increasing its rate of consumption or by depressing its synthesis by stimulating other competitive synthetic processes. Another observation by Fritz and Habben (1972) was that ascorbic acid content is inversely related to shading of plants. The excessive vegetative growth

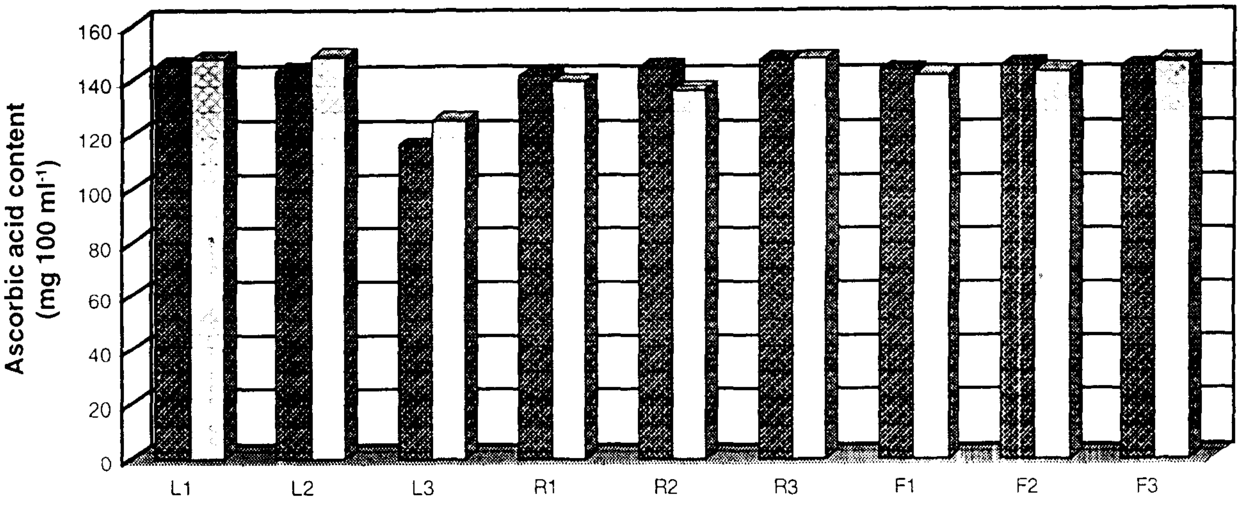

Fig. 15 Ascorbic acid content of fruits - Expt - I

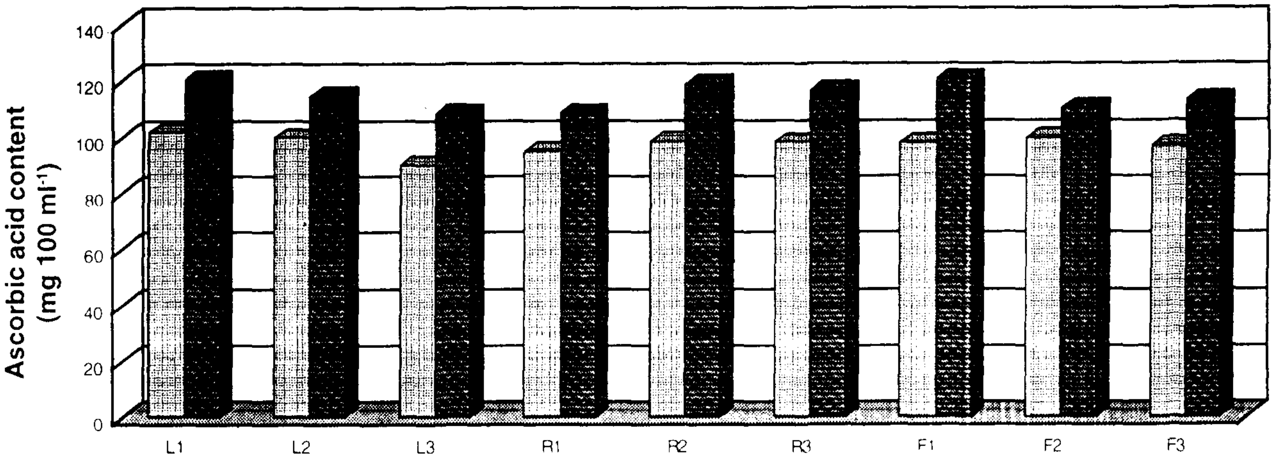

Fig. 16 Ascorbic acid content of fruit - Expt - II

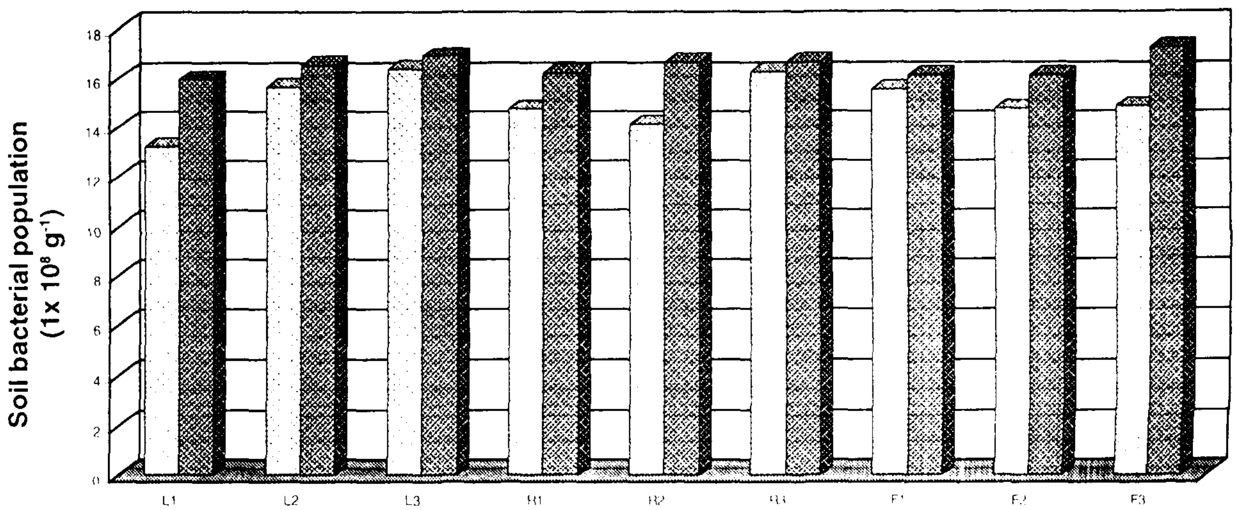

Fig. 17 Soil bacterial population - Expt - I

consequent to the higher levels of application of N especially in a pandal trailed crop like bitter gourd would have caused excessive shading which would eventually have lowered the ascorbic acid content. Higher levels of N nutrition inhibiting the ascorbic acid content was reported by Yu (1972) and Maurya (1987) in cucumber.

Different ratios of substitutions or frequencies of application had no influence on ascorbic acid content of fruits in Experiment I and II.

Various interaction effects too did not have any influence on ascorbic acid content of fruits in Experiment I and II.

5.10 Soil biological properties

5.10.1 Soil bacterial population ($1x10^8$ g^{-1})

Influence of levels of nitrogen nutrition on soil bacterial population is depicted in Table 75 and Table 79. Higher levels of application of nitrogen increased the soil bacterial population in both the experiments during first year. This effect is clearly indicated by Fig. 17 and Fig. 18. Higher levels of N nutrition might have enhanced the bacterial activity as suggested by Tisdale *et al.* (1995) due to the stimulatory effect of NO_3^- on organic anion synthesis and resultant accumulation of cations like Ca^{2+}. According to Brady (1996), high calcium concentration in soil is best for most bacteria. Higher levels of N prolonging the rhizosphere bacterial activity was reported by Jagadeesh *et al.* (1994). Recent workers like Biedenbeck *et al.* (1996) reported the increase in bacterial population with increasing N levels.

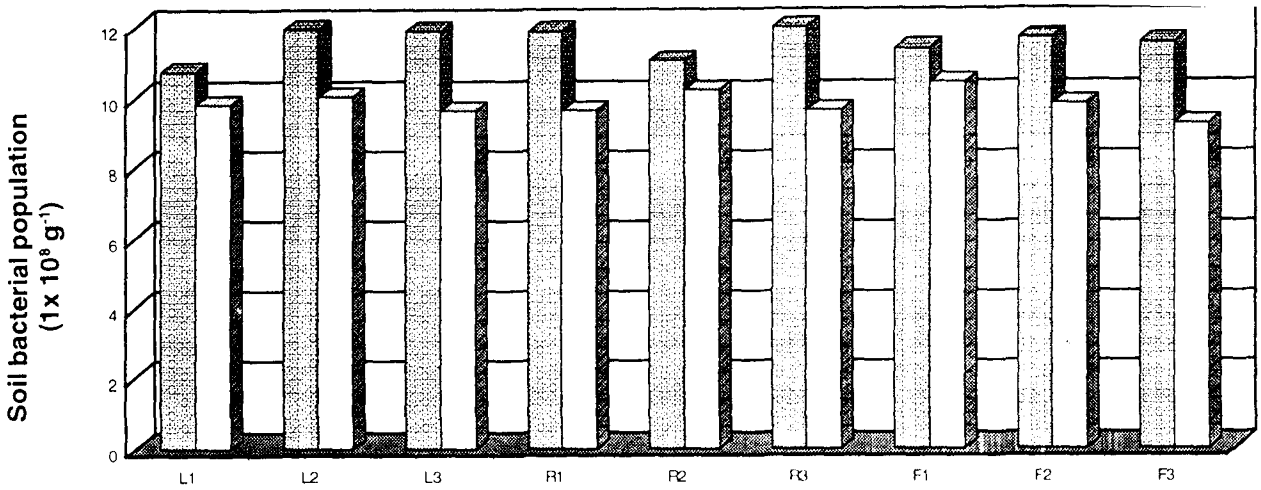

Fig. 18 Soil bacterial population Expt - II

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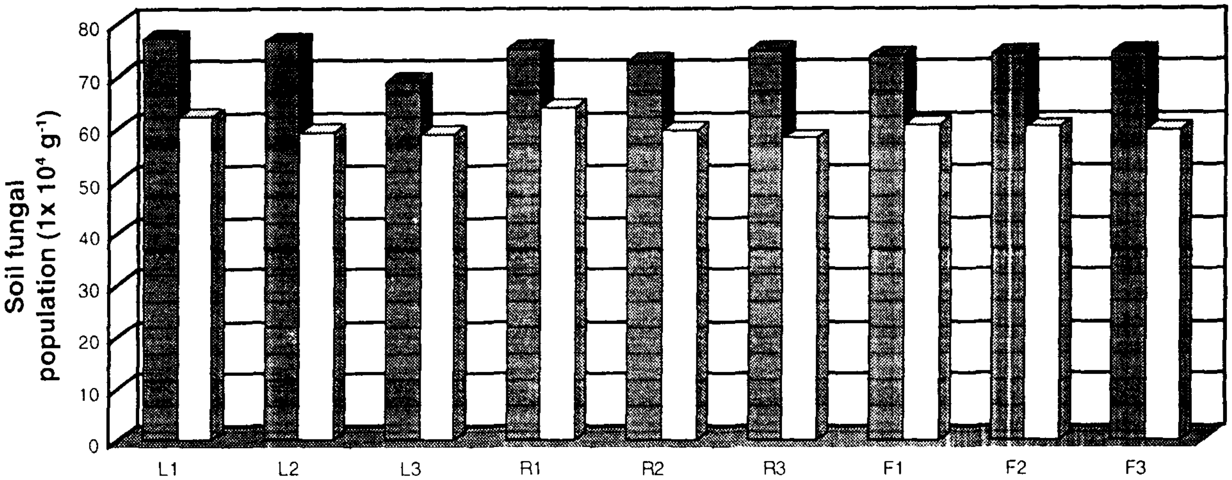

Fig. 19 Soil fungal population - Expt - I

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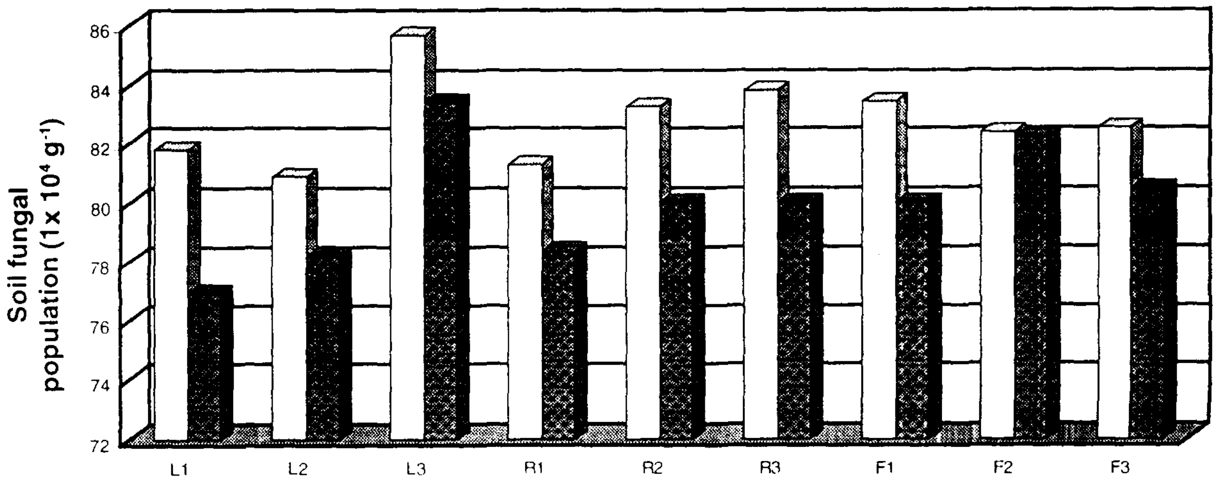

Fig. 20 Soil fungal population - Expt - II

1995 - 96 1996 - 97

As illustrated by Fig. 17 (Experiment I) and Fig. 18 (Experiment II), bacterial population build up was higher with 2:1 ratio (r_3) of organic-chemical N source substitution using farm yard manure/poultry manure as organic source compared to 1:1 or 1:2 ratios in first year. As suggested by Brady (1996), organic matter is used as an energy source by majority of heterotrophic bacteria and therefore enhanced supply of organic matter would have favoured the growth of bacteria in soil. Besides this, amino acids and other organic compounds released by the organic source decomposition might have stimulated the native bacterial activity through increased nutrient availability. In case of Experiment II, application of poultry manure in greater proportion is likely to contribute to the adequate soil fertility levels of nutrients like P, K, Ca, Mg, Mn, Cu and Zn (Bitzer and Sims, 1988). Most of these nutrients have specific roles in microbial growth processes as opined by Brady (1996). Increased availability of such nutrients consequent to the application of poultry manure in greater proportion would have promoted the soil bacterial population. Acea and Carballas (1988) reported the favourable influence of organic sources of N on bacterial population in soil.

Different frequencies of application influenced the soil bacterial population in Experiment I (Table 75) and Experiment II (Table 79). As indicated in Fig. 17 and 18, application of full quantity of farm yard manure/poultry manure as basal dose and basal + fortnightly split doses of chemical N source (f_1) increased the soil bacterial population compared to f_2 or f_3 frequencies. The process of decomposition of organic source is more facilitated when entire quantity is applied as basal dose in f_1 frequency compared to f_2 or f_3 frequencies where the organic manure is top dressed in split doses. The decomposition products of organic matter such as aminoacids and other organic acids might have stimulated the bacterial activity which resulted in higher soil bacterial population count. The organic matter also increased the moisture retention capacity (Table 83 and 87) which is also a requirement of microbial population. In this context, Brady (1996) opined that various growth promoting compounds such as vitamins, amino acids, auxins and gibberellins are formed during organic matter decomposition, which might stimulate the microorganisms in soil.

As shown in Table 76 that the LxR interaction significantly influenced the soil bacterial population in Experiment I while it did not show any influence in Experiment II. Application of highest level of N (300 kg) through 2:1 organic-chemical N substitution ratio (l_3r_3) resulted in significantly higher soil bacterial population. As seen in case of main effects of L and R, their combinations too reflected the same trend wherein higher levels of N through greater proportion of organic source stimulated the bacterial population in soil. As discussed in the case of main effects, the greater quantity of organic source used to supply the highest level of N on equivalent nitrogen basis would have stimulated the soil bacterial population by way of decomposition and subsequent release of organic compounds as narrated by Brady (1996).

The LxF interaction (Table 77) influenced the soil bacterial population in Experiment I while the interaction was not significant in Experiment II. Application of highest level of N (300 kg) through f_1 frequency (l_3f_1) promoted the soil bacterial population. When higher levels of N was applied with its organic source (farm yard manure) fully as basal dose, the cumulative effect of stimulatory influence of nutrient N and better organic source decomposition resulting from the full basal application would have promoted the growth and development of soil bacteria which was manifested in its count.

The RxF interaction (Table 78) was significant only in case of Experiment I wherein nitrogen nutrition through 2:1 ratio of substitution using farm yard manure as organic source in f_1 frequency recorded higher soil bacterial population. The trend observed in case of main effects of R and F is reflected in case of their interactions too wherein application of higher quantity of farm yard manure fully as basal dose (r_3f_1) would have promoted the bacterial population by way of decomposition.

5.10.2 Soil fungal population ($1x10^4$ g^{-1})

As shown in Table 75 and Fig.19 increasing levels of N had a depressing effect on soil fungal population in Experiment I. This suppression of fungal growth at higher levels of N can be assumed to be due to the competition between soil bacteria and fungi. As indicated by Table 75, the bacterial growth was greatly promoted by higher doses of N nutrition in Experiment I. Brady (1996) suggested the possibilities of an intense intermicrobial rivalry for food in soil which may dominate or suppress certain microorganics. Considering this possibility it could be presumed that intermicrobial rivalry between bacteria and fungi would have counteracted the general favourable influence of nitrogen nutrition on soil fungal population as reported by Nambiar (1994) and Singh *et al.* (1998). However nitrogen nutrition exhibited a different trend in Experiment II (Table 79). As the N level was enhanced from low to moderate level (200 to 250 kg) there was a slight suppression of fungal population and however it improved with the next higher level of N (300 kg); Fig. 20. The improvement in fungal population at higher levels of N nutrition can be attributed to the general favourable influence of

N on crop biomass production and root growth, thereby enhancing the residue build up in soil and thus creating a more congenial condition for soil microorganisms. This congenial condition would have prevented the intermicrobial rivalry, ultimately promoting the fungal population in Experiment II.

Different ratios of substitution or frequencies of application did not have any influence on soil fungal population in Experiment I and II.

Various interaction effects were also not significant to influence the soil fungal population in Experiment I and II.

5.10.3 Soil actinomycetes population ($1 x 10^6$ g^{-1})

Different levels of N application did not influence the soil actinomycetes population in Experiment I and II.

As indicated in Table 75, actinomycetes population was higher when farm yard manure and chemical N source were applied in 2:1 ratio on equivalent N basis in first year in Experiment I (Fig. 21). This effect was however not significant in Experiment II. According to Brady (1996), actinomycetes are most sensitive to soil pH and their optimum development takes place between pH 6 to 7.5. When organic manure is applied in higher proportion to the acidic soil, it has a neutralising effect on soil pH by way of buffer action which would have promoted the growth of actinomycetes in soil. Application of organic source of farm yard manure favouring the actinomycetes population in soil was previously reported by Mukherjee and Gaur (1980) and Nambiar (1994).

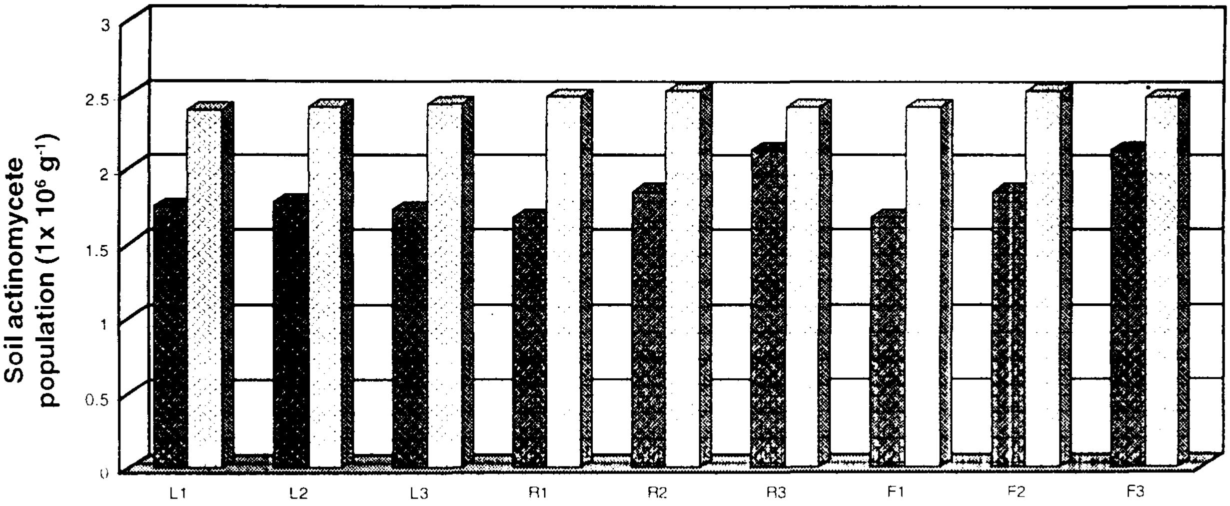

Fig. 21 Soil actinomycete population - Expt - I

1995 - 96 1996 - 97

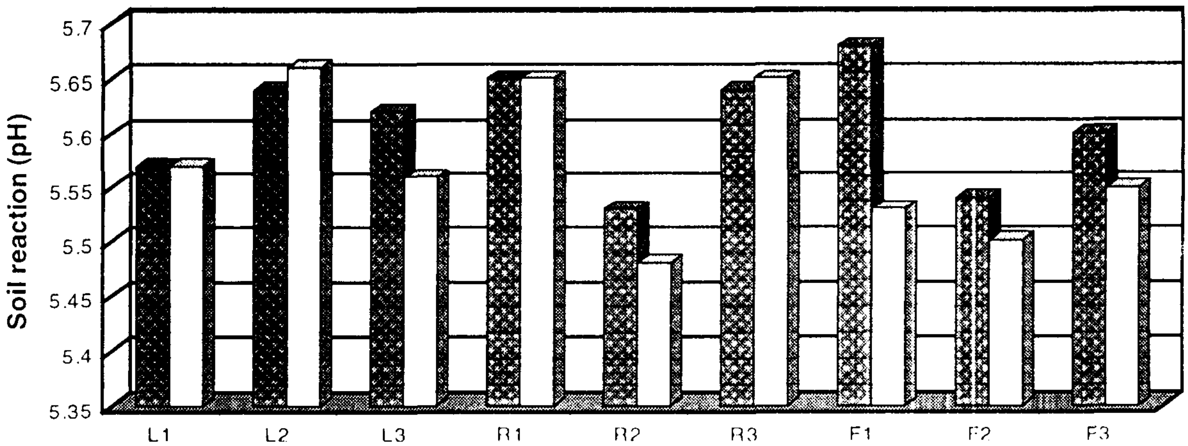

Fig. 22 Soil reaction (pH) - Expt - I

1995 - 96 1996 - 97

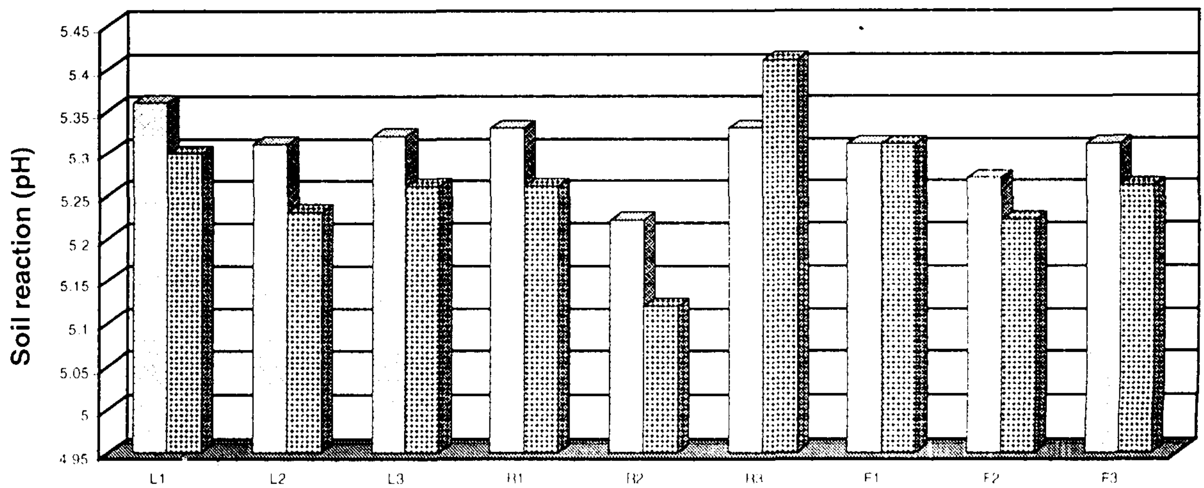

Fig. 23 Soil reaction (pH) - Expt - II

1995 - 96 1996 - 97

Various frequencies of application did not influence the soil actinomycetes population in Experiment I and II.

None of interaction effects was significant to affect the actinomycetes population in Experiment I and II.

5.11 Soil physico-chemical properties

5.11.1 Soil Reaction (pH)

Different levels of N application had no influence on soil reaction in Experiment I and II.

Different ratios of organic-chemical N substitution ratios affected the soil reaction in Experiment I (Table 83) and Experiment II (Table 84). In case of Experiment I, soil pH increased when farm yard manure and chemical N source were applied in 2:1 or 1:1 ratio and it was higher than the initial pH value as well as pH recorded with 1:2 ratio of substitution (Fig.22). Application of farm yard manure in greater proportion or equal proportion with chemical N enhanced the soil pH which may be probably due to the buffering action associated with organic manure as suggested by Brady (1996) wherein decreased activity of Al^{3+} ions in the soil solution due to chelation by organic molecules takes place. The moderating effect of farm yard manure on soil acidity was earlier reported by Yifong and Chingwen (1993) and Nambiar (1994). In case of Experiment II, there was a general reduction in the pH compared to its initial value. Bitzer and Sims (1988) suggested that inorganic N in poultry manure is primarily NH_4^+ and acidity is generated when NH_4^+ is utilised by plants (Brady, 1996). The noticeable reduction in soil pH in Experiment II compared to Experiment I and initial value may be attributed to the chemical nature of this manure which promotes the acidity. As illustrated by Fig.23, application of poultry manure and chemical N source through 1:1 (r_1) or 2:1 (r_3) ratio recorded higher soil pH during the first year compared to 1:2 (r_1) ratio although the 2:1 ratio of substitution resulted in higher pH during the succeeding year compared to other ratios. The slight modification in the soil pH with 1:1 or 2:1 ratio of substitution can be attributed to the fact that higher quantities of application of poultry manure brings about long term increases in P, Ca, Mg, Mn etc. as opined by Bitzer and Sims (1988), which would have slightly improved the soil pH. Similar observation was reported by Sim (1986).

Different frequencies of application influenced the soil reaction in Experiment I (Table 83) while it did not have any effect in Experiment II. In the present study higher soil pH was recorded with f_1 frequency compared to f_2 or f_3 (Fig. 22). The f_1 frequency in which total quantity of farm yard manure was applied as basal dose showed a pH moderating effect probably on account of better decomposition and resultant buffer action.

The LxR interaction could not influence the soil reaction in Experiment I and II.

The LxF interaction was significant only in case of Experiment I (Table 85). Application of moderate or higher levels of N through f_1 frequency recorded higher soil pH. The reason cited for the enhancement of pH for main effect of full basal organic source treatment (f_1) is valid for its interaction effects with different levels of N too. The treatment combination had a moderating effect on pH in acidic conditions on account of better decomposition and resultant buffering action consequent to full basal application.

The RxF interaction was not significant to influence the soil reaction in Experiment I and II.

5.11.2 Organic carbon content of soil (%)

Different levels of N nutrition did not influence the organic carbon content of soil in both Experiment I and II.

As indicated by Tables 83 and 87, organic carbon content of soil was higher with 2:1 ratio wherein farm yard manure/poultry manure was applied in 2:1 ratio with chemical N source in both the experiments. Influence of ratios of N substitution on organic carbon content of soil are illustrated in Fig. 24 (Experiment I) and Fig. 25 (Experiment II). The organic carbon content of soil which is an index of soil health and fertility tend to enhance with the addition of organic materials or residues to the soil (Tisdale *et al.*, 1995). Therefore the application of farm yard manure or poultry manure in higher proportion is likely to exert a promoting effect on soil organic carbon content compared to the application of chemical N source in greater proportion. Incorporation of farm yard manure along with inorganic fertilisers increasing the organic carbon content of soil was reported by Helkiah *et al.* (1981) and Nambiar (1994). Favourable influence of poultry litter on soil organic carbon content was reported by Rubeiz *et al.* (1992).

Different frequencies of application influenced the soil organic carbon content in Experiment I (Table 83) while it did not have any effect in Experiment

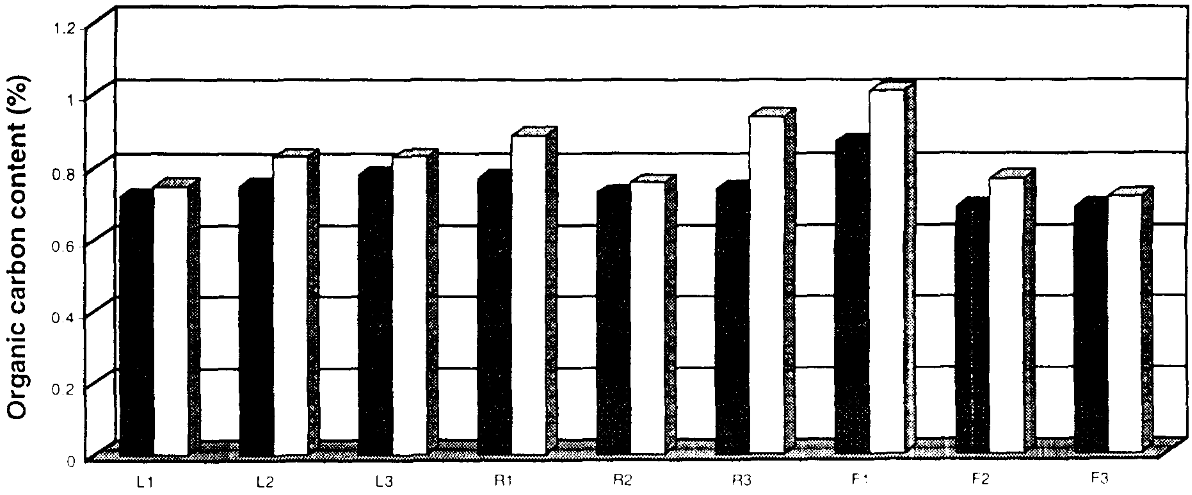

Fig. 24 Organic carbon content of soil - Expt - I

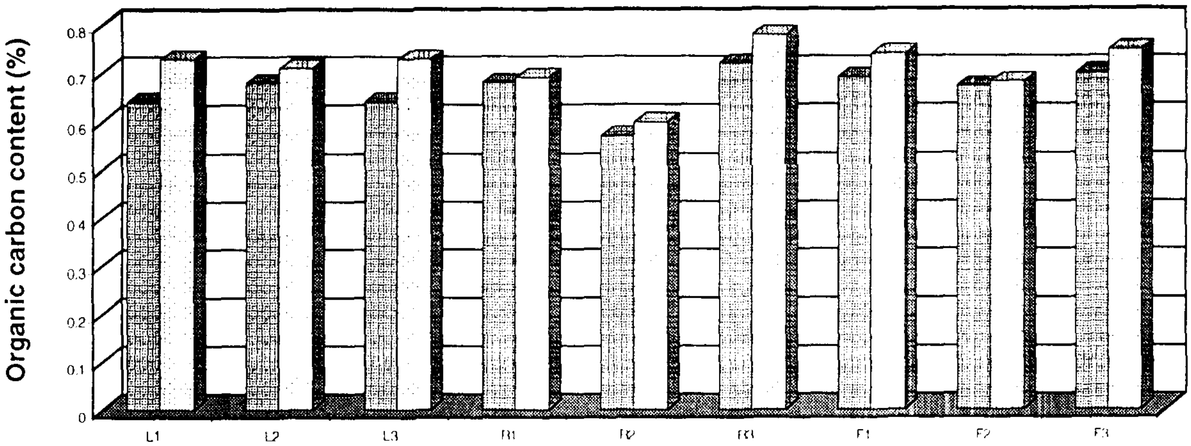

Fig. 25 Organic carbon content of Soil - Expt - II

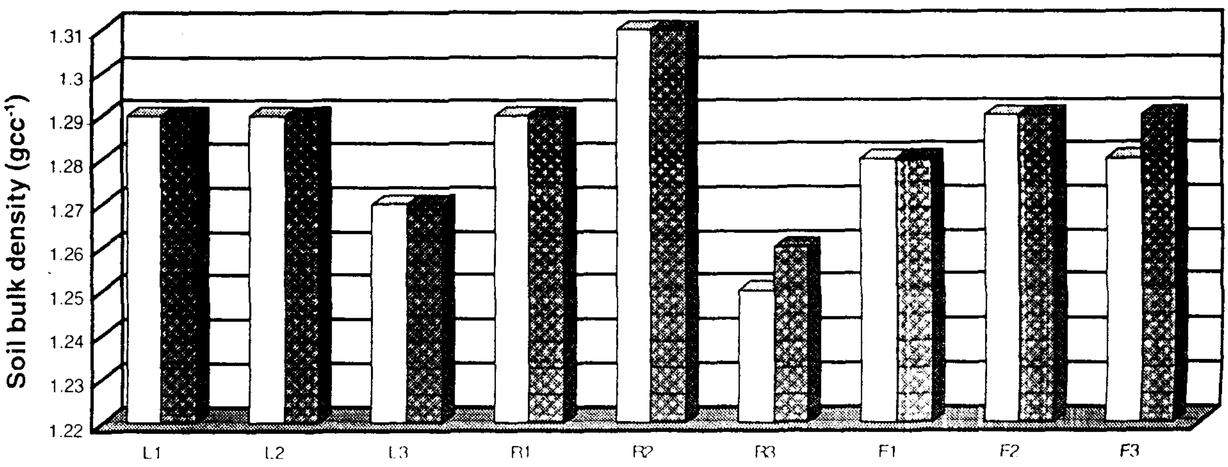

Fig. 26 Soil bulk density - Expt - I

II. When full quantity of farm yard manure was applied as basal dose (f_1), organic carbon content of soil was significantly higher compared to f_2 or f_3 treatments wherein split application of manure was followed (Fig. 24). When farm yard manure was applied in split doses, the soil around the plant was earthed up during each application which generally increases the soil aeration. This practice would have increased the organic matter oxidation potential of soils which resulted in reduced organic carbon content compared to the complete basal application of organic matter. Soil tillage producing greater aeration which stimulates aerobic microbial activity and subsequently aids in increasing the rate of disappearance of organic carbon was suggested by Tisdale *et al.* (1995).

The LxR interaction influenced the organic carbon content of soil in Experiment I (Table 84). Application of highest level of N (300 kg) through 2:1 N substitution ratio produced higher organic carbon content in l_3r_3 combination compared to other combinations in Experiment I. These effects were however not significant in Experiment II. The supply of highest dose of N through 2:1 ratio of N substitution needed the application of larger quantity of farm yard manure under l_3r_3 combination which would have favoured the organic carbon content in soil, compared to the supply of lower levels of N through moderate or lower quantities of farm yard manure in other combinations. Favourable influence of higher quantity of organic sources on organic carbon content of soil was previously reported by workers like Yifong and Chingwen (1993) and Nambiar (1994).

The LxF interaction was significant only in case of Experiment I (Table 85). Application of highest level of N (300 kg) through f_1 frequency resulted in higher organic carbon content of soil in l_3f_1 compared to the application of low or higher levels of N through f_2 or f_3 frequencies wherein split application of farm yard manure was followed. When highest level of N requiring higher quantities of organic manure for equivalent N substitution was applied in full quantity as basal dose in pits, the chances of organic matter oxidation would have been relatively less compared to the top dressing application in other combinations which ultimately produced higher organic carbon content in soil.

The RxF interaction significantly influenced the organic carbon content in Experiment I (Table 86). Nitrogen nutrition through 2:1 or 1:1 ratio of substitution using farm yard manure as organic source at f_1 frequency recorded higher organic carbon content in soil. As discussed in case of main effects, when moderate or higher quantities of organic manure was fully applied as basal dose it would have resulted in low organic matter oxidation which subsequently would have enhanced the organic carbon content in soil. In case of Experiment II, the RxF interaction produced a different trend with respect to organic carbon content. As shown in Table 90, organic carbon content was higher when 2:1 ratio of substitution was followed with f_3 frequency in r_3f_3. The low rate of decomposition of later applied dose of poultry manure due to time factor would have helped in maintaining higher organic carbon content in soil.

5.11.3 Soil physical properties

5.11.3a Bulk density (g cc^{-1})

Different N levels could not influence the bulk density of soil in both the experiments.

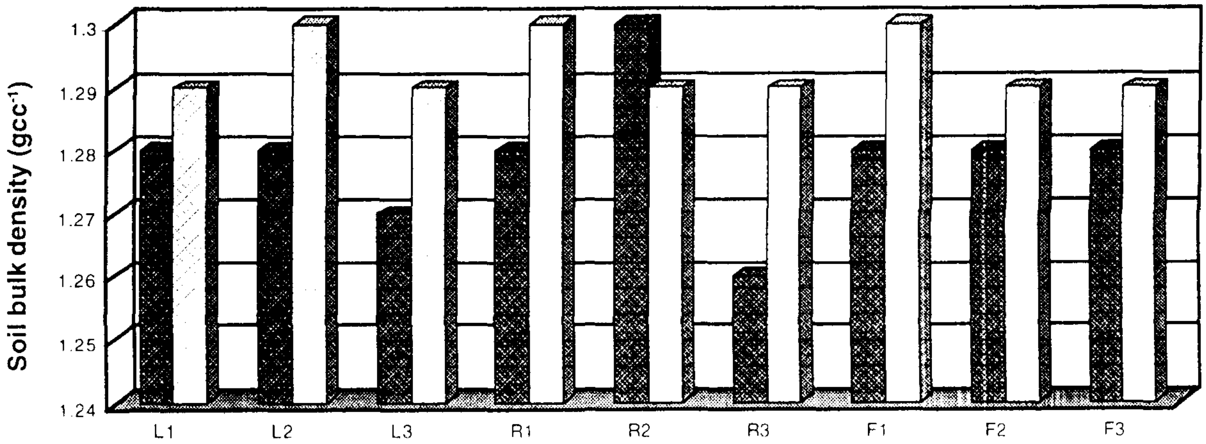

Fig. 27 Soil bulk density - Expt - II

1995 - 96 1996 - 97

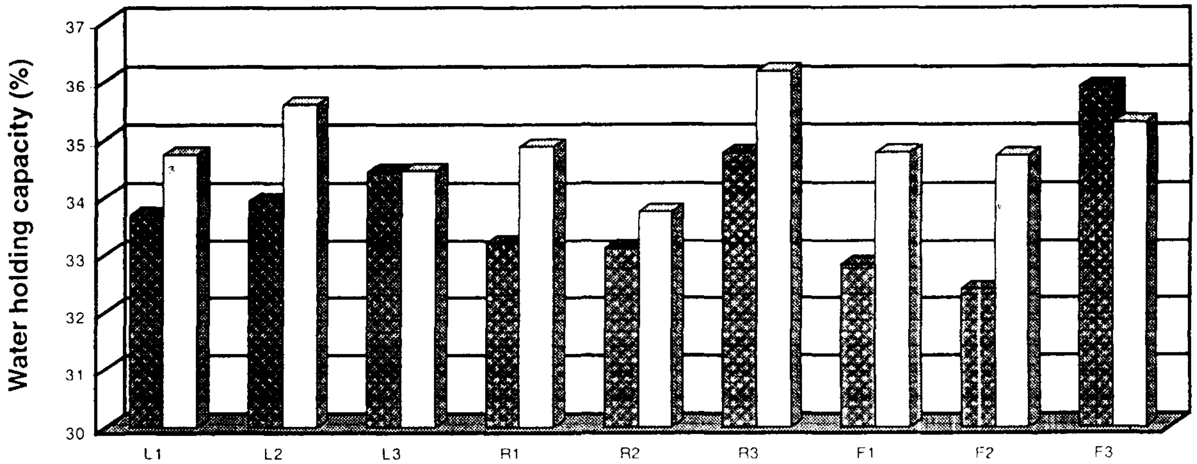

Fig. 28 Water holding capacity of soil - Expt - I

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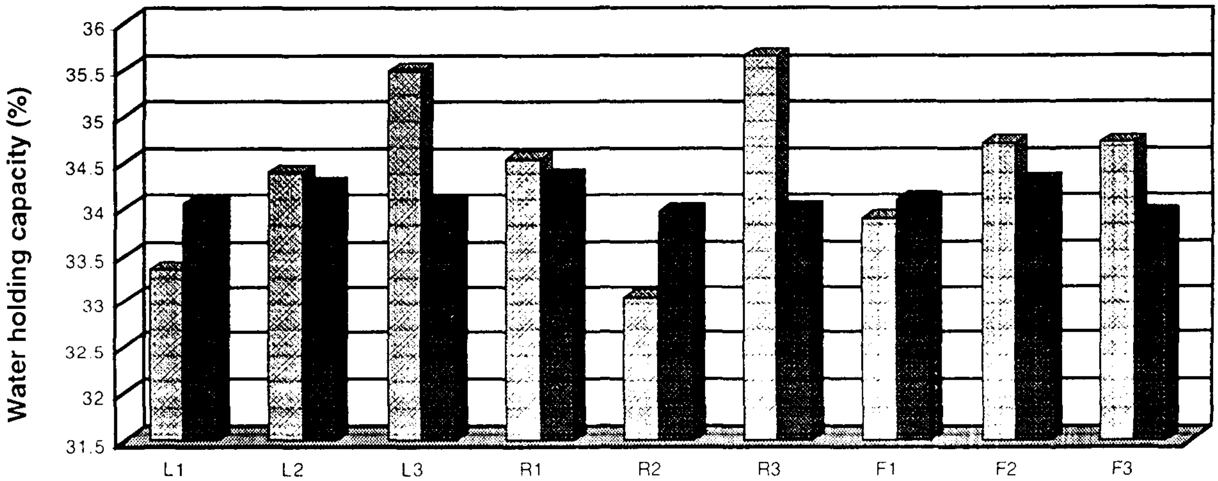

Fig. 29 Water holding capacity of soil - Expt - II

1995 - 96 1996 - 97

Bulk density was significantly lower when farm yard manure or poultry manure was applied in 2:1 proportion with chemical N source (Tables 83 and 87). The soil bulk density influenced by ratios of substitution is indicated by Fig. 26 (Experiment I) and Fig. 27 (Experiment II). The solid particles of the fine textured soils tend to be organised in porous grains or granules if adequate organic matter is present (Brady, 1996). The greater proportion of organic source would have promoted the granulation of soil in 2:1 ratio which might have lowered the bulk density in comparison with other ratios. The farm yard manure application lowering the soil bulk density was reported by Helkiah *et al.* (1981), Bhadoria (1987) and Nambiar (1994). The poultry manure application lowering the soil bulk density was corroborated by Hafez (1974) and Aravind (1987).

Bulk density was not influenced by different frequencies of nitrogen nutrition in Experiment I and II.

The LxR interaction significantly influenced the bulk density of soil in both the experiments (Table 84 and 88). When higher or moderate doses of N was applied through 2:1 ratio of organic-chemical N source, soil bulk density was significantly lower in Experiment I and in case of Experiment II, application of highest dose of N (300 kg) through 2:1 ratio using poultry manure as organic source was efficient in lowering the soil bulk density. Supply of higher level of N through 2:1 organic-chemical N ratio required the addition of higher quantity of farm yard manure/poultry manure, which through their indirect effects on soil granulation and porosity would have lowered the bulk density as suggested by Brady (1996).

The LxF interaction in Experiment I or II was not significant to influence the bulk density of soil.

The RxF interaction influenced the soil bulk density (Table 86 and 90). When 2:1 (r_3) ratio of N substitution was followed with few (f_2) or more (f_3) split applications of farm yard manure or poultry manure, the soil bulk density was considerably lower in both the experiments. When nutrient N was supplied through 2:1 ratio through f_2 or f_3 frequencies, few or more split applications of higher quantity of organic source was needed. The soil was turned in or earthed up with each split application of organic source for incorporation of manure while the soil was not much disturbed with f_1 frequency wherein the whole quantity of manure was applied in the pit before sowing. The inter cultivation practices have profound influence on soil porosity and improvement of soil porosity and granulation consequent to the treatment combination would have lowered the bulk density, since the soils with higher proportion of pore space to solids have lower bulk densities compared to compact soils as pointed out by Brady (1996).

5.11.3b Water holding capacity (%)

Different levels of N nutrition had no influence on water holding capacity of soil in both the experiments.

As shown in Table 83 and 87, different ratios of N substitution influenced the soil water holding capacity. Significantly higher water holding capacity was recorded with 2:1 ratio of organic-chemical N substitution using farm yard manure or poultry manure as organic source (Fig. 28 and Fig.29). Favourable influence of organic matter on water holding capacity of soil is well known. According to Brady (1996), organic matter binds mineral particles into granules that are largely responsible for the loose, easily managed condition of productive soils and increases the quantity of water a soil can hold. The higher proportion of organic source used in r_3 ratio would have resulted in higher water holding capacity through favourable influence on soil physical conditions. Similar results were reported by Bhadoria (1987), Yifong and Chingwen (1993) and Darwish *et al.* (1995).

Different frequencies of application influenced the water holding capacity of soil in Experiment I (Fig. 28) while in Experiment II it did not show any effect. Higher water holding capacity was recorded with f_3 frequency in Experiment I. The mode of nutrient application in f_3 was such that along with the chemical N source, the organic source (farm yard manure) also was applied as basal and fortnightly split doses. Such top dressings are likely to help in breaking the hard surface while incorporating the manure through soil turnings and these operations would have increased the porosity of soil, which ultimately improved the moisture holding capacity. Further more, less decomposition of organic matter due to top dressing might have also contributed to better water holding capacity of soil.

The LxR interaction was significant in both the experiments (Table 84 and 88). Increased water holding capacity was noted when highest level of N (300 kg) was applied through r_3 ratio in l_3r_3 combination in both the experiments. Addition of highest dose of N through 2:1 ratio which required the application of higher quantity of farm yard manure or poultry manure would have enhanced the water holding capacity of soil through better aggregation and aggregate size distribution as suggested by Brady (1996).

The LxF interaction was significant only in case of Experiment I (Table 85) and higher water holding capacity of soil was recorded with l_3f_3 combination. When higher levels of nutrient N was applied through f_3 frequency wherein the farm yard manure and chemical N source were applied in fortnightly splits, each split dose of organic manure was incorporated through soil turning which might have helped in breaking the hard surface, increasing the porosity and water holding capacity of soil.

The RxF interaction significantly affected the water holding capacity of soil in Experiment I (Table 86), while it did not have any effect in Experiment II. Higher water holding capacity in soil was recorded with r_3f_3 treatment combination. The trend noticed in case of main effects of R and F are reflected in case of their interaction effects too. Nitrogen nutrition through 2:1 ratio of organic-chemical N substitution using farm yard manure as organic source with f_3 frequency might have improved the soil physical conditions through the combined influence of organic source and earthing up operations done to incorporate its split doses which would have increased the water holding capacity of soil.

5.11.3c Particle Density (g cc^{-1})

Different levels of N application did not affect the soil particle density.

As indicated by Table 83 and 87, ratios of N substitution significantly influenced the particle density of soil. Fig. 30 and 31 indicated that the r_2 (1:2) ratio of N substitution recorded higher particle density in soil compared to r_1 (1:1) or r_3 (2:1) ratios in both the experiments. Organic matter weighs much less than equal volume of mineral solids and therefore the soils having high organic

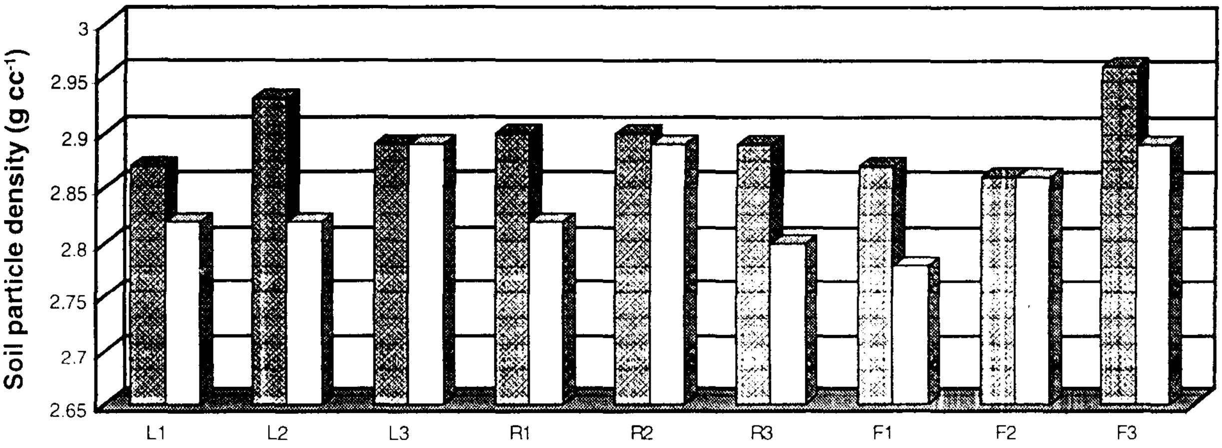

Fig. 30 Soil particle density - Expt - I

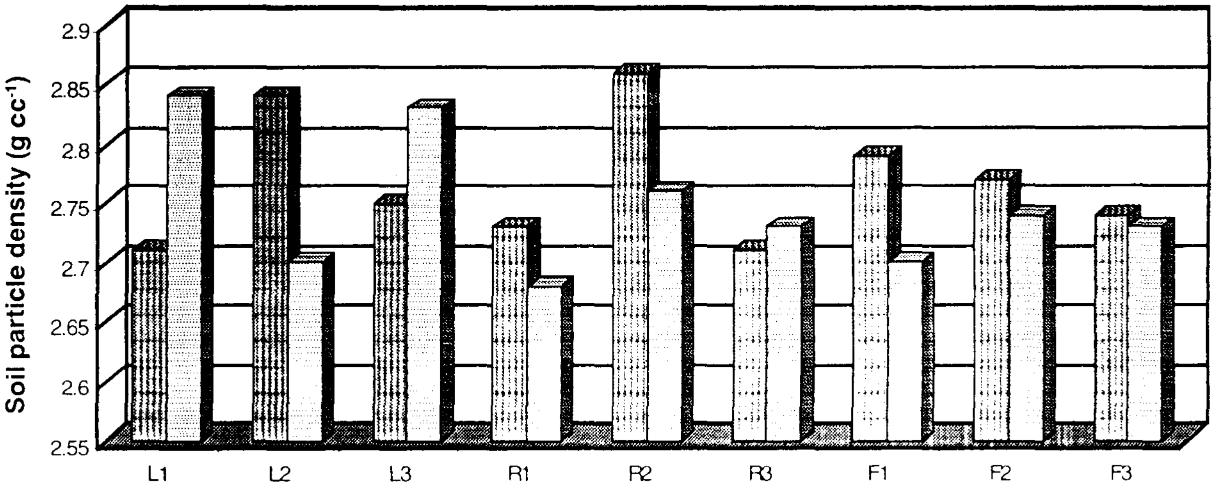

Fig. 31 Soil particle density Expt - II

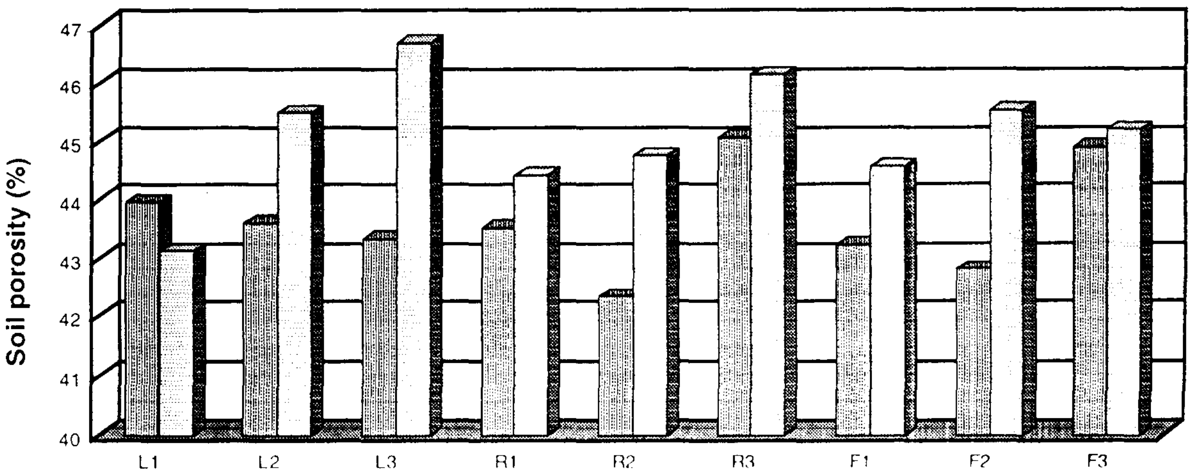

Fig. 32 Soil porosity - Expt - I

matter content usually have lower particle densities (Brady, 1996). Therefore the r_2 ratio in which lesser proportion of farm yard manure or poultry manure was applied appeared to have higher particle density compared to the other two ratios wherein moderate or greater proportion of organic source was applied. The profound influence of organic source on soil physical properties might have been more apparent since the manure was applied to the pit in a localised manner.

As illustrated by Fig. 30, higher particle density was registered in Experiment I when f_3 frequency was followed. In f_3 frequency, the farm yard manure was applied in several split doses where each dose was incorporated by an earthing up operation. This would have enhanced the soil aeration and as a result, organic matter oxidation would have taken place at a faster pace. As explained by Brady (1996), the low organic matter content of soil tend to increase the particle density. The frequencies of N nutrition however could not influence the soil particle density in Experiment II.

Various interaction effects could not influence the particle density of soil.

5.11.3d Porosity (%)

Different levels of nitrogen nutrition significantly influenced the soil porosity only in Experiment I (Table 83). As shown in Fig. 32, enhancing the N dose from low (200 kg) to moderate (250 kg) level significantly enhanced the soil porosity in second year. Nitrogen nutrition through its effect on root proliferation and root extension might have promoted the granulation of soil which in turn improved the porosity of soil. Plant roots playing a major role in soil aeration has been previously suggested by Brady (1996).

Different ratios of substitution affected the soil porosity in Experiment I (Table 83) while it did not have any influence in Experiment II. At depicted in Fig. 32, soil porosity was greater when N was supplied through 2:1 ratio using farm yard manure as organic source compared to 1:2 or 1:1 ratios. When nutrient N was supplied in such a way that its major source is of organic nature, there is likely to be a favourable influence on total pore spaces in soil and porosity of soil. According to Brady (1996), organic matter is the major agent that stimulates the formation and stabilisation of granular and crumb type aggregates. As organic residues decompose, gels and other viscous microbial products are evolved which along with associated fungi and bacteria encourage the crumb formation and the net effect of these activities would have increased soil granulation, aggregation and porosity. Favourable influence of farm yard manure on soil porosity was reported by Helkiah *et al.* (1981) and Loganathan (1990).

Different frequencies of application showed significant influence on porosity in Experiment I only (Table 83). Higher porosity was recorded with f_3 frequency. In f_3 frequency, application of nutrient N was done in several fortnightly split doses wherein each split of organic source was incorporated by earthing up of soil. This practice invariably would have helped in breaking the clods and crumbs, thus finally enhancing the soil porosity.

The LxR interaction as shown in Table 84 influenced the porosity in Experiment I. Application of lower (200 kg) or higher (300 kg) N through 2:1 organic-chemical N ratio using farm yard manure as organic source was found to favour the soil porosity. This influence was possibly due to the positive effect of higher quantities of organic manure on soil granulation and aggregation which would have enhanced the soil porosity. Favourable influence of farm yard manure as organic source on soil porosity was earlier pointed out by Loganathan (1990). The LxR interaction could not influence the porosity in Experiment II.

The LxF interaction given in Table 85 showed that supply of moderate (250 kg) or higher (300 kg) levels of N through basal + fortnightly split doses of farm yard manure and chemical N source enhanced the soil porosity in Experiment I. This improvement in soil porosity would have been brought about by way of soil turning done to incorporate the farm yard manure with each split application. However the porosity in Experiment II was unaffected by the LxF interaction.

The RxF interaction significantly influenced the soil porosity in Experiment I only (Table 86). Higher soil porosity was obtained when N was supplied through r_3 (2:1) ratio at f_3 frequency. Trend observed in the case of main effects of R and F was reflected in case of their interaction too. Combined influence of higher levels of organic source and soil turning done several times to incorporate the farm yard manure would have promoted the soil aggregation, granulation and total porosity. Favourable influence of farm yard manure application on soil porosity was reported earlier by Helkiah *et al.* (1981).

5.12 Nutrient balance studies

5.12.1 Nitrogen balance in soil

5.12.1a N-uptake (kg ha^{-1})

As depicted in Table 91, highest level of N application (300 kg) enhanced the N-uptake in Experiment I compared to low (200 kg) or moderate (250 kg)

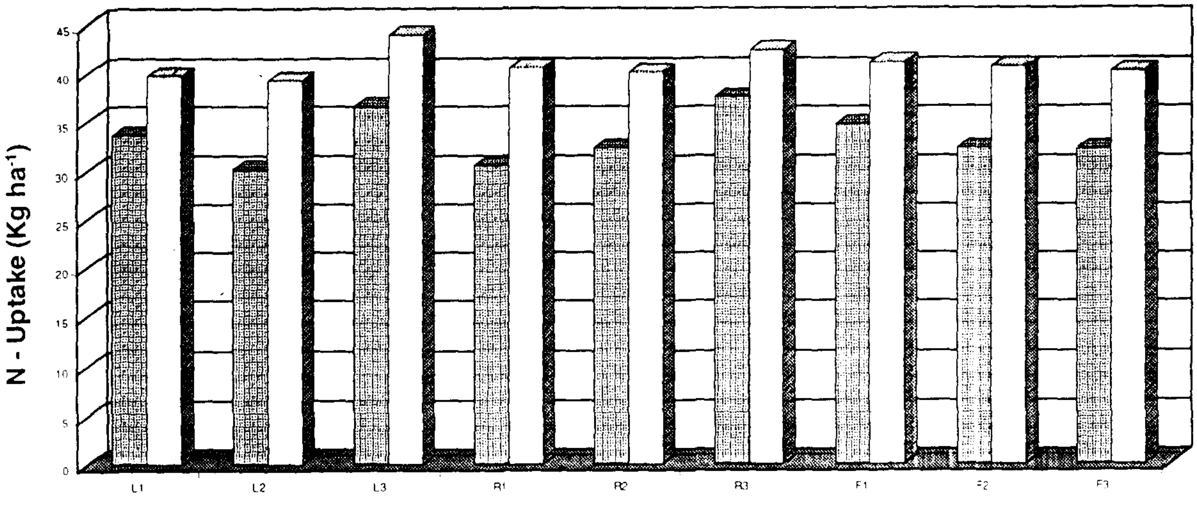

Fig. 33 N - Uptake - Expt - I

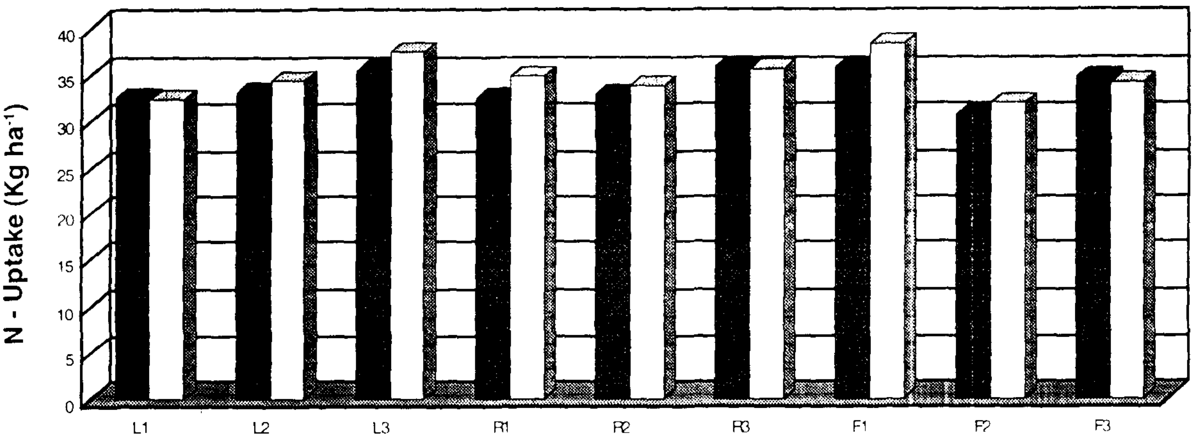

Fig. 34 N - Uptake - Expt - II

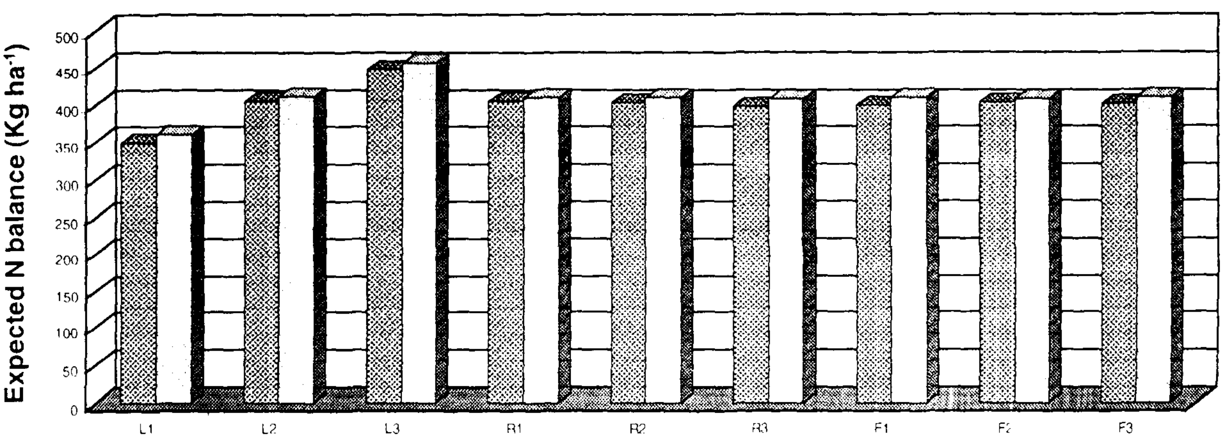

Fig. 35 Expected N balance in Soil - Expt - I

levels. The N-uptake was found to have increased in proportion to the quantities of applied N (Fig. 33). Application of higher levels of nutrient N enhancing the N-uptake was previously reported by Hegde (1987) in water melon, Haris (1989) in snake gourd and Ravikrishnan (1989) in bitter gourd. Levels of N nutrition did not influence the N-uptake in Experiment II.

Different ratios of substitution significantly influenced the N-uptake in Experiment I only (Table 91). Maximum N-uptake was recorded with r_3 (2:1) ratio compared to r_2 (1:2) or r_1 (1:1) ratios (Fig.33). According to Tisdale *et al.* (1995), one of the beneficial effects of organic manure is that it may have a warming effect on soil. The enhanced root zone temperature resulting from this warming effect might have enhanced the N-uptake when farm yard manure was applied in greater proportion. In this context, Mooby and Graves (1980) and Nkansah and Ito (1995) reported the increased N-uptake consequent to the warming up of root zone area. Higher quantity of farm yard manure application promoting the N-uptake was reported earlier by Subbiah *et al.* (1983) in brinjal.

Different frequencies of nitrogen nutrition did not influence the N-uptake in Experiment I. As shown in Table 95, higher N-uptake was observed with f_1 frequency in Experiment II (Fig.34). In f_1 frequency, the entire quantity of poultry manure was applied as basal dose and the possible warming up effect of root zone area was more likely with this treatment since the manure was well mixed into the soil in pit compared to the other frequencies wherein only limited quantity was applied in pit and remaining quantity was top dressed around the plant. Favourable influence of higher root zone temperature on N-uptake was reported by Mooby and Graves (1980).

The LxR interaction influenced the N-uptake only in Experiment II (Table 96). Maximum uptake was noticed when highest level (300 kg) of N was applied through 2:1 (r_3) ratio. Application of highest level of N through 2:1 organic-chemical N substitution ratio required the application of large quantities of poultry manure as an organic source which would have favourably influenced the soil properties as suggested by Tisdale *et al.* (1995), resulting in better uptake. Favourable influence of poultry manure application on N-uptake was indicated by Heathman *et al.* (1995).

The LxF interaction or RxF interaction did not influence the N-uptake.

5.12.1b Expected N balance in soil (kg ha^{-1})

As shown in Table 91 and 95, expected N balance in soil increased with increasing levels of N application in both Experiment I and II. These effects are further illustrated in Fig. 35 (Experiment I) and Fig.36 (Experiment II). The expected N balance in soil is a function of N added through manures and fertilisers which is calculated by deducting the N-uptake of crop from the nitrogen added to the soil through manures and fertilisers and adding the initial N status of the soil to the value obtained. However the expected N balance in both the experiments were found to be under the influence of N added to the soil wherein it increased with increase in level of N and uptake did not seem to have a major influence on expected N balance. Increasing levels of N enhancing the expected N balance of the soil when the N-uptake is not variable was reported previously by Nambiar (1986).

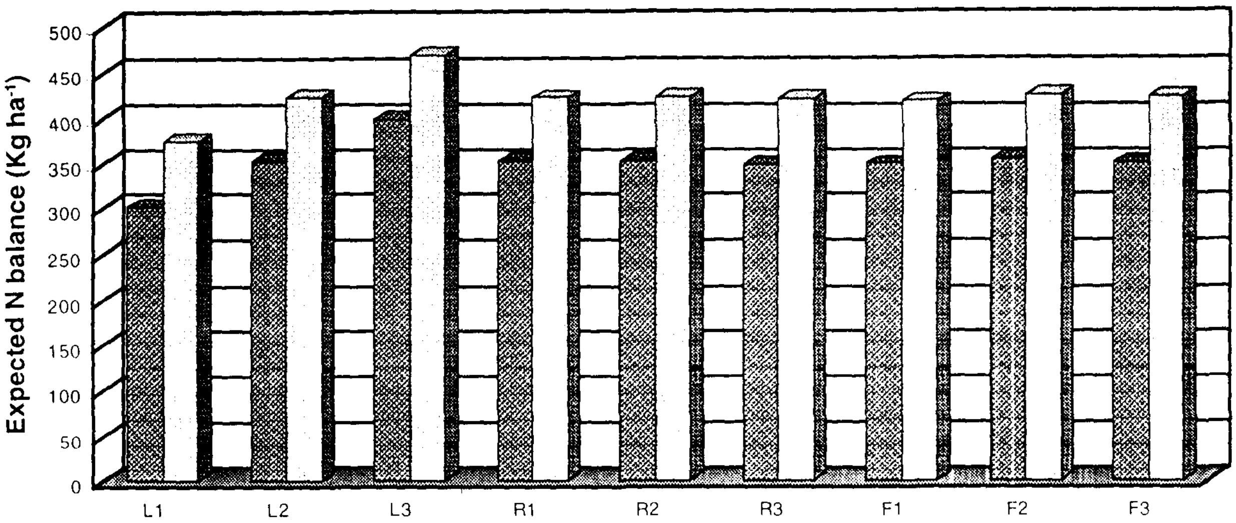

Fig. 36 Expected N balance in Soil - Expt - II

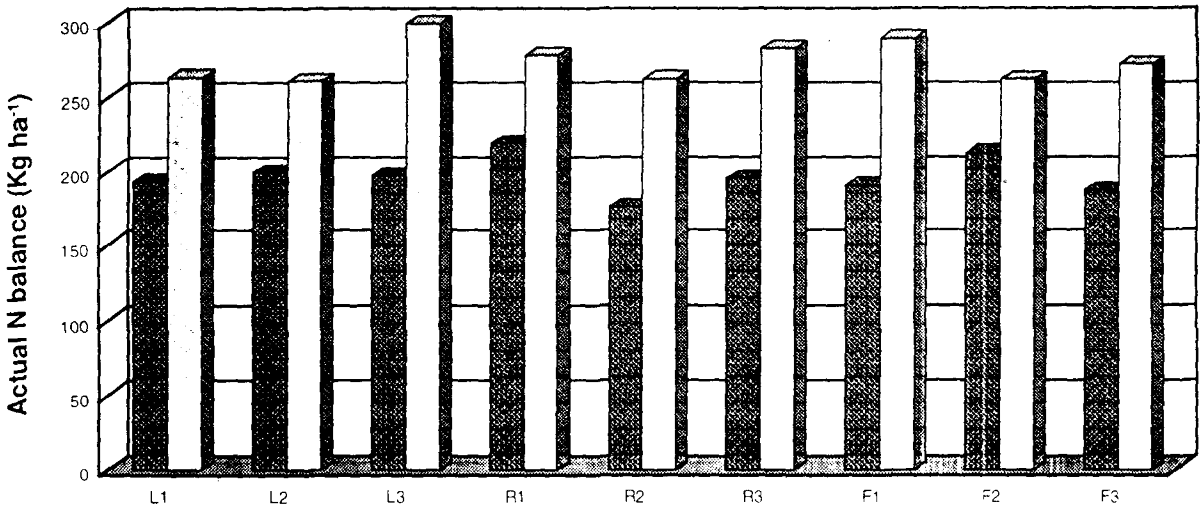

Fig. 37 Actual N balance/Available N content of soil - Expt - I

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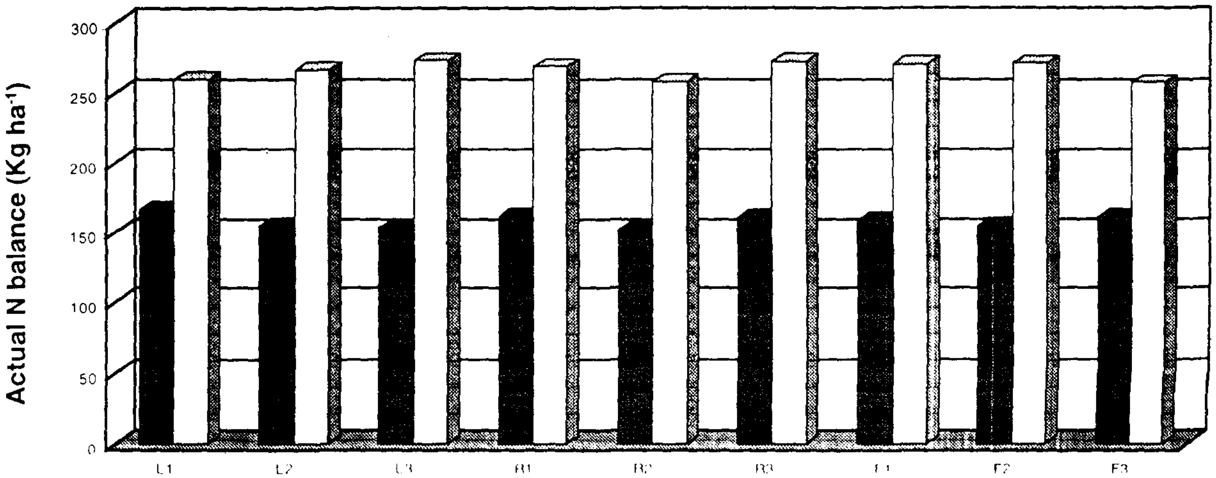

Fig. 38 Actual N balance/Available N content of soil - Expt - II

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The expected N balance in soil was influenced by different ratios of organic-chemical N substitution in Experiment I (Table 91 and Fig. 35) while it was unaffected in Experiment II. Higher expected N balance was obtained with r_1 (1:1) or r_2 (1:2) ratios of substitution. The only aspect which would have influenced the expected N balance in Experiment I must be the N-uptake by crop, since the variations in N-uptake produced corresponding changes in expected N balance of soil as evident from Table 91. Variation in N-uptake bringing in apparent changes in the expected N balance of the soil when dose of N applied is immaterial was reported earlier by Nambiar (1986).

Different frequencies of application could not influence the expected N balance in Experiment I. However, Table 95 and Fig. 36 indicated that the expected balance of N was higher with f_2 frequency compared to f_3 or f_1 in Experiment II. Variation in expected N balance of soil at different frequencies of application was found to be in tune with the N-uptake pattern by the crop wherein treatments with higher uptake resulted in lower expected N balance of soil as evident from Table 95. Similar findings were reported by Nambiar (1986).

The LxR interaction did not significantly influence the expected N balance of soil in Experiment I. However it influenced the same in Experiment II (Table 96). Application of 300 kg N (l_3) through r_2 (1:2) ratio of N substitution recorded significantly higher expected N balance in l_3r_2 combination. Levels of N application and uptake of N by the crop were the two major factors influencing the expected N balance of soil wherein the addition of N exhibited a positive influence and uptake exhibited an inverse relationship and both these factors showed their influence in LxR interaction.

The LxF or RxF interactions did not influence the expected N balance in soil in Experiment I and II.

5.12.1c Actual N balance or available N content of soil (kg ha^{-1})

Different levels of N application significantly influenced the actual N balance of soil in Experiment I (Table 91) and Experiment II (Table 95). In case of Experiment I, highest level of N application recorded significantly higher actual N balance in soil in 1996-97 (Fig. 37). Application of higher levels of N increasing the actual N balance or available N content of soil was reported previously by Haris (1989) and Ravikrishnan (1989). In case of Experiment II (Fig. 38), the lower dose of N (200 kg) recorded higher actual N balance of soil compared to higher levels. Higher levels of N application using poultry manure as organic source would have enhanced the N-uptake, which in turn would have reduced the actual N balance of the soil. The trend in N-uptake shown in Table 95 further supports this observation.

Different ratios of N substitution affected the actual N balance of soil in both the experiments (Table 91 and 95). In case of Experiment I, when farm yard manure and chemical N source were applied in 1:1 proportion, the actual N balance was higher in soil compared to 2:1 ratio and the balance was considerably lower with 1:2 ratio of substitution during the first year of experimentation. The nitrogen nutrition through 1:2 ratio of substitution would have resulted in greater losses as the chemical fertiliser source applied in greater proportion would have been subjected to leaching and other losses, while the 2:1 ratio treatment wherein organic source was applied in higher quantity would have resulted in N immobilisation. Tisdale *et al.* (1995) pointed out chances of immobilisation of N when organic manure with low N content was applied in greater proportion since the microorganism which need N in a C:N ratio of about 8:1 utilise the inorganic N in soil for their activities which lower the available N content of the soil. However the 1:1 ratio of N substitution successfully maintained higher N balance in soil possibly due to limited immobilisation and losses during the initial year. But in the succeeding year the trend was slightly different where 1:1 or 2:1 ratios were equally effective in maintaining actual N balance of soil. This might be due to the fact that the N immobilised in the previous year would have been mineralised back to inorganic N when the microbial activity subsided after decomposition of the low N residue as suggested by Tisdale *et al.* (1995) which eventually resulted in higher N balance in soil with 2:1 ratio of substitution. The general increase in actual N balance during the second year compared to the first year also can be attributed to the mineralisation of N immobilised during the previous year. In case of Experiment II similar result was noticed wherein 1:1 or 2:1 ratio of substitution recorded higher actual N balance wherein poultry manure as organic source was used in equal or higher proportion with chemical N source and the 1:2 ratio registered lower actual N balance in soil. According to Bitzer and Sims (1988), the inorganic N in poultry manure is mainly present as NH_4^+ and its agronomic efficiency might be slightly more since volatalisation and leaching losses are reduced by incorporation of manure in soil. However in case of 1:2 ratio of substitution, leaching loss of chemical N fertiliser is more likely in a daily or alternate day irrigated crop like bitter gourd which would have reduced its agronomic efficiency and lowered the actual N balance in soil.

Different frequencies of N application significantly influenced the actual N balance of soil in Experiment I and II (Table 91 and Table 95). In case of Experiment I, the f_2 frequency recorded higher actual N balance or available N content in soil (Fig. 37) during the first year while during the succeeding year f_1 was efficient in improving the available N content of soil. During the first year. when nutrient N was supplied through f_2 frequency (basal + 2 equal splits of farm yard manure), the released N could not have been utilised by the plant as the mineralisation of organic source would have released the inorganic N towards the end of the crop duration which might have enhanced the available N content in soil. The low available N content associated with f_1 can be attributed to N immobilisation and that with f_3 can be associated with lack of time for proper decomposition of last split doses of farm yard manure. However during the succeeding year. the immobilised N of the previous year at f_1 (full basal - organic) frequency would have been mineralised thereby supplying surplus N to the soil nutrient pool. Remineralisation of immobilised N after decomposition of organic residue low in N was suggested by Tisdale *et al.* (1995). In case of Experiment II (Fig. 38) also similar trend was noticed wherein nitrogen nutrition through f_1 or f_2 frequency resulted in higher actual N balance in soil when poultry manure was used as organic source. Presence of a rapidly mineralisable organic N fraction in poultry manure has been noted in earlier studies. In this context, Gale and Gilmour (1986) reported that three phases of decomposition and mineralisation occurs when broiler poultry manure was incorporated with the soil. The first a rapid phase, was complete within 7 days and was followed by an intermediate phase (7-14 days) and a slow phase (14-35 days). Considering the mineralisation pattern of poultry manure. it could be presumed that when it was completely applied as basal dose (f_1) or as basal + 2 splits at 40^{th} and 70^{th} days after sowing (f_2), the mineralisation of the manure would have occurred to the maximum extent possible by the crop harvest which contributed to the actual N balance of soil under conditions of low uptake and reduced losses of N. In f_3 frequency wherein the total quantity of poultry manure was applied as basal + fortnightly splits, all the split applications would not have coincided with the peak N requirement and its utilisation by the crop. Since 80-85 per cent of total quantity of mineralised N in poultry manure is released within one or two weeks of application as explained before, during the low uptake periods the released N would have been subjected to leaching and immobilisation which coupled with possible incomplete mineralisation of the final split application of poultry manure would have reduced the actual N balance in soil in case of f_3 frequency.

The LxR interaction (Table 92) significantly influenced the actual N balance or available N content of soil only in case of Experiment I. During the first year, application of 300 kg N through 1:1 ratio of substitution (l_3r_1) recorded higher actual N balance in soil. During the second year there was a general increase in actual N balance in soil in case of all the treatment combinations although the maximum balance was obtained with l_3r_3 combination (300 kg N + 2:1 ratio). When highest level of nutrient N was supplied through an equal organic-chemical N proportion, the likelyhood of immobilisation or losses would have been less when compared to the application of the same quantity of N through 2:1 or 1:2 ratio of N substitution which when coupled with moderate uptake would have resulted in higher actual N balance of soil. However the mineralisation of N immobilised during the previous year when organic source was applied in larger proportion (l_3r_3) would have improved the actual N balance in soil during the succeeding year.

The LxF interaction did not influence the actual N balance in Experiment I. Table 97 indicated that more available N content was registered with l_1f_1 combination and increase in N levels reduced the available N content of soil in l_3f_1 during the initial year in Experiment II. However during the second year of experimentation, all the treatment combinations improved the actual N balance of soil when compared to the previous year and was maximum with the application of l_3f_2 combination. When low quantity of N was applied with its organic source fully as basal dose in pits, chances of N losses through volatalisation was considerably reduced since the manure which mostly consisted of NH_4-N was well incorporated into the soil in pit in case of l_1f_1 combination which would have resulted in higher available N content in soil. Chances of volatalisation loss of ammonia in poultry manure was previously reported by Hadas *et al.* (1983) and the reduced NH_3 volatalisation losses under soil incorporation of manure/fertiliser source was previously suggested by Tisdale *et al.* (1995). However increasing the levels of N would have simultaneously increased the losses of its chemical source mainly through leaching losses of chemical N inspite of reduced losses with organic source which would have lowered the actual N balance of soil in l_3f_1 combination during the first year. However during the second year, higher actual N balance to be associated with l_3f_2 combination can only be considered as an outcome of mineralisation of N which might have been immobilised during the previous year. According to Hadas *et al.* (1983), the possibility of immobilisation of N in poultry manure can not be excluded.

The RxF interaction (Table 94) significantly influenced the actual N balance of soil in Experiment I while it did not affect the N balance in Experiment II. During the first year nitrogen nutrition with r_1f_2 frequency resulted in higher actual

N balance in soil while during the next year the trend was slightly different wherein the actual N balance of soil was maximum with the r_3f_3 combination. The trends observed in case of main effects of R and F are manifested in case of RxF interaction during both the years of field experimentation.

5.12.1d The net loss (-) or gain (+) of N (kg ha^{-1})

As depicted in Table 91 and 95, increase in N levels increased the net loss of N in soil in case of both Experiment I and II. This effect is further illustrated by Fig. 39 (Experiment I) and Fig. 40 (Experiment II). The net loss or gain of N was arrived at by deducting the expected N balance in soil from the actual N balance or available N content of soil. The actual N balance in all the treatments were substantially lower than the corresponding expected N balances which in turn resulted in a net loss of N and this net loss increased with increasing levels of N. The negative balance of N in soil may be due to increased possibility of its loss due to various mechanisms like volatalisation, denitrification and leaching etc. under higher levels of N nutrition as narrated by Tisdale *et al.* (1995). Besides this, when part of the N requirement is fulfilled through poultry manure with NH_4-N as major component, losses through ammonia volatalisation has great implication (Hadas *et al.*, 1983).

Table 91 and 95 indicated that different ratios of N substitution significantly influenced the net loss or gain of N in Experiment I and II. Nitrogen nutrition through 1:2 ratio of organic-chemical N substitution resulted in higher net loss of N in soil in both Experiment I (Fig. 39) and Experiment II (Fig. 40) Chances of loss of fertiliser source of N might have been more with r_2 ratio since it was

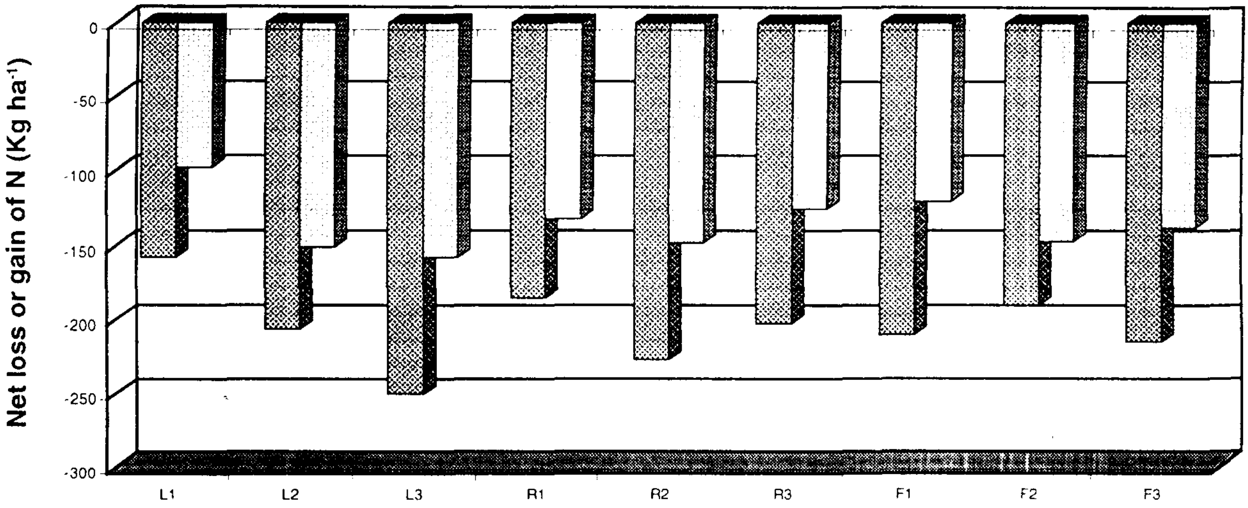

Fig. 39 Net loss or gain of N - Expt - I

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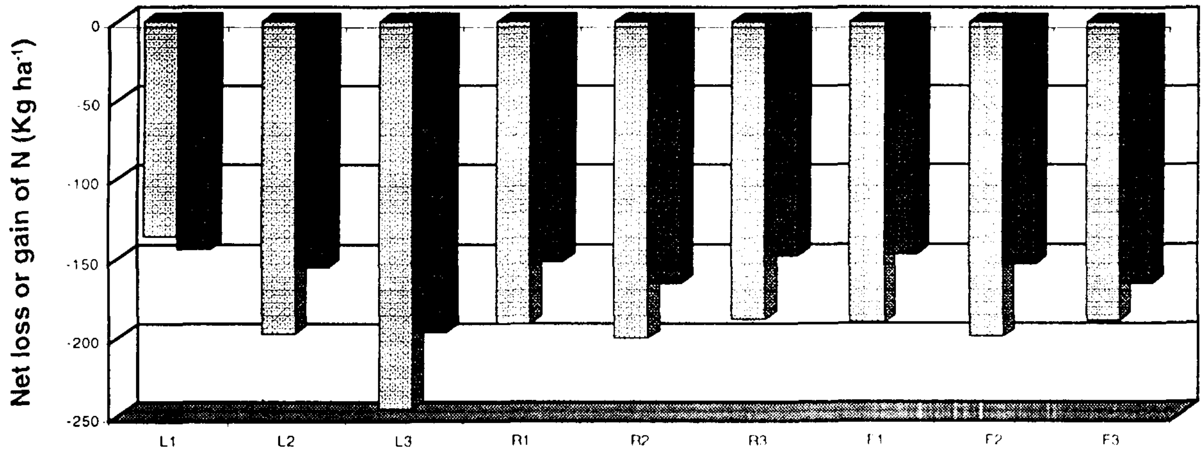

Fig. 40 Net loss or gain of N - Expt - II

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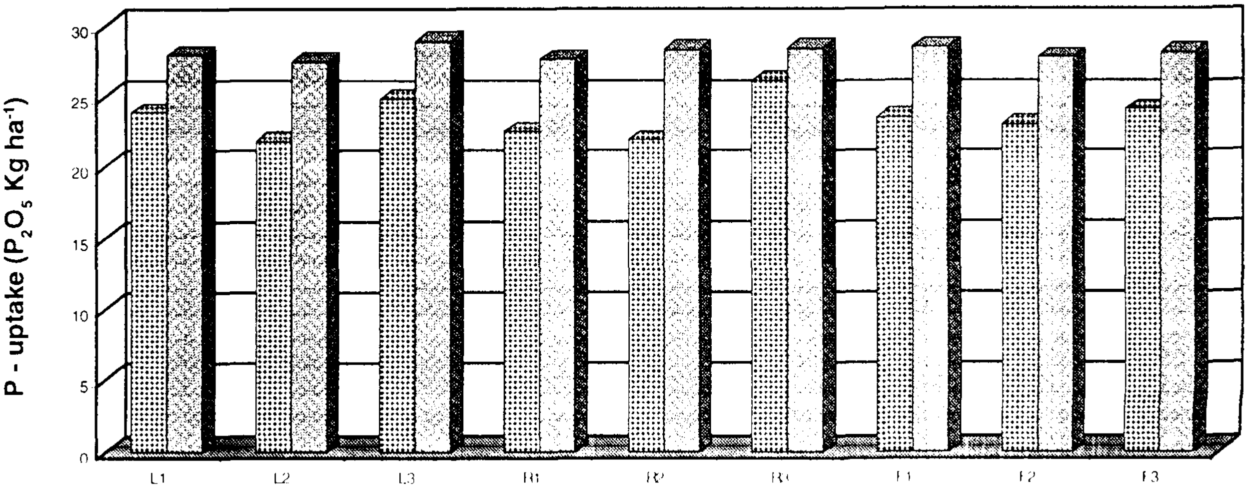

Fig. 41 P - uptake - Expt - I

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applied in higher proportion when compared to other ratios. Such losses would have lowered the actual N balance of soil resulting in higher net loss of this nutrient.

Different frequencies of application affected the net loss or gain of N only in Experiment I (Table 91). During the first year, higher net loss of N occurred with f_3 frequency while in the next year net loss of N was reduced with all frequencies of application although it was maximum with f_2 frequency. During the first year, the decomposition and subsequent release of N would not have occurred from the late split doses of farm yard manure in f_3 frequency which in turn would have resulted in low actual N balance of soil compared to the expected N balance and this in turn caused higher net loss of N in soil. The decomposition of organic source which was not mineralised in the previous year would have contributed to the N pool of soil during the succeeding year thus reducing the net loss. Higher net loss associated with f_2 frequency might be on account of excess loss of applied N from the soil.

It is shown in Table 92 that the LxR interaction influenced the net loss or gain of N in Experiment I while it could not influence the same in Experiment II. During both the years of field experimentation net loss of N was high with l_3r_2 combination although there was a general moderation of net loss during the succeeding year. When highest dose of N was supplied through 1:2 ratio of N substitution, the quantity of fertiliser source of N that had to be applied was highest which might have increased its probable losses through various mechanisms like denitrification, volatalisation or leaching losses as described by Tisdale *et al.* (1995) compared to other ratios which require lower quantity of fertiliser source. During the succeding year mineralisation of organic source applied in the previous year would have improved the N balance in soil thus reducing the observed net loss of N.

The LxF interaction did not have any influence on net loss or gain of N in Experiment I or II.

The RxF interaction (Table 94) significantly influenced the net loss or gain of N in Experiment I and in Experiment II, the RxF interaction could not influence the net loss or gain of N. Higher net loss of N occurred when nutrient N was applied through 1:2 ratio of substitution at f_3 frequency in r_2f_3 combination. There was a moderation of net loss of N during the second year compared to first year. The combined influence of higher proportion of chemical N which is vulnerable to losses and incomplete mineralisation of later applied doses of organic manure would have lowered the actual N balance and subsequently increased the net loss of N in soil with r_2f_3 combination. Mineralisation of undecomposed farm yard manure applied during the previous year would have moderated the net loss of N during the second year.

5.12.2 Phosphorus balance in soil

5.12.2a P-uptake (P_2O_5 kg ha^{-1})

Different levels of N application could not influence the P-uptake in Experiment I or II.

P-uptake was affected by different ratios of substitution in Experiment I (Table 99) while it was unaffected in Experiment II. Maximum P-uptake was

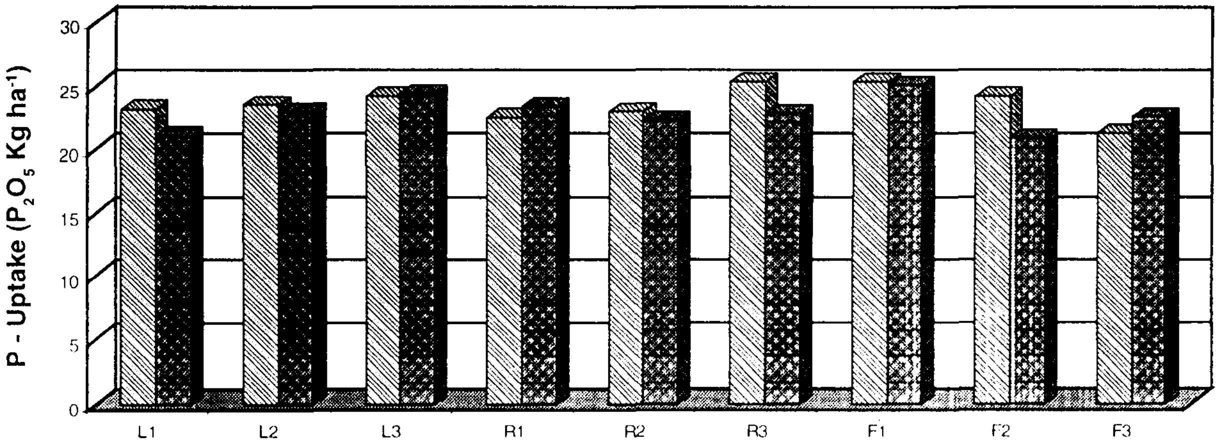

Fig. 42 P - Uptake - Expt - II

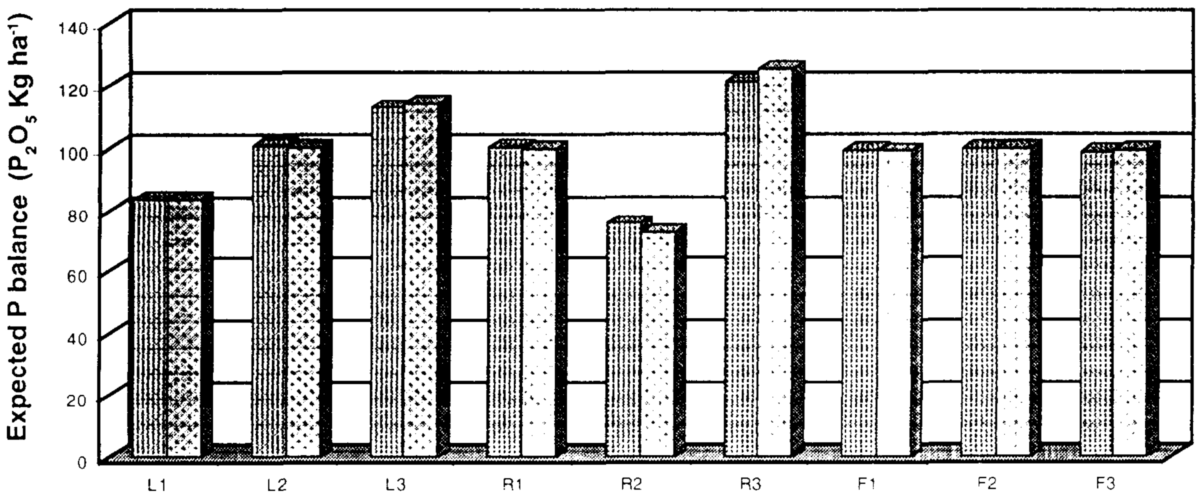

Fig. 43 Expected P balance in Soil - Expt - I

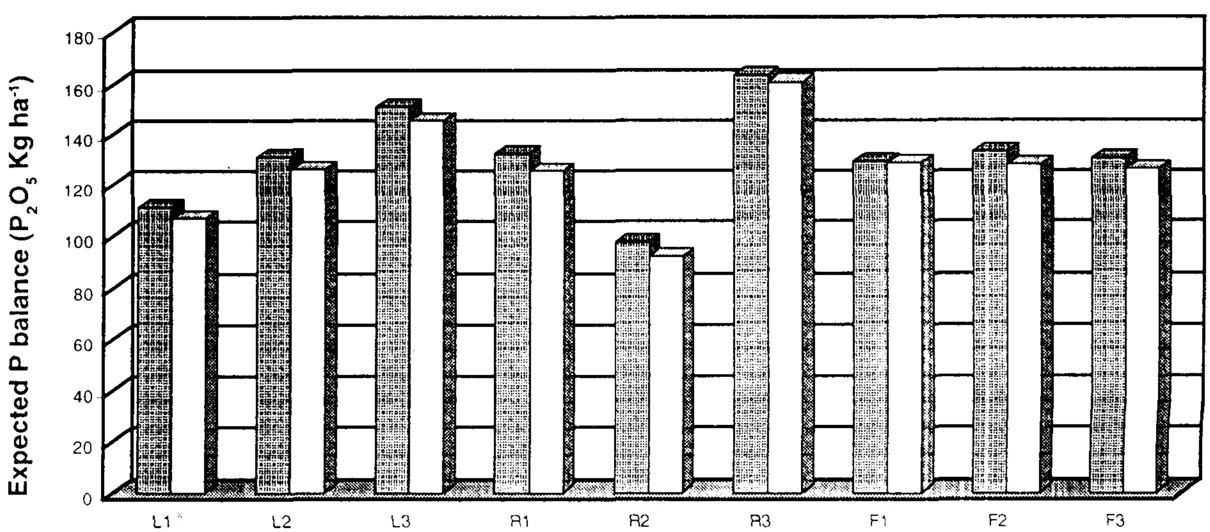

Fig. 44 Expected P balance in soil - Expt - II

noticed with r_3 (2:1) ratio in Experiment I which is clearly evident from Fig.41. When organic source of N was applied in higher proportion in r_3 ratio of N substitution using farm yard manure as organic source, it would have improved the P-uptake through increased P availability in soil. According to Tisdale *et al.* (1995), organic matter increased the P availability and uptake through formation of organophosphate complexes that are more easily assimilated by plants, anion replacement of $H_2PO_4^-$ on adsorption sites and reducing P adsorption by coating a protective cover on Fe and Al particles by humus. Application of higher quantities of farm yard manure promoting the P-uptake was observed earlier by Subbiah *et al.* (1983) and Bagavathiammal and Muthiah (1995).

The P-uptake was unaffected by different frequencies of N nutrition in Experiment I, while in case of Experiment II, P-uptake was maximum with f_1 frequency (Fig. 42). When entire quantity of organic source was applied as basal dose in f_1 frequency, it would have enhanced the P availability and uptake through the formation of easily assimilatable organophosphate complexes as a result of better decomposition of early applied organic manure in comparison with other frequencies of application wherein split applications of poultry manure was done. The formation of organophosphate complexes increasing plant availability and uptake of P was previously suggested bdy Tisdale *et al.* (1995). The favourable effect of poultry manure application on P-uptake was reported by Warneke and Siregar (1994).

The LxR interaction did not affect the P-uptake in Experiment I. In case of Experiment II (Table 104), maximum P-uptake was noticed with l_3r_3 combination. When highest dose of N was supplied through 2:1 ratio of organic-chemical N substitution, it required the application of higher quantity of organic manure (poultry manure) in Experiment II, which would have favoured the availability and uptake of P as suggested by Tisdale *et al.* (1995). The fact that the N present in poultry manure was primarily NH_4-N (Bitzer and Sims, 1988) further strengthens this opinion since ammoniacal N sources are found to have greater stimulating effect on P absorption as indicated by Tisdale *et al.* (1995). Application of poultry manure favouring the P-uptake was previously reported by Abusaleha (1992).

The LxF and RxF interactions could not influence the P-uptake in Experiment I or II.

5.12.2b Expected P balance in soil (P_2O_5 kg ha^{-1})

Different levels of N application significantly influenced the expected P balances in Experiment I (Table 99) and Experiment II (Table 103). The expected P balance in soil increased with increase in level of N application in both the experiments (Fig. 43 and Fig. 44). The expected P balance of soil invariably depend on P added through manures and fertilisers and was calculated by deducting the P-uptake by crop from the P added to the soil through manures and fertilisers and then adding the initial P status of soil to the value obtained. Since the P-uptake pattern (Table 99) showed that it was not under the influence of levels of N application, the variation in expected P balance with varying levels of N could be solely attributed due to the variation in quantity of P added through organic sources as the P addition through fertiliser P material was uniform for all the treatments. With the increase in levels of nutrient N, the quantity of farm yard manure/poultry manure required for its substitution also increased which would have enhanced the expected P balance in soil.

As illustrated in Fig.43 (Experiment I) and Fig. 44 (Experiment II), the expected P balance of soil was higher with 2:1 ratio of substitution in both Experiment I and II. When 2:1 ratio was followed, higher proportion of farm yard manure/poultry manure was applied which was the major source of P compared to other ratios of N substitution and therefore higher expected P balance was the outcome of r_3 ratio. This is further evident from the relatively higher percentage of phosphorus contained in poultry manure (Table 2).

The expected P balance of soil was not under the influence of frequencies of application in Experiment I or II.

The LxR interaction (Tables 100 and 104) influenced the expected P balance of soil in both the experiments. Higher expected P balance was observed with l_3r_3 treatment combination in both the experiments. The trend observed in case of main effect of L and R was reflected in case of their interactions too wherein the highest level of N application through 2:1 ratio of organic-chemical N substitution recorded the maximum expected P balance since it required the supply of higher quantity of farm yard manure or poultry manure being a source of P besides N compared to other combinations.

The LxF interaction or RxF interaction did not have any influence on expected P balance in Experiment I or II.

5.12.2c Actual P balance or available P content of soil (P_2O_5 kg ha^{-1})

Higher levels of N nutrition increased the actual P balance of soil in Experiment I and II (Table 99 and 103). These effects are further evident from Fig. 45 (Experiment I) and Fig. 46 (Experiment II). The nitrogen nutrition promoting the solubility and availability of P in soil was previously pointed out by Tisdale *et al.* (1995). The higher level of application of nutrient N would have thus favoured the actual P balance or available P content of soil through better solubility of phosphorus. Similar observation was previously noted by Ravikrishnan (1989).

Different ratios of N substitution influenced the actual P balance of soil in Experiment I only (Table 99). As shown in Fig. 45, nitrogen nutrition through 2:1 ratio of substitution using farm yard manure as organic source promoted the actual P balance or available P content of soil in Experiment I. Application of higher proportion of farm yard manure would have improved the available P content of soil through various processes like anion replacement of $H_2PO_4^-$ on adsorption sites, by reducing the P adsorption etc. as suggested by Tisdale *et al.* (1995) in addition to more P_2O_5 added through organic manure. . Similar results were reported by Yifong and Chingwen (1993) and Selvi and Ramaswami (1995).

Different frequencies of application influenced the actual P balance or available P content of soil in Experiment I (Table 99) and Experiment II (Table 103). Higher actual P balance was recorded with f_1 frequency in Experiment I (Fig. 45) and Experiment II (Fig. 46). In case of Experiment I, the f_3 frequency was equally effective as f_1 frequency in promoting the actual P balance of soil

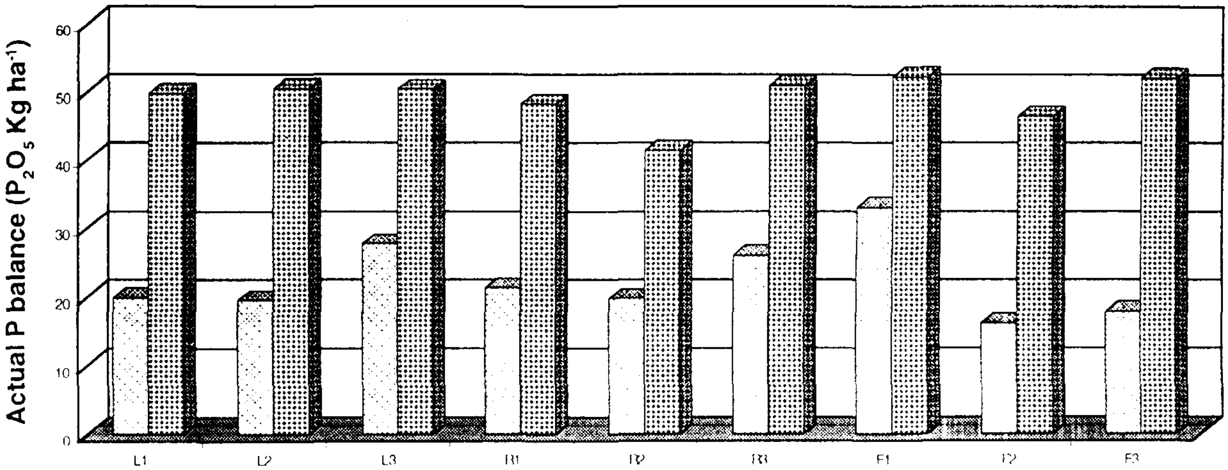

Fig. 45 Actual P balance/Available P content of soil - Expt - I

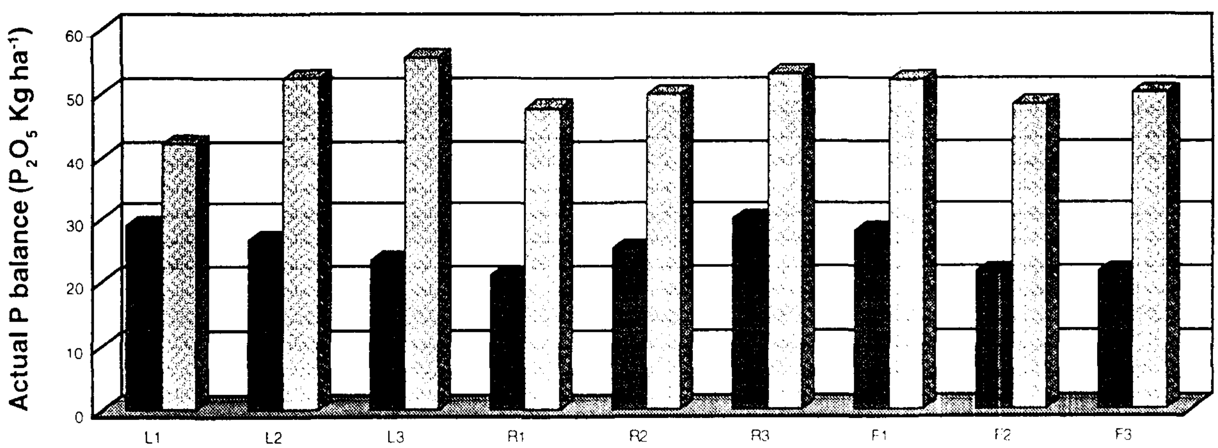

Fig. 46 Actual P balance/Available P content of Soil - Expt - II

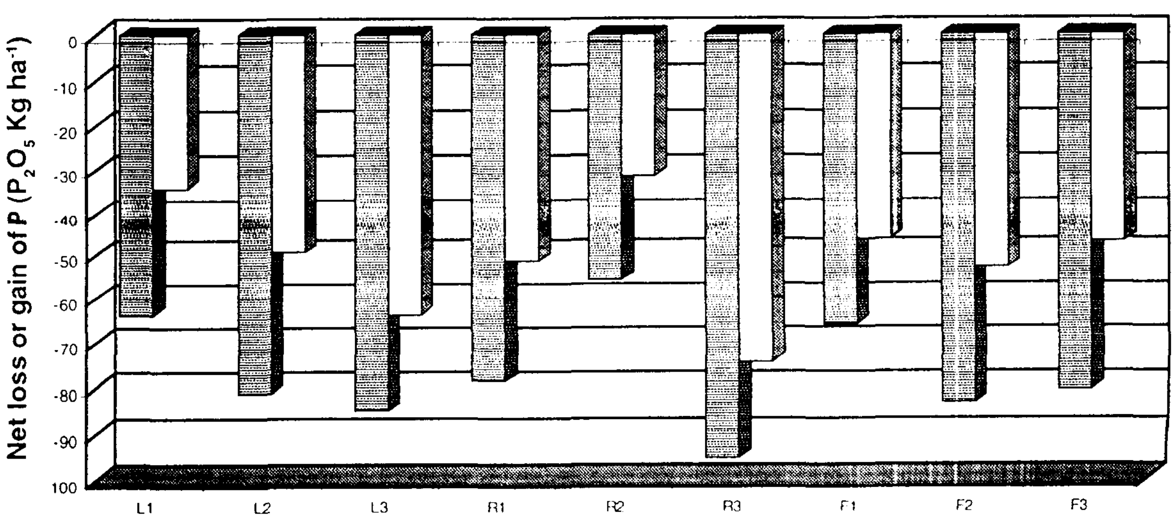

Fig. 47 Net Loss or gain of P - Expt - I

during the second year of experimentation. In general, actual P balance of soil showed marked increase during second year compared to first year of experimentation in both the experiments. When entire quantity of farm yard manure or poultry manure was applied fully as basal dose in f_1 frequency, it would have promoted the better decomposition of organic matter which in turn would have increased the available P content or actual P balance of soil compared to split applications of farm yard manure or poultry manure. According to Tisdale *et al.* (1995), organic anions produced from the decomposition of organic matter may form stable complexes with Fe and Al thus preventing their reaction with $H_2PO_4^-$ and these complex ions also may release P previously fixed by Fe and Al by the same mechanism. However during the second year, the residual effect of undecomposed organic manure applied as late split-dose in the previous year in Experiment I would have contributed to the higher actual P balance of soil associated with f_3 treatment. The residual effect of organic source can be attributed towards the general improvement in P status of soil during the second year of experimentation. The farm yard manure application promoting actual P balance of soil was reported by Yifong and Chingwen (1993). Favourable influence of poultry manure on actual P balance of soil was reported by Shortall and Liebhardt (1975) and Heathman *et al.* (1995).

The LxR interaction (Table 100) influenced the actual P balance of soil in Experiment I while it was unaffected by LxR interaction in Experiment II. Actual P balance in soil was higher with l_3r_3 combination in Experiment I. Application of highest level of N (300 kg) through 2:1 ratio (r_3) of organic-chemical N substitution which required the application of higher quantity of farm yard manure would have improved the actual P balance of soil through various mechanisms like organic anion complexing, reducing P adsorption etc. Higher levels of farm yard manure application promoting the actual P balance of soil was reported by Selvi and Ramaswami in 1995.

The LxF interaction could not influence the actual P balance or available P content of soil.

The RxF interaction (Table 102) influenced the actual P balance of soil only in case of Experiment I. Higher actual P balance was recorded with r_3f_1 treatment combination. Application of organic source (farm yard manure) in higher quantity as full basal dose would have resulted in better decomposition of organic matter compared to split applications, thus enriching the actual P balance of soil through anion replacement and complexing.

5.12.2d Net loss (-) or gain of P (P_2O_5 kg ha^{-1})

As depicted in Tables 99 and 103, higher levels of N application increased the net loss of P in Experiment I (Fig. 47) and Experiment II (Fig. 48). The net loss or gain of P was calculated by deducting the actual P balance from expected P balance of soil. As indicated by Table 99 and 103, greater P balances were expected out of higher levels of N nutrition since the quantity of organic source used increased with increase in levels of N. However the actual P balances obtained with higher levels of nitrogen nutrition were not as high as the respective expected P balances which increased the net loss of P in soil. Furthermore, the expected P balance is theoritically computed on assumption that 100 per cent mineralisation of organic P takes place. In this connection Tisdale *et al.* (1995)

pointed out that P mineralisation in soil is affected by numerous factors such as N/P ratio wherein increased supply of N might limit the mineralisation of organic P. This would have reduced the actual P balances in comparison with the expected P balance, thus enhancing the net loss of P in soil.

As indicated in Table 99 and 103, net loss of P was higher with 2:1 ratio of N substitution in Experiment I and II. Application of farm yard manure or poultry manure in higher proportion was supposed to add proportionately higher quantity of P in the soil and therefore more soil P balance was expected out of this ratio. However the actual P contents consequent to this ratio did not vary much from the contents obtained with 1:1 or 1:2 ratio which in turn resulted in higher net loss of P in soil. Although addition of organic matter has a general favourable influence on P availability in soil, its hundred per cent mineralisation is impossible since P mineralisation or immobilisation in soil is controlled by numerous factors like temperature, moisture, aeration, pH, cultivation intensity, P fertilisation, C/P ratio of residues etc. (Tisdale *et al.*, 1995). Therefore the actual P-balance could never be upto the expected balance which was theoritically computed.

As shown in Table 99 and 103 frequencies of N nutrition influenced the net loss or gain of P in Experiment I and II. Increased net loss of P occurred with f_2 or f_3 treatments compared to f_1 in Experiment I (Fig. 47) and Experiment II (Fig. 48). The variation in net loss of P associated with different frequencies could be considered as an outcome of difference in resultant actual P balances. The actual P balances were not as high as expected balances for f_2 or f_3 frequencies wherein split application of farm yard manure or poultry manure was practiced, and this would have increased the net loss of P. According to Tisdale *et al.*

(1995), when organic matter was added to the soil, net P immobilisation occurs during the early stage of decomposition followed by net P mineralisation as the C/P ratio of the residue decreases. Therefore it could be presumed that chances of organic P mineralisation is more with full basal organic source application in comparison with its split applications, where incomplete decomposition might occur which would have reduced the actual P balance and increased the net loss of P with the latter treatment.

The LxR interaction (Table 100 and 104) affected the net loss or gain of P in case of Experiment I and II. Application of moderate (250 kg) or higher (300 kg) dose of N through r_3 (2:1) ratio resulted in higher net loss of P. Application of moderate or higher levels of N through greater proportion of organic source was expected to add higher quantity of P to the soil. However the corresponding actual P balances were not as high as expected values which invariably increased the net loss of P in soil. As discussed earlier, the actual P balances in soil might not be upto the expected balances on account of variation in P mineralisation and immobilisation due to edaphic, climatic and cultivation practices.

The LxF or RxF interactions had no influence on net loss or gain of P in Experiment I and II.

5.12.3 K balance in soil

5.12.3a K-uptake by crop (K_2O kg ha^{-1})

Different levels of N application or ratios of substitution had no influence on K-uptake by crop.

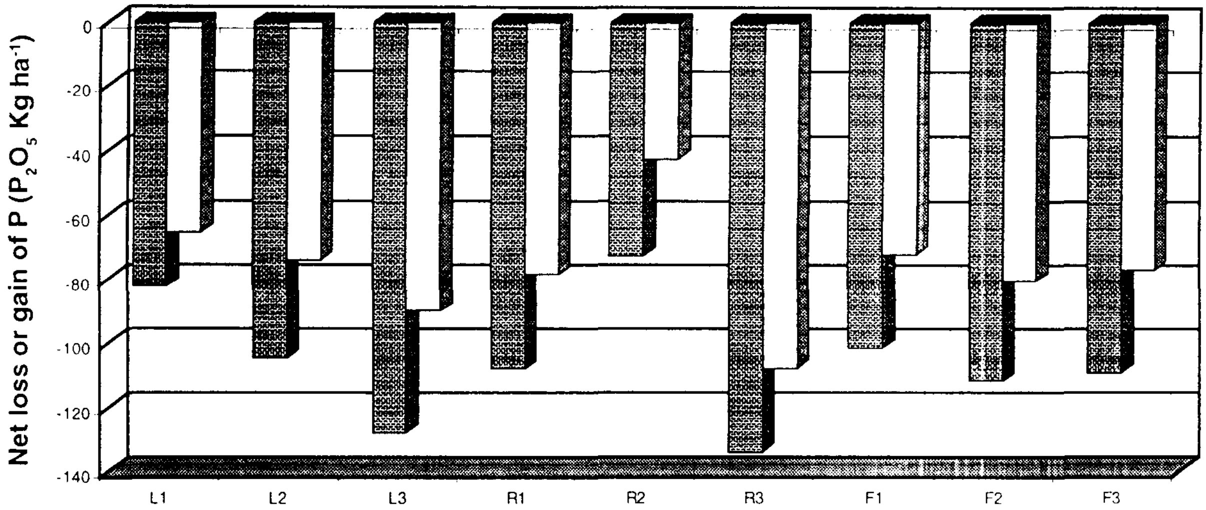

Fig. 48 Net loss or gain of P - Expt - II

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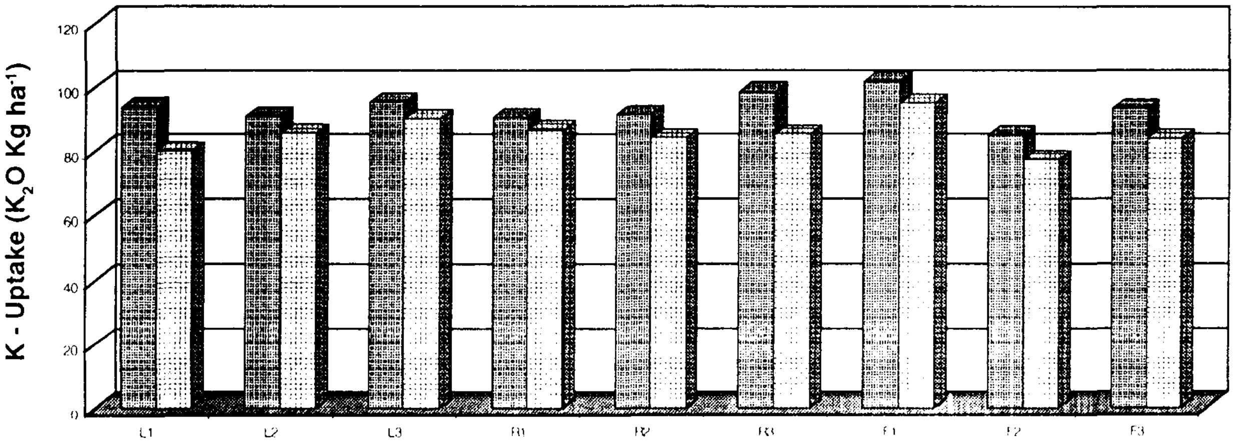

Fig. 49 K - Uptate by crop - Expt - II

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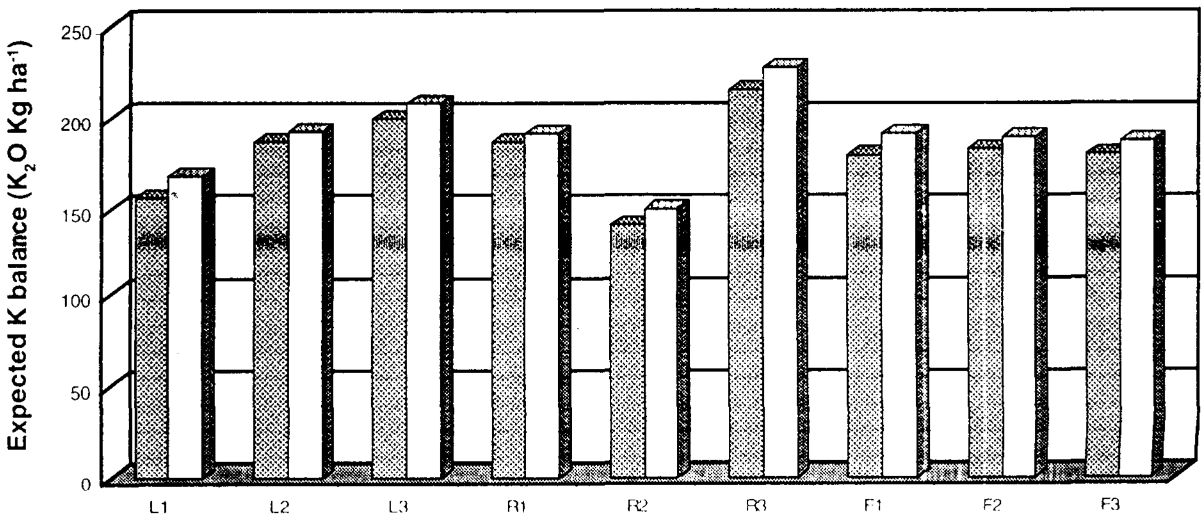

Fig. 50 Expected K balance in soil - Expt - I

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The K-uptake in Experiment I was unaffected by different frequencies of N nutrition. In case of Experiment II (Table 111), the f_1 frequency was efficient in recording maximum K-uptake (Fig. 49) when the entire quantity of poultry manure was applied and well mixed with the soil in the pit as basal dose, it might have enhanced the root zone temperature which would have favourably influenced the K-uptake by plant. Organic manure application increasing the soil temperature which in turn enhances the K-uptake was suggested by Tisdale *et al.* (1995). Nkansah and Ito (1995) observed increased K-uptake due to higher root zone temperature. Favourable influence of poultry manure on K-uptake was earlier reported by Abusaleha (1992).

The LxR interaction could not affect the K-uptake in Experiment I or II.

Although the LxF interaction did not influence the K-uptake in Experiment I, it did influence the uptake in Experiment II (Table 113). Maximum uptake was observed when moderate dose of N was applied through f_1 frequency. Moderate doses of N with its organic source (poultry manure) as full basal was found to record higher K-uptake. Similar observation was recorded by Ravikrishnan (1989).

The RxF interaction had no influence on K-uptake in Experiment I or II.

5.12.3b Expected K balance in soil (K_2O kg ha^{-1})

Increasing levels of N significantly increased the expected K balance of soil in Experiment I (Table 107 and Fig.50) and Experiment II (Table 111 and Fig. 51). Higher levels of N application required the addition of higher quantity of farm yard manure or poultry manure on equivalent N basis when N was partially

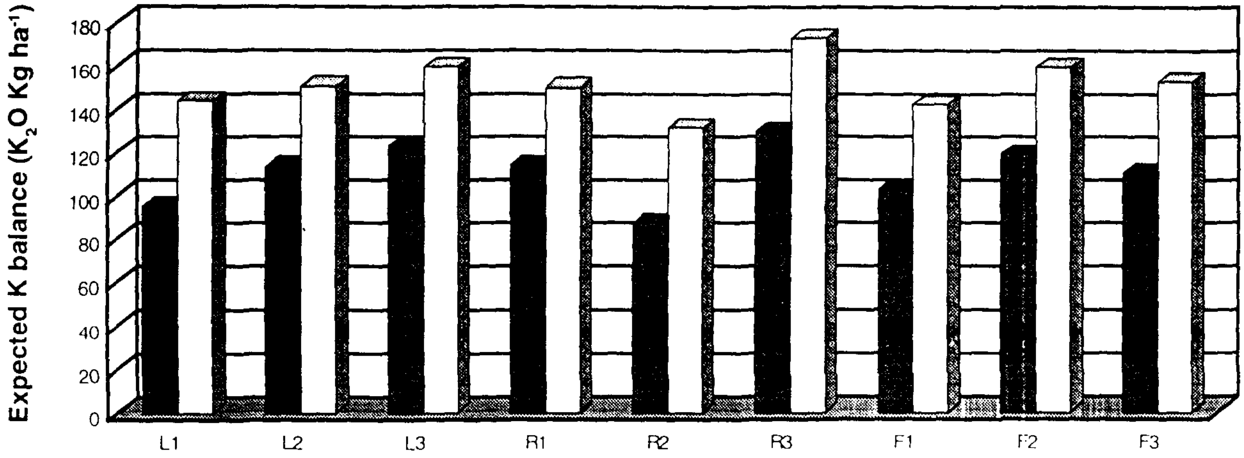

Fig. 51 Expected K balance - Expt - II

■ 1995 - 96 □ 1996 - 97

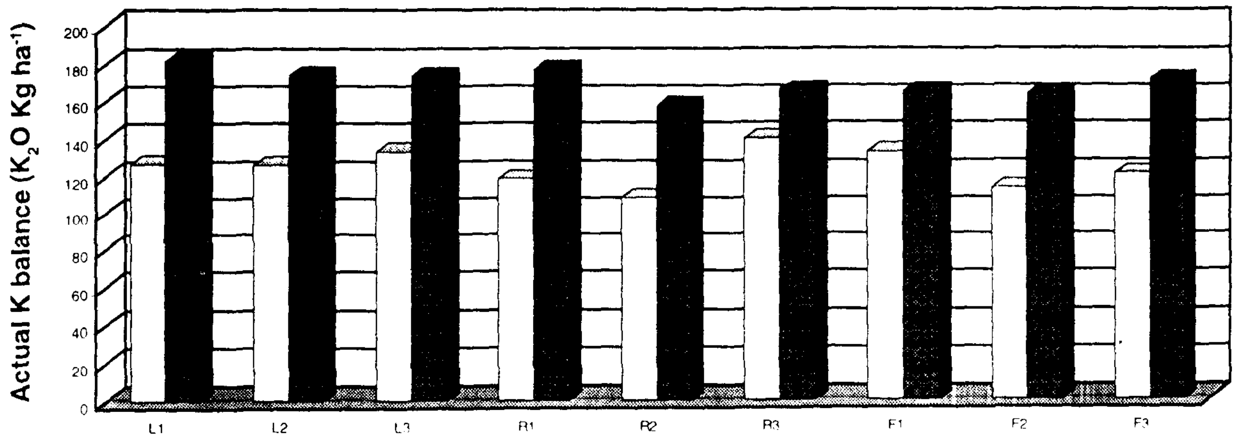

Fig. 52 Actual K balance/Available K content of Soil - Expt - I

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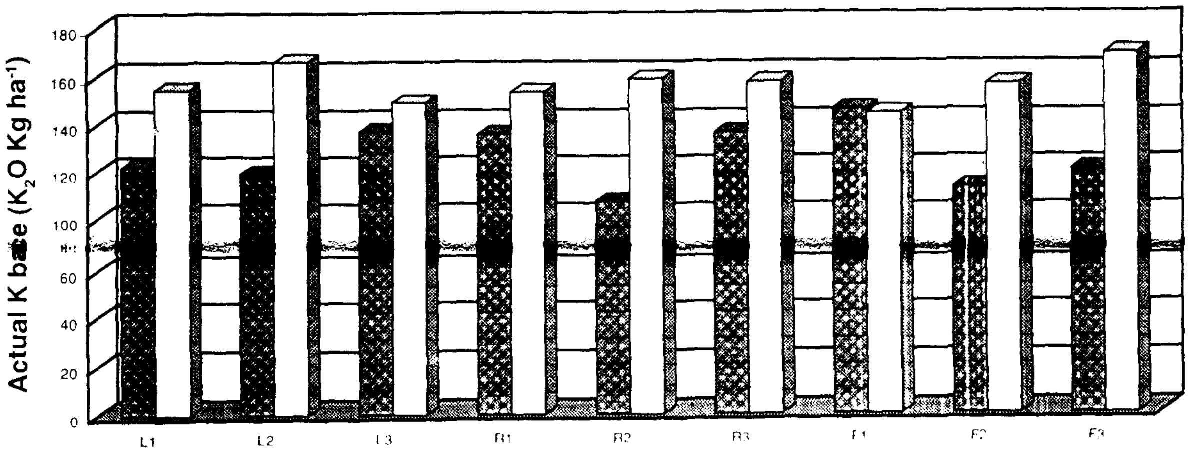

Fig. 53 Actual K balance/Available K content of Soil - Expt - II

▩ 1995 - 96 □ 1996 - 97

substituted through organic source. The organic source in turn was considered as a major source of K while theoritically calculating the K expected to be added from various sources which resulted in higher expected K balance in soil.

Nitrogen nutrition through 2:1 ratio of substitution recorded higher expected K balance of soil in both Experiment I (Fig. 50) and II (Fig. 51) compared to other ratios. Application of farm yard manure or poultry manure in greater proportion in 2:1 ratio was theoritically expected to add more K to the soil, since organic manure was considered as a major source of K in balance studies.

Different frequencies of application could not influence the expected K balance in Experiment I. However in case of Experiment II (Fig. 51), expected K balance was higher with f_2 or f_3 frequencies. The expected K balance was computed by deducting the K-uptake from the K added to the soil to which the initial K status of soil was added. Therefore the relationship between the expected K balance and frequencies of N application seem to be influenced only by the K-uptake by crop and lower uptake occurred with f_2 and f_3 resulted in higher expected K balance in soil.

None of the interaction effects significantly influenced the expected K balance in Experiment I and II.

5.12.3c Actual K balance or available K content in soil (K_2O kg ha^{-1})

Different levels of N application did not influence the actual K balance.

Various ratios of substitution affected the expected K balance in Experiment I (Table 107) and Experiment II (Table 111). Actual K balance of soil was higher with 2:1 or 1:1 ratio of N substitution in both Experiment I (Fig. 52) and Experiment II (Fig. 53). As opined by Tisdale *et al.* (1995) organic matter application enhances the buffering capacity of soil which represents the ability of soil to resupply an ion to the soil solution and under higher buffering capacity, the exchangeable K^+ is desorbed to resupply solution K^+ when K^+ is removed from the soil by crop uptake. Considering this, it is logical to assume that application of farm yard manure or poultry manure in equal or higher proportion with chemical N source would have enhanced the soil buffering capacity thus improving the available K content of soil. Favourable influence of cattle manure on available K content was previously reported by Yifong and Chingwen (1993). Poultry manure application increasing the exchangeable and available K content of the soil has been reported by Julia *et al.* (1993) and Kingery *et al.* (1993).

Different frequencies of N nutrition did not have any influence on actual K balance or available K content of soil in Experiment I. However Table 111 indicated that the f_1 frequency recorded higher actual K balance of soil during the first year of experimentation in Experiment II while during the succeeding year f_2 or f_3 frequencies were efficient in maintaining actual K balance of soil (Fig. 53). The full basal application of poultry manure with a comparatively higher K content (1.35-1.50 per cent) would have released more K to the soil since sufficient time for decomposition was there compared to the split application of poultry manure during the first year of experimentation. However during the second year, the fixation or leaching losses of released K would probably have reduced the actual K balance in soil with full basal application. Favourable influence of poultry manure on K content of soil was previously reported by Lu *et al.* (1991).

The LxR interaction depicted in Table 108 showed that application of 300 kg N through 2:1 ratio (l_3r_3) recorded higher actual K balance of soil during the first year of Experiment I while during the second year the above said combination failed to maintain available K content of soil and higher actual K balance was observed with l_1r_1 combination. However these effects were not significant in Experiment II. When highest level of N was to be supplied through a higher ratio of organic source (farm yard manure), it required the application of higher quantity of farm yard manure which would have favourably influenced the buffering capacity of soil as explained by Tisdale *et al.* 1995 which in turn promoted the actual K balance of soil. During the succeeding year, fixation or leaching losses would have lowered the actual K content of soil in Experiment I.

The LxF interaction did not influence the actual K balance of soil in Experiment I or II.

The RxF interaction (Table 110) significantly influenced the actual K balance in Experiment I, while it did not have any influence in Experiment II. Application of moderate or higher levels of organic source (farm yard manure) in few or more splits increased the actual K balance of soil compared to its full basal application. Organic manure applied in split doses was incorporated through light earthing up which would have enhanced the soil aeration which in turn enhanced the K availability in soil as suggested by Tisdale *et al.* (1995).

5.12.3d Net loss (-) or gain of K in soil (K_2O kg ha^{-1})

Different levels of N application significantly influenced the net loss or gain of K in Experiment I (Table 107) and Experiment II (Table 111). Highest

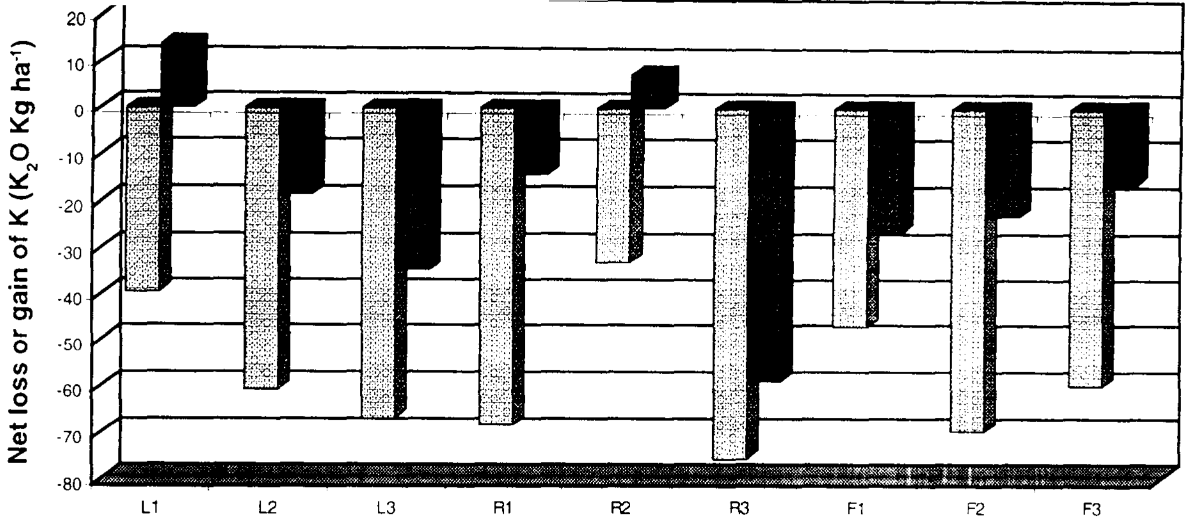

Fig. 54 Net loss or gain of K - Expt - I

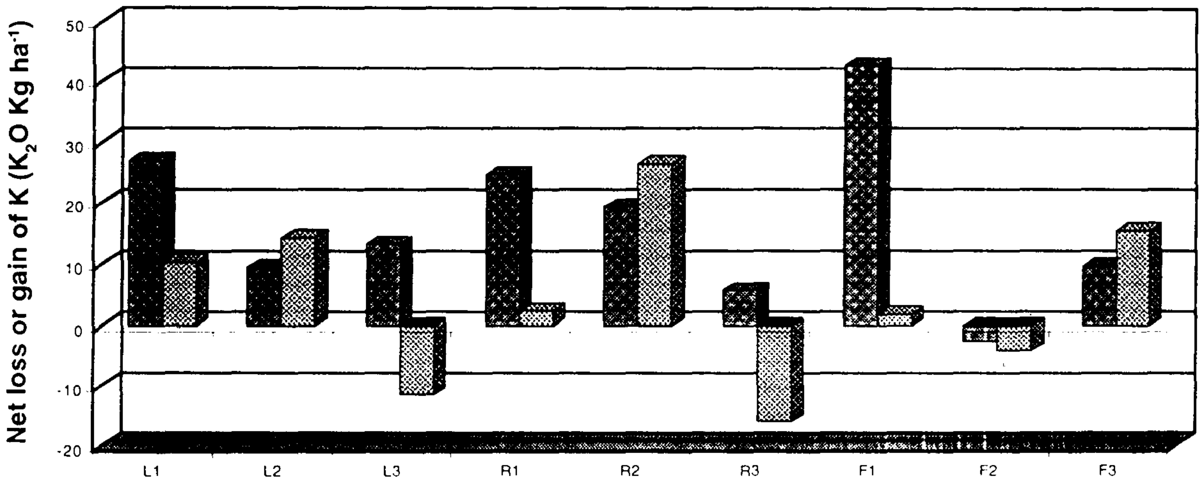

Fig. 55 Net loss or gain of K in Soil - Expt - II

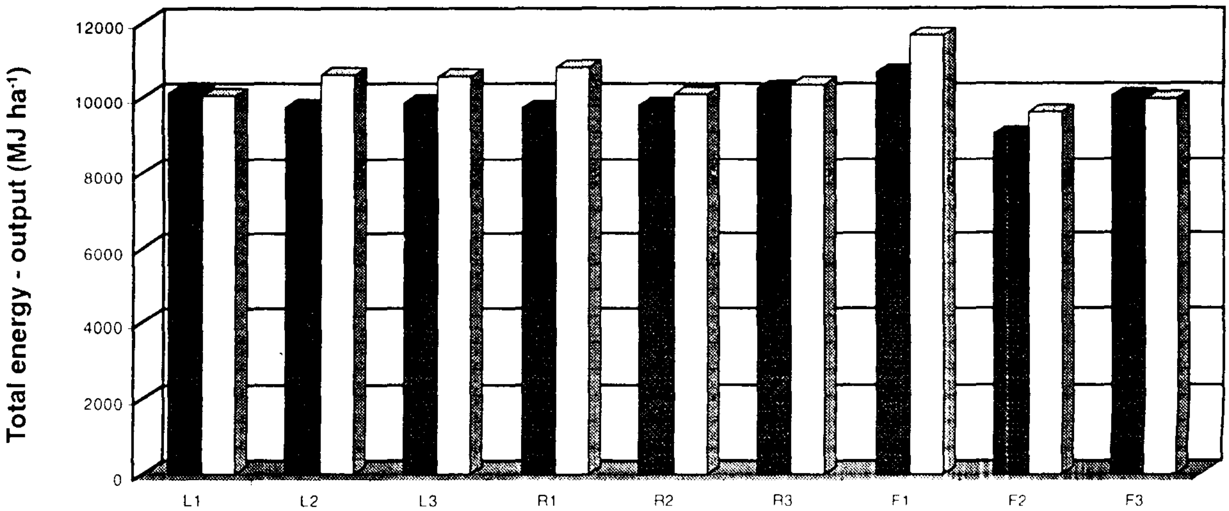

Fig. 56 Total energy - Output - Expt - II

level of N application resulted in higher net loss of K in both the experiments (Fig. 54 and Fig. 55) while net loss was either reduced or net gain occurred with lower levels of N nutrition. Higher levels of N application was supposed to add greater quantity of K to the soil as the quantity of farm yard manure or poultry manure used for N substitution increased with increasing levels of N which also served as a major source of K to the soil. However the actual K content of soil was not as high as the theoritically calculated expected K balance of soil which led to greater losses of K at higher levels of N nutrition. Comparatively higher actual K balances occurred with lower or moderate levels of N application, resulting in a net gain or positive balance of K in soil.

Different ratios of N substitution significantly influenced the net loss or gain of K in Experiment I (Table 107) and Experiment II (Table 111). In case of Experiment I, r_3 (2:1) or r_1 (1:1) ratios resulted in higher net loss of K while the r_2 (1:2) ratio resulted in minimum loss or net gain of K in soil (Fig. 54). Almost similar trend was noticed in case of Experiment II also wherein the r_3 (2:1) ratio resulted in a net loss of K while r_1 (1:1) or r_2 (1:2) ratios recorded net gains of K in soil (Fig. 55). Nitrogen nutrition through greater proportion of farm yard manure or poultry manure required the addition of higher quantity of manure which also expected to add higher amount of K to the soil compared to other ratios. But the corresponding available K contents of soil were not upto the expectation which increased the net loss of K in soil. When 1:2 or 1:1 ratios was used, it was supposed to add comparatively less K to the soil compared to 2:1 ratio since the quantity of organic source required was low or moderate and this in turn moderated the net loss of K or resulted in net gain of K in soil.

Different frequencies of N nutrition did not influence the net loss or gain of K in Experiment I while it was significant in case of Experiment II (Table 111). Higher net gain of K was observed with f_1 frequency while the f_2 frequency resulted in net loss of K. The higher net gain of K associated with full basal application of poultry manure could be considered as an outcome of the better decomposition which would have released more K to the soil thus increasing the actual K balance and net gain of K in soil.

The LxR interaction influenced the net loss or gain of K in soil only in case of Experiment I (Table 108). Net loss of K experienced was maximum with l_2r_3 combination. Application of moderate levels of N through 2:1 ratio of N substitution resulted in greater net loss of K as the actual K balance of soil was not upto the expected value.

The LxF interaction did not have any effect on net loss or gain of K in Experiment I. However in case of Experiment II (Table 113), higher net gain of K was observed when 250 kg N was applied through f_3 frequency in l_2f_3 combination. Addition of moderate levels of N with its organic source (poultry manure) in fortnightly split doses would have resulted in higher available K content in soil due to better soil aeration consequent to the light earthing up operations performed to incorporate the manure and this would have ultimately enhanced the net gain of K in soil. Importance of soil aeration in K availability was suggested by Tisdale *et al*. (1995).

The RxF interaction did not have any effect on net loss or gain of K in Experiment I or II.

5.13 Energy Budgeting

5.13.1 Total energy output (MJ ha^{-1})

Different levels or ratios of N substitution could not influence on total energy output in Experiment I or II.

Different frequencies of application had no influence on total energy out put in Experiment I, although it did affect the energy output in Experiment II (Table 119). Total energy output was found to be maximum with f_1 frequency (Fig. 56). The total energy output was computed by adding energy equivalents of dry matter production per hectare and fruit yield (fresh) per hectare in energy budgeting studies. The higher dry matter production and fruit yield associated with full basal application of poultry manure would have reflected in their energy equivalents too. which in turn resulted in higher total energy output.

The LxR interaction did not influence the total energy out put in Experiment I or II.

The LxF interaction did not affect the total energy output in Experiment I. In case of Experiment II (Table 121), application of moderate levels of N (250 kg) at f_1 frequency was found to produce maximum total energy output. Higher dry matter production and fresh fruit yield associated with the combination would have contributed to higher total energy output since these parameters were the major considerations for total energy out put computations on the basis of their energy equivalents.

The RxF interaction could not influence the total energy output in Experiment I and II.

5.13.2 Net energy returns (MJ ha^{-1})

Net energy loss occurred with increasing levels of N application in both Experiment I (Table 115) and Experiment II (Table 119) and the loss was maximum with highest level of N application in both the experiments (Fig. 57 and Fig. 58). The input energy required for higher levels of N application was higher in comparison with lower levels of N while their energy output did not show a corresponding increase which could have brought about net energy losses which increased with increasing levels of N.

As indicated by Fig. 57, different ratios of N substitution did influence the net energy returns in Experiment I while it did not have any effect in Experiment II. Net energy loss or negative returns were recorded in Experiment I and the loss was maximum with r_1 (1:1) or r_2 (1:2) ratios of substitution compared to the r_3 (2:1 ratio). Two reasons can be attributed for the higher net energy loss when organic and chemical N sources were applied in an equal ratio or chemical N in a greater proportion, one being more energy expended for the chemical N source or urea (Chatterjee *et al.*, 1989) in comparison with organic source and the other being lower energy outputs derived with r_1 and r_2 in comparison with r_3

Different frequencies of N nutrition could not influence the net energy returns in Experiment I. However in case of Experiment II (Table 119), net energy loss occurred and the loss was maximum with f_2 or f_3 frequencies compared to f_1

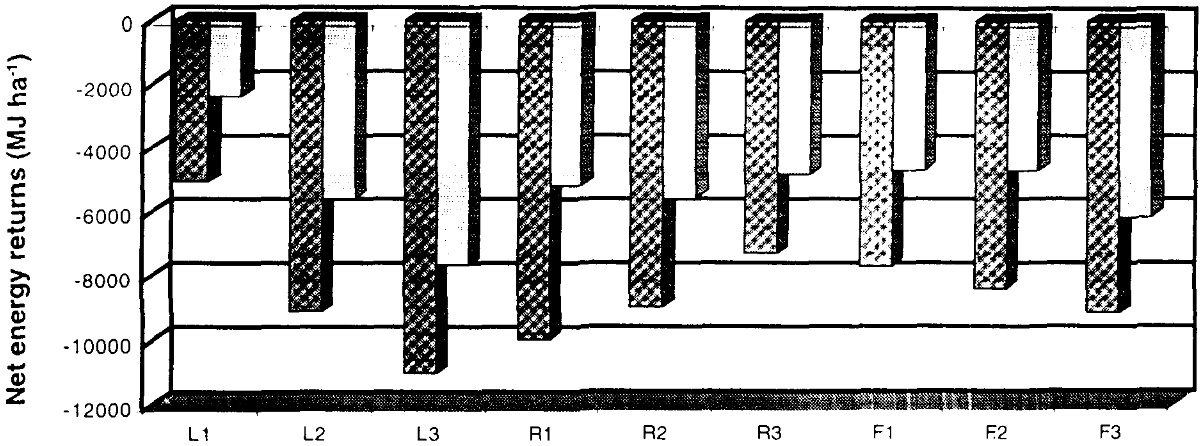

Fig. 57 Net energy returns - Expt - I

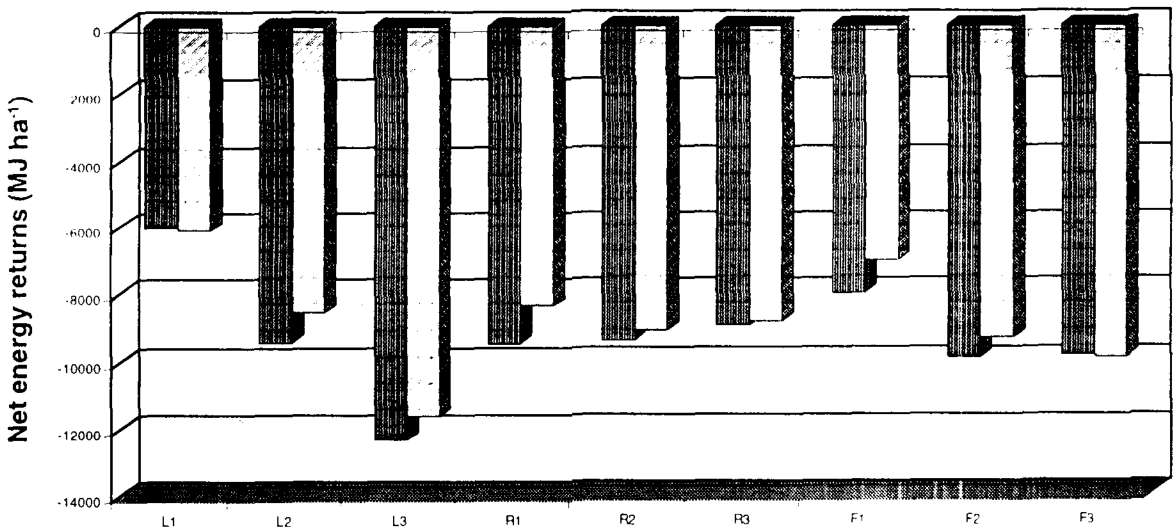

Fig. 58 Net energy returns - Expt - II

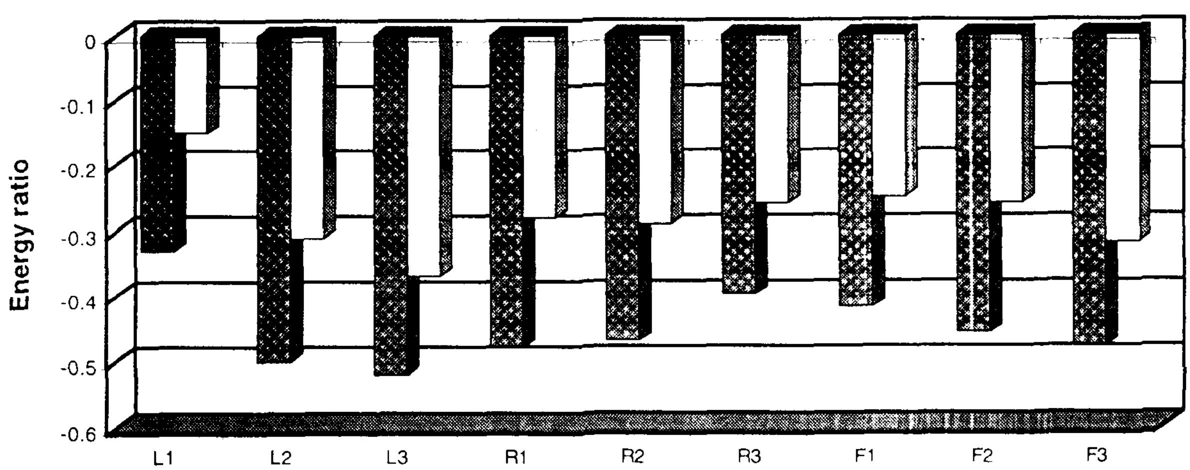

Fig. 59 Energy ratio - Expt - I

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(Fig. 58). The net energy returns was computed by deducting the total energy output from the total energy input for the treatment. While calculating the total energy input, both manure/fertiliser input along with labour input was considered based on their energy equivalents. The split applications of organic manure in f_2 and f_3 required additional labour for earthing up operations to incorporate the manure when compared to its full basal application in f_1 which increased the total input energy required for f_2 and f_3. However the energy outputs produced with split application of manure were not enough to compensate the additional input energy required which in turn caused higher net energy loss.

The LxR interaction did not have any influence on net energy returns in Experiment I and Experiment II.

The LxF interaction influenced the net energy returns in Experiment II while it did not produce any effect in Experiment I. As indicated by Table 121, net energy loss occurred with all the treatment combinations in Experiment II and the loss was higher with l_3f_2 combination. Application of higher levels of N which required higher input energy when combined with split application which required more labour energy would have increased the total input energy and since the energy outputs produced were not sufficient to compensate higher input energy requirement, the net result was increased net loss of energy as discussed above.

The RxF interaction was not significant in Experiment I and Experiment II.

5.13.3 Energy ratio

Different levels of N nutrition influenced the energy ratios in Experiment I

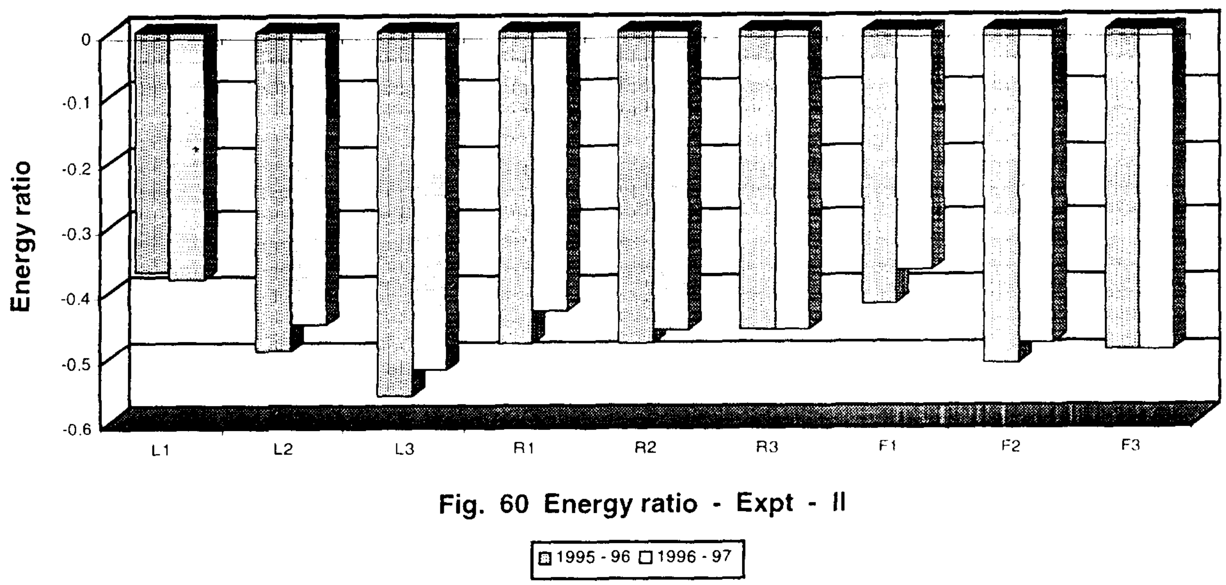

Fig. 60 Energy ratio - Expt - II

(Table 115) and Experiment II (Table 119). In both the experiments, higher levels of N application resulted in higher negative energy ratios indicating more energy losses (Fig. 59 and 60). The energy ratio was computed as a ratio of net energy returns to the total energy input. Higher levels of N application which required more input energy lowered the energy returns which in turn produced energy ratios with higher negative values clearly indicating energy losses.

Different ratios of substitution influenced the energy ratios in Experiment I (Table 115) while it could not influence the same in Experiment II. Negative energy ratios were recorded in Experiment I indicating energy losses and the r_3 (2:1) ratio recorded a low negative ratio suggesting moderate energy losses while r_1 and r_2 resulted in higher negative energy ratios suggesting higher energy losses. Nitrogen nutrition through a higher proportion of chemical N source of urea required more input energy compared to the application of organic source in higher proportion since the energy equivalent value for chemical N source was slightly higher than that for an organic source (Chatterjee *et al.*, 1989). Further more, the energy outputs were not higher enough to compensate this higher input energy required for these ratios. As a result, low energy returns were resulted which would have lowered the energy ratio. In this connection Freedman (1980) opined that traditional production practices involve minimum input energy and increasing modernisation in general involves larger input of energy in crop production. He also pointed out that energy ratio studies showed that traditional production technology was the most efficient energy user and the least efficient was the green revolution technology.

Different frequencies of application could not influence the energy ratio in Experiment I. In case of Experiment II, as illustrated by Fig. 60, negative energy ratios were obtained and greater negative energy ratios were recorded with f_2 and f_3 indicating higher energy losses while the energy ratio obtained with f_1 frequency indicated only moderate energy loss. The lower energy loss associated with f_1 frequency might be due to the fact that less input energy (labour input energy) was required for this treatment compared to split application of organic manure (poultry manure) and further more the energy output was also more with this treatment which improved net energy returns and ratios.

The LxR interaction did not have any effect on energy ratio in Experiment I or II.

Although the LxF interaction had no influence on energy ratio in Experiment I, as depicted by Table 121 in Experiment II, the low level of N (200 kg) at f_2 frequency recorded a negative energy ratio which was lower than other frequencies which indicated minimum energy loss and application of highest level of N (300 kg) at f_1, f_2 or f_3 frequencies recorded higher negative ratios indicating more energy losses. Higher level of N nutrition which required more input energy expenditure resulted in increased energy loss instead of returns which eventually lowered the energy ratio and the variation was conspicuous irrespective of frequencies of application.

The RxF interaction was not significant in Experiment I or II.

5.14 Economics of cultivation

5.14.1 Gross returns (Rs. ha^{-1})

Different levels of N application or ratios of substitution had no influence on gross returns in Experiment I or II.

Different frequencies of application did not significantly influence the gross returns in Experiment I. However as indicated by Table 123 and Fig. 61, higher gross returns was obtained with f_1 frequency in Experiment II. Maximum gross returns produced with full basal application of poultry manure in f_1 frequency was on account of higher fruit yield produced by the treatment.

The LxR interaction (Table 124) significantly influenced the gross returns only in case of Experiment II. When 300 kg N was supplied through 2:1 ratio of N substitution in l_3r_3 combination it recorded higher gross returns when compared to other combinations. Highest level of N application through a greater proportion of poultry manure would have enhanced the gross returns probably through better fruit production.

The LxF or RxF interaction had no influence on gross returns in Experiment I and II.

5.14.2 Net returns (Rs. ha^{-1})

Different levels of N nutrition influenced the net returns only in case of Experiment I (Table 123). Application of lowest level of N (200 kg) produced higher net returns and higher levels of N recorded lower net returns. In short, increasing the N level beyond 200 kg would have reduced the net returns probably

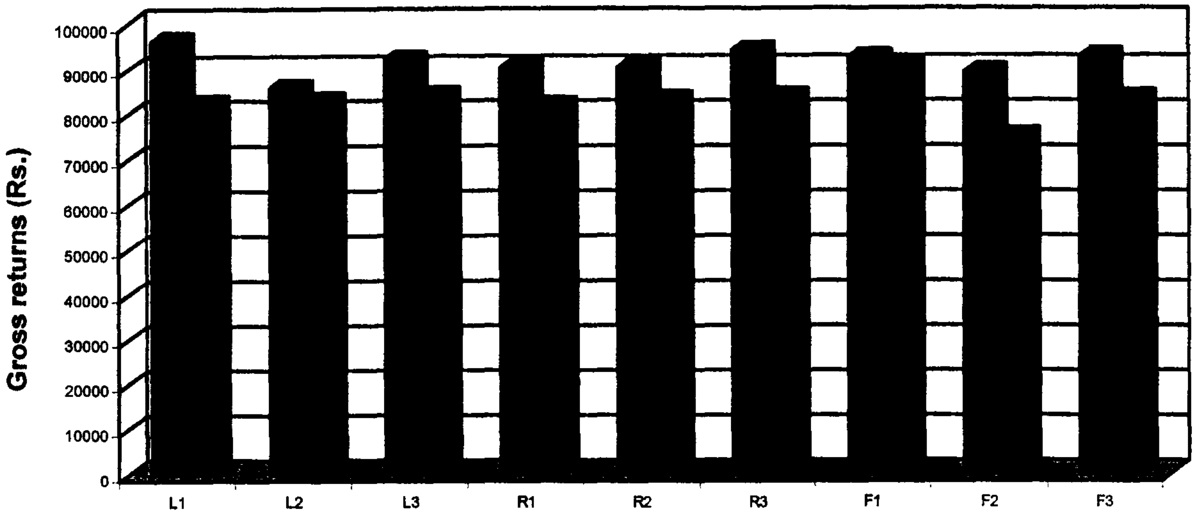

Fig. 61 Gross returns

■ Expt I ■ Expt II

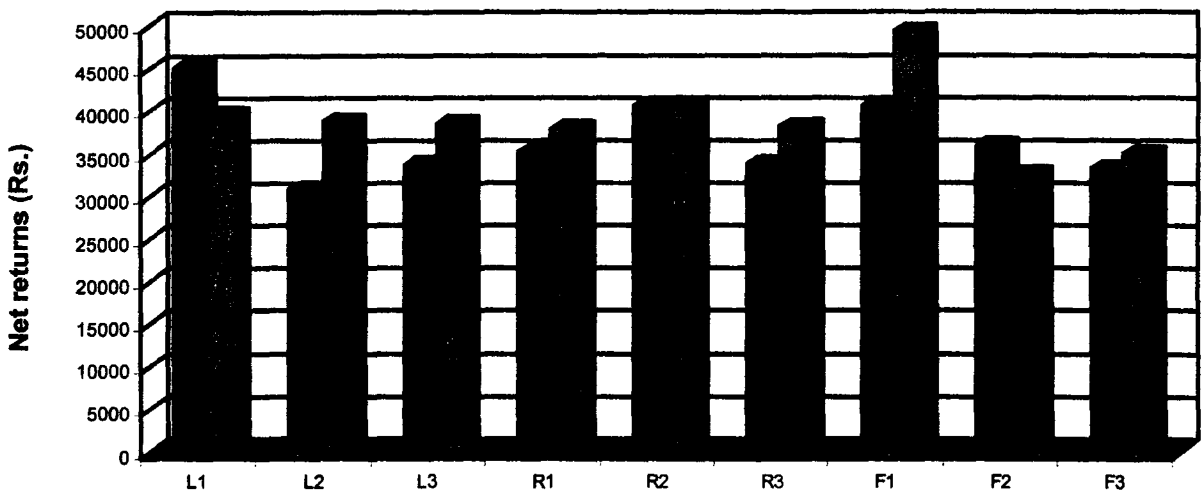

Fig. 62 Net returns

■ Expt I ■ Expt II

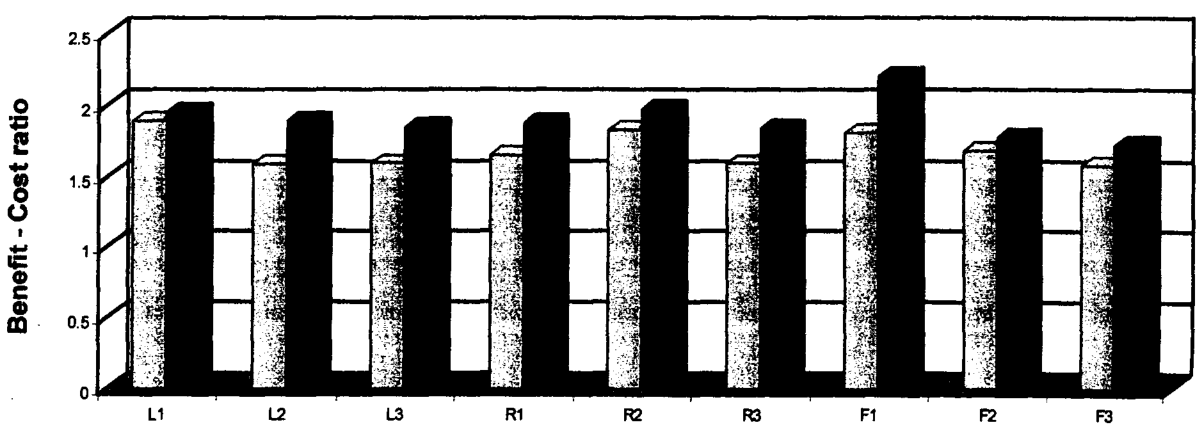

Fig. 63 Benefit - Cost ratio

□ Expt I ■ Expt II

due to higher input cost and lack of yield response at higher levels of N application.

Different ratios of N substitution did not influence the net returns in Experiment I or II.

Different frequencies of N application was not significant in Experiment I. However in case of Experiment II (Fig. 62) the net returns were maximum with f_1 frequency. When full quantity of poultry manure was applied as basal dose, it saved the labour cost for split application and incorporation of manures brought about general reduction in input cost and the low input cost combined with better economic yield increased the net returns.

Interaction effects were not significant to influence net returns in Experiment I or II.

5.14.3 Benefit-Cost ratio (B/C ratio)

Different N levels did not affect the B/C ratio in Experiment II, while it had significant influence in Experiment I (Table 123). Increasing the N level from 200 to 250 or 300 lowered the B/C ratio (Fig. 63). Application of higher levels of N not only increased the input cost, but also failed to produce better fruit yield to compensate the higher input cost which in turn lowered the benefit-cost ratio of production which also indicated that it was uneconomical to raise the N level beyond 200 kg ha^{-1}.

Different ratios of N substitution influenced the B/C ratio in Experiment I while the ratio remained unaffected in Experiment II. As indicated by Table 123, nitrogen nutrition through r_2 (1:2) ratio of organic-chemical N substitution ratio

SUMMARY

SUMMARY

Field experiments were conducted at Instructional Farm attached to the College of Agriculture, Vellayani, Thiruvananthapuram during January - May 1995-96 and 1996-97 to find out the efficacy of different levels of N in different organic-chemical N ratios, at different frequencies and in different combinations to achieve maximum productivity in bitter gourd (*Momordica charantia* L.). The treatments consisted of three levels of N viz 200, 250 and 300 kg ha^{-1}, three ratios of organic-chemical N substitution viz. 1:1, 1:2 and 2:1 and three frequencies of application viz. f_1 (Full quantity of organic source as basal + chemical N source in equal splits as basal and at fortnightly intervals upto one month before final harvest), f_2 (Organic source in three equal splits as basal and at 40th and 70th days after planting + chemical N source in equal splits as basal and at fortnightly intervals upto one month before final harvest) and f_3 (Organic and chemical N sources in equal splits as basal and at fortnightly intervals upto one month before final harvest). Two different sources viz. farm yard manure and poultry manure were tried as organic sources for N substitution in two simultaneous experiments (Experiment I using farm yard manure and Experiment II using poultry manure) in each year. Each experiment was laid out as confounded 3^3 design in 9 - plot blocks with two replications, confounding LR^2F in RI and LRF^2 in RII.

The data generated from the experiments were statistically analysed, presented and discussed in the foregoing chapters. The findings of this investigation are summarised below.

produced higher B/C ratio (Fig.63) than other treatments and r_3 (2:1) ratio recorded low B/C ratio. Result indicated that using farm yard manure in higher proportion to supply N on equivalent N basis would not have been economic since the unit cost of N through this organic source was higher when compared to that through a chemical N source of urea. However the benefit of organic source can never be looked upon on the basis of its nutrient content alone, but on the cumulative influence on soil properties and general soil health in the long run (Thampan, 1993).

Different frequencies of application did not have any effect on B/C ratio of Experiment I. In case of Experiment II (Table 123), B/C ratio was found to be higher with f_1 frequency (Fig. 63). When full quantity of poultry manure was applied as basal dose, it expended lower input cost as it saved the additional labour expenses which other wise would have been utilised for the incorporation of split application of manure. The low input cost thus resulted when combined with better economic yield resulted in higher B/C ratio which suggested that it was most economical to adapt full basal application of organic manure in commercial bitter gourd cultivation.

Various interaction effects could not influence the B/C ratio in Experiment I or II.

In general different ratios of N substitutions and frequencies of N application were found to produce positive responses in terms of keeping quality and soil properties. Increasing N levels above 200 kg ha^{-1} did not produce appreciable increases in yield and yield attributes and was also found to be causing energy loss and was less economic for commercial bitter gourd cultivation.

1. Days taken to flower was reduced when N level was raised from 200 to 250 or 300 kg ha^{-1}. The split application of both farm yard manure and chemical N source in f_3 required more number of days for flowering (33.72 days) than full basal farm yard manure application in f_1 (32.22 days). Application of 300 kg N through 2:1 ratio of farm yard manure - chemical N source required less number of days for the appearance of first flower (31.67 days).

2. Jassid [*Hishimonas phycitis* (Dist.)] population was higher (4.06) in plots where 300 kg N was supplied through 2:1 ratio of N substitution as farm yard manure and chemical N source at 60 DAS.

3. Leaf spot infestation (C.O. *Pseudoperonospora cubensis*) was maximum (62.41 per cent) when 200 kg N was applied at 90 DAS. Higher leaf spot infestation was noticed at 30 DAS (4.58 per cent) and 60 DAS (6.39 per cent) when farm yard manure and chemical N sources were applied as basal and as fortnightly splits in f_3. Application of 200 kg N through 2:1 ratio of organic - chemical N source using farm yard manure as organic source recorded higher leaf spot infestation of 64.61 per cent at 90 DAS.

4. The shelf life of fruits was maximum (4.28 days) under room temperature storage when nutrient N was supplied through 2:1 ratio of organic- chemical N sources with farm yard manure as organic source. Split application of organic and chemical nitrogen sources as basal and at fortnightly intervals (f_3) registered higher shelf life of fruits under room temperature storage (5.27 days during 1995-96 and 5.17 days during 1996-97). Application of 200 kg N through 2:1 ratio of N substitution recorded higher shelf life of fruits under room temperature (4.67 days). When the N level was increased beyond 200 kg ha^{-1} shelf life of fruits showed a decremental increase even

when it was predominantly supplied through organic source. Application of 200 kg N as basal and as fortnightly split doses of farm yard manure and chemical N source recorded the higher shelf life of 5.67 days under room temperature storage. Nitrogen nutrition through 2:1 ratio of organic-chemical N sources as basal and fortnightly equal split doses produced higher shelf life of fruits (5.17 days during first and 5.50 days during the second year) under room temperature storage.

5. Higher levels of N application reduced the shelf life of fruits under refrigeratory storage when organic source of N used was farm yard manure. Shelf life was higher (16.61 days) when nutrient N was supplied predominantly through farm yard manure in 2:1 ratio of N substitution.

6. Application of highest level (300 kg N) of N recorded maximum total plant N content of 2.11 per cent. Full basal application of farm yard manure (organic source) along with basal + fortnightly split applications of chemical N fertiliser recorded the maximum total plant N content of 2.11 per cent.

7. Increasing levels of N application was found to improve the total P content of plants and 300 kg N application produced the maximum total plant P content of 0.34 per cent during first year and 0.33 per cent during the succeeding year.

8. Total K content of plants increased with increasing N levels and was maximum with l_3 (2.44 per cent during 1995-96 and 2.50 per cent during 1996-97). The total K content was higher (2.33 during 1995-96 and 2.41 per cent during 1996-97) when nutrient N was applied through 2:1 ratio of organic-chemical N sources using farm yard manure as an organic source.

9. Application of highest level of N (300 kg) recorded maximum crude protein content of 21.78 per cent and 20.91 per cent during 1995-96 and 1996-97 respectively. Crude protein content was maximum (21.03 per cent) when nutrient N was supplied through 2:1 organic-chemical N ratio using farm yard manure as an organic source. Supply of 300 kg N through 2:1 ratio of organic-chemical N substitution recorded the maximum crude protein content 23.93 per cent with the general indication that higher levels of N application through a major source of farm yard manure improved the crude protein content of fruits.

10. Application of highest level of N (300 kg ha^{-1}) increased the total P content fruits to 1.09 per cent in Experiment I wherein farm yard manure was used as organic source.

11. When 300 kg N ha^{-1} was applied, higher total K content of fruit was recorded during 1995-96 (6.78 per cent) and 1996-97 (6.60 per cent) in Experiment I using farm yard manure as organic source of N.

12. The ascorbic acid content of fruit decreased with increase in N levels and was maximum with the application of 200 or 250 kg N ha^{-1} (145.53 and 148.85 mg 100 ml^{-1} respectively during 1995-96 and 1996-97) in Experiment I.

13. Highest level of N application (300 kg) produced maximum soil bacterial population of 16.38 ($1x10^8$ g^{-1}). Nitrogen nutrition through 2:1 organic-chemical N ratio recorded higher soil bacterial count of 16.30 (1×10^8 g^{-1}). Application of full dose of farm yard manure as basal + fortnightly split application of chemical N source registered the higher soil bacterial

population of 15.56 ($1x10^8$ g^{-1}) and split application of organic source produced lower soil bacterial counts. When 300 kg N was supplied predominantly through organic source of farm yard manure (2:1 organic-chemical N ratio) it resulted in maximum soil bacterial population of 17.92 ($1x10^8$ g^{-1}). Soil bacterial population build up was more ie. 16.55 ($1x10^8$ g^{-1}) when 300 kg N was applied with its organic source farm yard manure fully as basal + basal and fortnightly split applications of chemical N source. Nitrogen nutrition through 2:1 organic-chemical N source with its organic source (farm yard manure) applied fully as basal along with basal and fortnightly split application of chemical N source recorded more soil bacterial population of 17.40 ($1x10^8$ g^{-1}). Higher levels of N applications and higher proportion of organic source had a general favourable influence on soil bacterial population.

14. Higher levels of N application was found to exert a depressing effect on soil fungal population and was maximum ie. 77.14 ($1x10^4$ g^{-1}) with lowest (200 kg N) level of N application in Experiment I.

15. Soil actinomycetes population was higher ie.2.13($1x10^6$ g^{-1}) with 2:1 ratio of N substitution using farm yard manure as organic source.

16. Application of organic source of farm yard manure in equal or higher proportion with chemical N produced higher soil pH. When full dose of farm yard manure was applied as basal and chemical N source applied in fortnightly split doses, higher soil pH of 5.68 was recorded. Soil pH was higher when moderate or higher level of N was applied in such a way that the organic source was fully applied as basal and chemical N source was applied at fortnightly splits.

17. Organic carbon content of soil was maximum (0.94 per cent) when N was supplied through 2:1 ratio of organic-chemical N substitution ratio using farm yard manure as an organic source. When full quantity of organic source (farm yard manure) was applied as basal, maximum organic carbon content of 0.87 per cent and 1.01 per cent were recorded during 1995-96 and 1996-97 respectively and split application of organic source lowered the soil organic carbon content. When highest level of N (300 kg) was supplied through a greater proportion of organic source (2:1) using farm yard manure, maximum organic carbon content of 0.88 and 1.07 per cent were noticed during 1995-96 and 1996-97 respectively. Organic carbon content was also maximum (0.97 per cent for 1995-96 and 1.19 per cent for 1996-97) when highest level of N (300 kg) was applied with its organic component fully as basal and chemical N source in equal fortnightly splits. Addition of organic source in equal or higher quantity with full dose as basal along with fortnightly split application of chemical N produced maximum soil organic carbon content.

18. Application of farm yard manure in 2:1 organic-chemical N ratio lowered the bulk density of soil to 1.25 (1995-96) and 1.26 (1996-97). Highest level of N application (300 kg) through 2:1 organic - chemical N substitution ratio recorded the lowest bulk density of 1.23 (1995-96) and 1.21 (1996-97). When farm yard manure was applied in higher proportion than chemical N source with both the sources as basal and at fortnightly intervals, soil bulk density recorded was lower (1.24).

19. N substitution through greater proportion (2:1) of farm yard manure registered maximum soil water holding capacity of 34.76 per cent (1995-96) and 36.16 per cent (1996-97). When farm yard manure as an organic source was

applied along with chemical N source as basal and in fortnightly splits, soil water holding capacity was higher. When 300 kg N ha^{-1} was applied through 2:1 ratio of organic- chemical N ratio using farm yard manure as an organic source, soil water holding capacity was maximum (35.95 per cent during 1995-96 and 36.90 per cent during 1996-97). Higher water holding capacity was noticed on applying 300 kg N with its organic and chemical N sources as basal and fortnightly equal splits.

20. Soil particle density was higher (2.89) upon following 1:2 ratio of organic-chemical N substitution wherein chemical N source dominated the organic source. Split application of organic and chemical N sources as basal and in fortnightly splits recorded greater particle density of 2.89.

21. Enhancing the N level from lower to moderate doses enhanced the soil porosity. When N nutrition was done predominantly through an organic source of farm yard manure compared to chemical N source, higher soil porosity was observed (45.05 per cent in the first year and 46.14 per cent in the second year). Porosity was more (44.88 per cent) with basal and fortnightly split applications of organic and chemical N sources. Lower or higher level of N nutrition through a major organic source of farm yard manure recorded the higher soil porosity. Application of moderate levels of N with its organic and chemical N sources as basal and in fortnightly splits registered maximum soil porosity of 45.76 per cent. Nitrogen nutrition through a major source of farm yard manure wherein it was applied along with lower quantities of chemical N source as basal and as fortnightly split doses recorded the maximum soil porosity of 47.03 per cent during the first year and 48.71 per cent during the second year. .

22. N-uptake was maximum (36.64 kg ha^{-1}) with the application of highest level (300 kg) of N. The nitrogen nutrition through a higher proportion of organic source (2:1 ratio) of farm yard manure registered maximum N-uptake (37.52 kg ha^{-1}).

23. Increase in levels of N applied increased the expected N balance in soil. When N was applied through an equal or 1:2 proportion of organic and chemical N sources expected N balance of soil was higher.

24. The available N content of soil after the conduct of experiment which denotes the actual N balance of soil was more (299.31 kg N ha^{-1}) with highest level (300 kg N) of N application. The actual N balance of soil was reduced when nutrient N was applied through 1:2 ratio of organic-chemical N sources using farm yard manure as an organic source. Split application of farm yard manure as basal and at 40th and 70th DAS combined with fortnightly split application of chemical N source registered higher actual N content in soil during first year (212.38 kg N ha^{-1}) while the full basal application of farm yard manure enhanced the actual N balance of soil to 289.21 kg during the succeeding year. When 300 kg N was applied through 1:1 substitution ratio, the actual N balance of soil was higher (232.06 kg) during the first year while during the succeeding year it was maximum when the same level was applied through 2:1 N substitution ratio (323.01 kg N ha^{-1}). During the first year when nutrient N was applied through equal proportion of organic and chemical N sources with the organic source as basal and as 2 splits along with fortnightly split application of chemical N, maximum actual N balance (240.95 kg ha^{-1}) was recorded while during the succeeding year it was maximum (304.72 kg ha^{-1}) when 2:1 ratio of N substitution and basal + fortnightly split application of organic and chemical N sources were followed.

25. The net loss of N in soil increased with increase in N levels. Maximum net loss was noticed when chemical N source was applied in a greater proportion in 1:2 organic chemical N substitution ratio (-227.37 kg during the first year and -148.40 kg during the second year). Application of highest dose of N (300 kg) through 1:2 ratio of substitution resulted in higher net loss of N and the loss was moderated during the final year of experimentation. Nitrogen application through a higher proportion of chemical N source (1:2 ratio) with basal + fortnightly split application of both the sources recorded higher net loss.

26. P-uptake was maximum (26.14 kg P_2O_5 ha^{-1}) when nitrogen nutrition was done through a higher proportion of farm yard manure (2:1 substitution ratio).

27. The expected P balance of soil increased with increase in levels of N nutrition and was higher when 2:1 ratio of organic-chemical N substitution was followed (121.43 kg in the first year and 125.24 kg P_2O_5 ha^{-1} in the second year). When highest level of N (300 kg) was applied through 2:1 ratio of organic-chemical N substitution, the expected P balance of soil was higher (140.42 kg P_2O_5 ha^{-1} in first year and 146.35 kg P_2O_5 ha^{-1} in second year).

28. Highest level of N application recorded higher actual P balance of 27.79 kg P_2O_5 ha^{-1} in soil. Nitrogen nutrition through a higher proportion of farm yard manure (2:1 ratio of N substitution) registered more actual P balance of 50.87 kg P_2O_5 ha^{-1} during second year of experimentation. Application of full quantity of farm yard manure as basal dose increased the actual P balance of soil during first year while full basal or fortnightly split doses recorded higher soil P content during the succeeding year. Improvement of actual soil P balance was noticed after second year of experimentation compared to the first year. Application of 300 kg N through 2:1 ratio of N

substitution using farm yard manure as organic source resulted in higher actual soil P balance (39.15 kg P_2O_5 ha^{-1}). When organic and chemical N sources were applied through 2:1 ratio of substitution with the organic source fully as basal, higher actual P balance (43.67 kg P_2O_5 ha^{-1}) was noticed.

29. Higher levels of N application was found to promote the net loss of P in soil. The net loss was also more (-95.29 kg P_2O_5 ha^{-1} in first year and -74.36 kg P_2O_5 ha^{-1} in second year) when farm yard manure as organic source was applied in higher proportion (2:1 substitution ratio). Basal + 2 split application of organic source and fortnightly split doses of chemical N fertiliser resulted in higher net loss of P in soil (-83.26 kg P_2O_5 ha^{-1}). Application of moderate or higher levels of N through 2:1 ratio of organic-chemical N ratio resulted maximum net loss of P in soil.

30. The expected K balance of soil was higher with higher levels of N nutrition in Experiment I. When farm yard manure as an organic source of N was substituted in higher proportion (2:1 ratio), more expected K balance was arrived at (215.76 kg K_2O ha^{-1}) in first year and (227.97 kg K_2O ha^{-1}) second year.

31. When organic source (farm yard manure) was applied in an equal or higher proportion with chemical N source, the actual K balance of soil was higher. When 300 kg N was supplied through 2:1 ratio of N substitution, actual K balance of soil was higher during first year while highest level of N application predominantly through chemical N source lowered the actual K balance of soil during succeeding year. Application of moderate or higher levels of organic source through few or more splits increased the actual K balance of soil.

32. Higher level of N application caused more net loss of K in soil (-66.75 kg K_2O ha^{-1} in first and -34.64 kg K_2O ha^{-1} in second year). When farm yard manure and chemical N source were applied in 2:1 or 1:1 ratio of substitution, net loss of K in soil was higher. Moderation of K loss in soil was observed during the second year when compared to first year. Application of moderate levels of N through 2:1 ratio of substitution using farm yard manure as organic source recorded higher net loss of K in soil (-100.67 kg K_2O ha^{-1}).

33. Higher levels of N application resulted in negative energy returns or net energy loss which was moderated during the second year of experimentation. Application of organic and chemical N sources in equal proportion or chemical N source in greater proportion caused more net energy loss when organic source of N applied was farm yard manure.

34. Energy ratios registered with different levels of N nutrition were negative, indicating energy losses and was higher (-0.33 in first and -0.15 in second year) with 200 kg N level. Application of farm yard manure in greater proportion to chemical N source produced higher energy ratio (-0.40) indicating moderate energy losses.

35. Application of lowest level (200 kg ha^{-1}) of N produced significantly higher net returns (Rs.45235.10). Increasing the N levels beyond 200 kg ha^{-1} was not economic when organic N substitution was done through farm yard manure.

36. Benefit-cost ratio was highest (1.89) for lowest level of N. Increasing the N level beyond 200 kg ha^{-1} lowered the benefit-cost ratio. Nitrogen nutrition through 1:2 ratio of organic - chemical N source resulted in higher benefit - cost ratio of 1.83.

37. In experiment II with poultry manure as organic source for nitrogen substitution, higher levels of N application narrowed the sex ratio to 11.97 at the late growth stage (90 DAS). When 300 kg N was applied in 2:1 ratio of organic - chemical N source using poultry manure as an organic source, sex ratio was reduced to 9.42 at 90 DAS in Experiment II.

38. More days were required for the appearance of first flower when poultry manure along with chemical N source was applied as basal + fortnightly equal splits (33.94 days in first and 32.72 days in second year) compared to its full basal or few split applications. When 200 kg N was supplied with its organic source as poultry manure + chemical N source as basal and fortnightly splits, more days were required (33.33 days) for the appearance of first flower.

39. Full basal application of poultry manure produced more fruit yield than its few or more splits (10.50 t ha^{-1} in first and 9.67 in second year). When 300 kg N was supplied with its organic source as poultry manure in higher proportion with chemical N source (2:1 ratio), fruit yield was maximum (10.71 t ha^{-1}).

40. Full basal application of poultry manure produced higher fruit yield $plant^{-1}$ than its split application (4.20 kg in 1995-96 and 3.87 kg in 1996-97). When 300 kg N was applied in 2:1 organic - chemical N substitution ratio using poultry manure as organic source, more fruit yield was recorded (4.28 kg $plant^{-1}$).

41. More number of fruits $plant^{-1}$(37.78) was produced when poultry manure as an organic source was applied fully as basal dose compared to its split

applications. Supply of 300 kg N through 2:1 ratio of N substitution using poultry manure as organic source recorded more number of fruits (40.33).

42. Total dry matter production was higher when full basal application of poultry manure was followed (489.63 g $plant^{-1}$ in first year and 524.0 g $plant^{-1}$ in second year).

43. Shelf life of fruits under room temperature was more (4.00 days) when nitrogen nutrition was given through 2:1 ratio of organic - chemical N using poultry manure as organic source in equivalent N basis. Fortnightly split applications of poultry manure increased the days of storage under room temperature (4.28 days). Shelf life was more under room temperature conditions when low or moderate levels of N was applied through a higher proportion of poultry manure. Low level of N with its organic source of poultry manure as basal and as fortnightly splits recorded higher shelf life of fruits under room temperature storage (5.00 days). Nutrient N supplied through a major source of poultry manure (organic) which was applied in several split doses was found to favour the shelf life of fruits under room temperature storage.

44. Increasing the N levels from low to moderate or higher levels reduced the shelf life of fruits under refrigeratory conditions. Higher shelf life of 15.11 days was resulted when N was applied through 2:1 ratio of organic - chemical N substitution using poultry manure as an organic source of N.

45. Highest level of N application produced maximum plant P content of 0.33 per cent. When poultry manure was applied in a greater proportion (2:1 ratio of organic - chemical N ratio), higher plant P content (0.33 per cent) was resulted.

46. Plant K content increased with increase in N levels and was maximum with the application of 300 kg N ha^{-1} (3.58 per cent in first year and 3.55 per cent in second year), in Experiment II using poultry manure as an organic source.

47. Crude protein content of fruits increased with increase in N levels and was maximum with the application of 300 kg N (21.77 per cent in first year and 21.93 per cent in the second year) in Experiment II using poultry manure.

48. Nitrogen nutrition improved the total P content of fruits and was higher with the application of 300 kg N (1.08 per cent in first year and 1.11 per cent in second year) in Experiment II.

49. Nitrogen nutrition to the level of 300 kg N ha^{-1} produced the maximum total K content of 7.83 per cent in Experiment II using poultry manure as organic source of N.

50. Fruit iron content was higher (0.10 per cent) with the application of 200 or 300 kg N ha^{-1} in Experiment II. Application of 300 kg N through a major source of poultry manure (2:1 ratio of organic - chemical N substitution) resulted in more fruit iron content of 0.19 per cent.

51. Higher level of N nutrition was found to reduce the ascorbic acid content of fruits in Experiment II.

52. Soil bacterial population was found to increase with N application in Experiment II. Higher soil bacterial population of 11.97 ($1x10^8$ g^{-1}) was noticed when poultry manure and chemical N sources were applied in 2:1 ratio of N substitution. Full basal application of poultry manure produced higher soil bacterial count of 10.42 ($1x10^8$ g^{-1}).

53. Nitrogen nutrition was found to promote the soil fungal population which was maximum with the application of 300 kg N ha^{-1} ie. 85.67 ($1x10^4$ g^{-1}) in first year and 83.45 ($1x10^4$ g^{-1}) in second year.

54. Poultry manure as an organic source used in equal proportion or higher proportion with chemical N source moderated the soil acidity.

55. Application of poultry manure in higher proportion or equal proportion with chemical N source (1:1 or 2:1 ratio) produced higher organic carbon content in soil. Basal and fortnightly split application of poultry manure and chemical N source in 2:1 organic - chemical N ratio resulted in maximum organic carbon content of 0.91 per cent.

56. When poultry manure as organic source was applied in higher proportion (2:1 ratio of N substitution), lower soil bulk density of 1.26 was resulted. Application of 300 kg N through 2:1 ratio of organic - chemical N substitution lowered the soil bulk density to 1.23. Nitrogen nutrition through 2:1 organic - chemical N ratio with both the sources applied in equal split doses as basal and at fortnightly intervals, or as basal + 2 splits registered lower bulk density of 1.24.

57. When poultry manure and chemical N sources were applied in 2:1 ratio of substitution on equivalent N basis, water holding capacity of soil was higher (35.64 per cent). Application of 300 kg N through 2:1 ratio of N substitution using poultry manure as an organic source resulted in higher water holding capacity of 38.85 per cent.

58. Soil particle density was higher (2.86) when chemical N source was applied in higher proportion than organic source of poultry manure (1:2 ratio).

59. Higher N-uptake (35.81 kg N ha^{-1}) was observed when full dose of poultry manure was applied as basal and chemical N source was applied in several splits. Uptake of N was also higher when 300 kg N was applied through 2:1 organic - chemical N ratio using poultry manure as organic source (46.38 kg N ha^{-1}).

60. The expected N balance in Experiment II was found to increase with increase in N levels and was more (399.24 kg N ha^{-1}) in first year and second year (469.49 kg N ha^{-1}) with 300 kg N level. Few split applications of poultry manure in f_2 frequency registered higher expected N balance of 354.21 kg ha^{-1}. The expected N balance of soil showed an increasing trend with increasing levels of N irrespective of its substitution ratios.

61. Low level of N application registered higher actual N balance or available N content of soil (166.56 kg N ha^{-1}). Application of organic source of poultry manure in equal or higher proportion with chemical N source resulted in more actual N balance in soil. Supply of full quantity of poultry manure as basal or as basal + 2 split doses registered higher actual N balance in soil. Low level of N application at any frequency was found to promote the actual N balance during the first year while a general increase in actual N balance was noticed during the second year.

62. The net loss of N increased with increase in N levels. When chemical N source was applied in a higher proportion in comparison with organic source of N, net loss of N was observed to be higher (-200.14 kg in first year and -165.20 kg in second year).

63. P-uptake was maximum (25.27 kg P_2O_5 ha^{-1}) when full quantity of poultry manure was applied as basal dose. P-uptake was also more when 300 kg N was applied through 2:1 ratio using poultry manure as an organic source (29.55 kg P_2O_5 ha^{-1}).

64. Expected P balance of soil increased with increase in N levels. Nitrogen nutrition through a major source of poultry manure increased the expected P balance of soil, when 2:1 ratio of N substitution was followed. Application of 300 kg N through 2:1 ratio of N substitution using poultry manure as an organic source produced higher expected balance of 190.29 kg in first year and 181.64 kg P_2O_5 ha^{-1} in second year.

65. Increasing N levels from low to moderate or higher level enhanced the actual P balance or available P content of soil in Experiment II. Full basal application of organic source (Poultry manure) favoured the actual P balance of soil (28.18 kg P_2O_5 ha^{-1}).

66. Increasing N levels increased the net loss of P in soil and was maximum with 300 kg N ha^{-1}. When poultry manure and chemical N sources were applied in 2:1 ratio of substitution, net loss of P in soil was higher. Few or more split applications of poultry manure resulted in higher net loss of P in soil. When 300 kg N was applied through 2:1 ratio of N substitution using poultry manure as an organic source, net loss of P in soil was higher (-125.20 kg P_2O_5 ha^{-1}).

67. Full basal application of poultry manure resulted in higher K-uptake by crop. Moderate dose of N application with its organic source (poultry manure) fully as basal dose was found to increase K-uptake.

68. Increase in levels of N application enhanced the expected K balance of soil and was maximum (123.36 kg K_2O ha^{-1}) with 300 kg N level. Expected K balance of soil was higher (130.10 kg K_2O ha^{-1} in first year and 173.34 kg K_2O ha^{-1} in second year) when poultry manure and chemical N sources were applied in 2:1 ratio of substitution. Basal + 2 split applications or basal + fortnightly split application of poultry manure enhanced the expected K balance of soil.

69. Actual K balance or available K content of soil was greater (135.89 kg K_2O ha^{-1}) when poultry manure and chemical N sources were applied in 2:1 ratio of N substitution. Full basal application of poultry manure promoted the actual K balance during the first year while it was higher with few or more split applications of poultry manure during the second year.

70. The net loss of K in soil was more (-11.39 kg K_2O ha^{-1}) with 300 kg N level and low levels of N application resulted in net gain of K in soil. When poultry manure was substituted in higher proportion with chemical N source, (2:1 ratio) net loss of K in soil was higher (-15.79 kg K_2O ha^{-1}) while net gain of K resulted when chemical N source was substituted in higher proportion. Higher net gain of K was noticed when poultry manure as an organic source was fully applied as basal dose (42.74 kg K_2O ha^{-1}). Application of moderate levels of N (250 kg) with its organic source (poultry manure) in fortnightly split doses resulted in higher net gain of K in soil (47.00 kg K_2O ha^{-1}).

71. Total energy output was higher when organic source (poultry manure) was applied fully as basal dressing (10673.72 MJ ha^{-1} in first year and 11641.72 MJ ha^{-1} in second year). Application of 250 kg N with its organic component completely as basal dressing resulted in higher total energy output.

72. Nitrogen nutrition was found to cause net energy losses and the loss increased with increase in N levels. Split applications of poultry manure (basal + 2 splits or basal + fortnightly splits) caused higher net energy loss. When 300 kg N was applied, it resulted in higher energy losses irrespective of frequencies of application.

73. Energy ratios registered a negative value for all the treatments indicating energy losses. Energy ratio value was higher with low levels of N nutrition. Full basal application of poultry manure resulted in an energy ratio of -0.42 in first year and -0.37 in second year, suggesting low energy losses while energy ratios obtained with split applications of poultry manure indicated higher losses. Low level of N (200 kg) applied as basal + 2 split doses of organic source recorded an energy ratio of -0.37 indicating lowest energy loss. Highest level of N application caused higher energy losses irrespective of frequencies of application.

74. Higher gross returns was obtained (Rs.90760.00) when full quantity of poultry manure was applied as basal dressing. More gross returns obtained (Rs.94200.00) when highest level of N (300 kg) was applied through 2:1 ratio of organic - chemical N substitution using poultry manure as an organic source.

75. Higher net returns was obtained (Rs.49505.20) when organic source of poultry manure was completely applied as basal dressing.

76. Higher benefit-cost ratio was observed (2.20) when organic source of poultry manure was applied in full dose as basal dressing.

Study revealed that N application through a major source of farm yard manure or poultry manure could produce beneficial influence on fruit quality, shelf life of fruits, soil physical, chemical and biological properties and these influences were more favourable when the organic source was applied fully as basal in seasonal vegetable cultivation. However, yield parameters or pest and disease incidence were not much influenced by N nutrition. It was not economic to raise the N level beyond 200 kg ha^{-1} when farm yard manure was used as an organic source for N substitution. Study also pointed out the suitability of poultry manure for commercial vegetable cultivation in Kerala which also was found to be an efficient source for N substitution at higher N levels.

Future line of research

Considering the over all beneficial influence of organic sources on soil and plant environment, it would be more appropriate to initiate studies on vegetable based cropping systems so that the indirect beneficial effects can be analysed and interpreted in terms of performance of succeeding crops. Another avenue of future research is that efficacy of poultry manure and other organic sources could be studied in combination with farm yard manure. These studies could be very well integrated with cultural measures to increase nitrogen use efficiency, especially under conditions of seasonal cultivation of vegetables as practised in the state.

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* Originals not seen

APPENDICES

APPENDIX I

Meteorological data during the cropping period

Standard weeks	Period From	Period To	Rain fall (mm)	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Evaporation (mm)
1995-96							
1	1.1.1996	7.1.1996	-	31.3	20.4	75.2	3.4
2	8.1.1996	14.1.1996	-	31.4	20.4	74.3	3.9
3	15.1.1996	21.1.1996	8.0	31.5	20.9	78.5	3.2
4	22.1.1996	28.1.1996	-	31.5	18.9	71.1	4.0
5	29.1.1996	4.2.1996	-	31.1	19.3	59.7	4.1
6	5.2.1996	11.2.1996	-	31.8	20.9	73.3	3.7
7	12.2.1996	18.2.1996	3.8	30.9	20.4	69.0	3.9
8	19.2.1996	25.2.1996	-	29.9	21.4	75.6	4.4
9	26.2.1996	3.3.1996	16.7	31.8	20.5	73.0	4.5
10	4.3.1996	10.3.1996	-	32.0	19.1	71.3	5.1
11	11.3.1996	17.3.1996	-	32.9	20.6	57.9	5.1
12	18.3.1996	24.3.1996	-	32.8	22.3	73.5	5.4
13	25.3.1996	31.3.1996	-	33.0	24.2	76.5	5.3
14	1.4.1996	7.4.1996	0.6	33.5	23.9	82.1	5.1
15	8.4.1996	14.4.1996	45.9	32.4	22.7	80.6	4.8
16	15.4.1996	21.4.1996	2.6	32.3	22.7	79.1	4.5
17	22.4.1996	28.4.1996	1.6	32.7	23.5	77.0	4.6
18	29.4.1996	5.5.1996	3.0	32.4	24.3	76.6	4.6
19	6.5.1996	12.5.1996	-	32.2	24.1	75.3	5.6

Standard weeks	Period From	Period To	Rain fall mm	Maximum temperature °C	Minimum temperature °C	Relative humidity %	Evaporation mm
1996-1997							
1	1.1.1997	7.1.1997	-	32.3	21.5	75.9	4.1
2	8.1.1997	14.1.1997	-	32.3	20.9	78.2	3.6
3	15.1.1997	21.1.1997	-	32.0	21.1	77.4	4.0
4	22.1.1997	28.1.1997	-	32.6	19.5	73.4	3.9
5	29.1.1997	4.2.1997	-	32.1	20.1	71.0	4.1
6	5.2.1997	11 2.1997	-	33.0	21.7	71.2	4.3
7	12.2.1997	18.2.1997	-	33.0	20.3	72.3	4.6
8	19.2.1997	25.2.1997	-	33.0	21.5	71.1	3.8
9	26.2.1997	4.3.1997	-	33.7	22.3	72.1	4.5
10	5.3.1997	11.3.1997	-	32.9	22.5	71.3	4.1
11	12.3.1997	18.3.1997	-	33.9	23.0	75.9	4.5
12	19.3.1997	25.3.1997	4.8	33.7	24.0	73.6	4.2
13	26.3.1997	1.4.1997	-	33.8	23.7	72.6	4.9
14	2.4.1997	8.4.1997	5.6	33.7	24.5	77.1	4.2
15	9.4.1997	15.4.1997	9.8	34.6	24.1	71.5	5.0
16	16.4.1997	22.4.1997	-	33.7	24.7	71.2	5.2
17	23.4.1997	29.4.1997	18.4	34.0	24.7	71.0	5.1
18	30.4.1997	6.5.1997	2.7	33.4	24.3	74.9	4.9
19	7.5.1997	13.5.1997	123.6	32.9	23.9	79.6	3.7
20	14.5.1997	20.5.1997	9.2	32.7	24.0	77.9	3.7

APPENDIX IIb

Actual quantity of manures and fertilisers applied, their frequency/time of application and ratio of substitution
1995-96

Treat-ment	MANURES				FERTILISER (UREA)	
	EXPERIMENT I (FARM YARD MANURE)		EXPERIMENT II (POULTRY MANURE)			
T1	200.0 q ha^{-1} or (8 kg pit^{-1})	Full as basal	39.06 q ha^{-1} or (1.56 kg pit^{-1})	Full as basal	217.39 kg ha^{-1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T2	200.0 q ha^{-1} or (8 kg pit^{-1})	66.67 q ha^{-1} (2.67 kg pit^{-1}) - Basal 66.67 q ha^{-1} (2.67 kg pit^{-1}) - On 40th Day 66.67 q ha^{-1} (2.67 kg pit^{-1}) - On 70th Day	39.06 q ha^{-1} (1.56 kg pit^{-1})	13.02 q ha^{-1} (0.52 kg pit^{-1} - Basal 13.02 q ha^{-1} (0.52 kg pit^{-1} - On 40th Day 13.02 q ha^{-1} (0.52 kg pit^{-1}) - On 70th Day	217.39 kg ha^{1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5 g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T3	200.0 q ha^{-1} (8 kg pit^{-1})	33.33 q ha^{-1} (1.33 kg pit^{-1}) - Basal 33.33+33.33+33.33+33.33+33.33 q ha^{-1} as 5 splits at fortnightly intervals	39.06 q ha^{-1} (1.56 kg pit^{-1})	6.51 q ha^{-1} (0.26 kg pit^{-1}) - Basal 6.51+6.51+6.51+6.51+6.51 q ha^{-1} as 5 splits at fortnightly intervals	217.39 kg ha^{-1} (87.0 g pit^{-1}	36.23 kg ha^{-1} (14.5 g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T4	134.0 q ha^{-1} (5.36 kg pit^{-1})	Full as basal	26.17 q ha^{-1} (1.05 kg pit^{-1})	Full as basal	289.13 kg ha^{-1} (115.7 g pit^{-1})	48.19 kg ha^{-1} (19.3 g pit^{-1} - Basal 48.19+48.19+48.19+48.19+48.19 kg ha^{-1} as 5 splits at fortnightly intervals
T5	134.0 q ha^{-1} (5.36 kg pit^{-1})	44.67 q ha^{-1} (1.79 kg pit^{-1}) - Basal 44.67 q ha^{-1} (1.79 kg pit^{-1}) - On 40th Day 44.67 q ha^{-1} (1.79 kg pit^{-1}) - On 70th Day	26.17 q ha^{-1} (1.05 kg pit^{-1})	8.72 q ha^{-1} (0.35 kg pit^{-1}) - Basal 8.72 q ha^{-1} (0.35 kg pit^{-1}) - On 40th Day 8.72 q ha^{-1} (0.35 kg pit^{-1}) - On 70th Day	289.13 kg ha^{-1} (115.7 g pit^{-1})	48.19 kg ha^{-1} (19.3 g pit^{-1}) - Basal 48.19+48.19+48.19+48.19+48.19 kg ha^{-1} as 5 splits at fortnightly intervals
T6	134.0 q ha^{-1} (5.36 kg pit^{-1})	22.33 q ha^{-1} (0.89 kg pit^{-1}) - Basal 22.33+22.33+22.33+22.33+22.33 q ha^{-1} as 5 splits at fornightly intervals	26.17 q ha^{-1} (1.05 kg pit^{-1})	4.36 q ha^{-1} (0.174 kg pit^{-1}) - Basal 4.36+4.36+4.36+4.36+4.36 q ha^{-1} as 5 splits at fortnightly intervals	289.13 kg ha^{-1} (115.7 g pit^{-1})	48.19 kg ha^{-1} (19.3 g pit^{-1}) - Basal 48.19+48.19+48.19+48.19+48.19 kg ha^{-1} as 5 splits at fortnightly intervals
T7	266.0 q ha^{-1} (10.64 kg pit^{-1})	Full as basal	51.95 q ha^{-1} (2.08 kg pit^{-1})	Full as basal	145.65 kg ha^{-1} (58.3 g pit^{-1})	24.28 kg ha^{-1} (9.7 g pit^{-1}) - Basal 24.28+24.28+24.28+24.28+24.28 kg ha^{-1} as 5 splits at fornightly intervals

Treatment	MANURES: EXPERIMENT I (FARM YARD MANURE)		MANURES: EXPERIMENT II (POULTRY MANURE)		FERTILISER (UREA)	
T8	266.0 q ha^{-1} (10.64 kg pit^{-1})	88.67 q ha^{-1} (3.55 kg pit^{-1}) - Basal 88.67 q ha^{-1} (3.55 kg pit^{-1}) - On 40th Day 88.67 q ha^{-1} (3.55 kg pit^{-1}) - On 70th Day	51.95 q ha^{-1} (2.08) kg pit^{-1})	17.32 q ha^{-1} (0.69 kg pit^{-1}) - Basal 17.32 q ha^{-1} (0.69 kg pit^{-1}) - On 40th Day 17.32 q ha^{-1} (0.69 kg pit^{-1}) - On 70th Day	145.65 kg ha^{-1} (58.3 g pit^{-1})	24.28 kg ha^{-1} (9.7 g pit^{-1}) - Basal 24.28+24.28+24.28+24.28+24.28 kg ha^{-1} as 5 splits at fortnightly intervals
T9	266.0 q ha^{-1} (10.64 kg pit^{-1})	44.33 q ha^{-1} (1.77 kg pit^{-1}) - Basal 44.33+44.33+44.33+44.33+44.33 q ha^{-1} as 5 splits at fortnightly intervals	51.95 q ha^{-1} (2.08 kg pit^{-1})	8.66 q ha^{-1} (0.35 kg pit^{-1}) - Basal 8.66+8.66+8.66+8.66+8.66 q ha^{-1} as 5 splits at fortnightly intervals	145.65 kg ha^{-1} (58.3 g pit^{-1})	24.28 kg ha^{-1} (9.7 g pit^{-1}) - Basal 24.28+24.28+24.28+24.28+24.28 kg ha^{-1} as 5 splits at fortnightly intervals
T10	250.0 q ha^{-1} (10 kg pit^{-1})	Full as basal	48.83 q ha^{-1} (1.95 kg pit^{-1})	Full as basal	271.74 kg ha^{-1} (108.7 g pit^{-1})	45.29 kg ha^{-1} (18.10 g pit^{-1}) - Basal 45.29+45.29+45.29+45.29+45.29 kg ha^{-1} as 5 splits at fortnightly intervals
T11	250.0 q ha^{-1} (10 kg pit^{-1})	83.33 q ha^{-1} (3.33 kg pit^{-1}) - Basal 83.33 q ha^{-1} (3.33 kg pit^{-1}) - On 40th Day 83.33 q ha^{-1} (3.33 kg pit^{-1}) - On 70th Day	48.83 q ha^{-1} (1.95 kg pit^{-1})	16.28 q ha^{-1} (0.65 kg pit^{-1}) - Basal 16.28 q ha^{-1} (0.65 kg pit^{-1} - On 40th day 16.28 q ha^{-1} (0.65 kg pit^{-1}) - On 70th day	271.74 kg ha^{-1} (108.7 g pit^{-1})	45.29 kg ha^{-1} (18.10 g pit^{-1}) - Basal 45.29+45.29+45.29+45.29+45.29 kg ha^{-1} as 5 splits at fortnightly intervals
T12	250.0 q ha^{-1} (10 kg pit^{-1})	41.67 q ha^{-1} (1.67 kg pit^{-1}) - Basal 41.67+41.67+41.67+41.67+41.67 q ha^{-1} as 5 splits at fortnightly intervals	48.83 q ha^{-1} (1.95 kg pit^{-1})	8.14 q ha^{-1} (0.33 kg pit^{-1}) - Basal 8.14+8.14+8.14+8.14+8.14 q ha^{-1} as 5 splits at fortnightly intervals	271.74 kg ha^{-1} (108.7 g pit^{-1})	45.29 kg ha^{-1} (18.10 g pit^{-1}) - Basal 45.29+45.29+45.29+45.29+45.29 kg ha^{-1} as 5 splits at fortnightly intervals.
T13	166.0 q ha^{-1} (6.64 kg pit^{-1})	Full as basal	32.42 q ha^{-1} (1.30 kg pit^{-1})	Full as basal	363.04 kg ha^{-1} (145.20g pit^{-1})	60.51 kg ha^{-1} (24.20 g pit^{-1}) - Basal 60.51+60.51+60.51+60.51+60.51 kg ha^{-1} as 5 splits at fortnightly intervals
T14	166.0 q ha^{-1} (6.64 kg pit^{-1})	55.33 q ha^{-1} (2.21 kg pit^{-1}) - Basal 53.33 q ha^{-1} (2.21 kg pit^{-1}) - On 40th Day 53.33 q ha^{-1} (2.21 kg pit^{-1}) - On 70th Day	32.42 q ha^{-1} (1.30 kg pit^{-1})	10.81 q ha^{-1} (0.43 kg pit^{-1}) - Basal 10.81 q ha^{-1} (0.43 kg pit^{-1}) - On 40th Day 10.81 q ha^{-1} (0.43 kg pit^{-1}) - On 70th Day	363.04 kg ha^{-1} (145.20g pit^{-1})	60.51 kg ha^{-1} (24.20 g pit^{-1}) - Basal 60.51+60.51+60.51+60.51+60.51 kg ha^{-1} as 5 splits at fortnightly intervals.
T15	166.0 q ha^{-1} (6.64 kg pit^{-1})	27.67 q ha^{-1} (1.11 kg pit^{-1}) - Basal 27.67+27.67+27.67+27.67+27.67 q ha^{-1} as 5 splits at fortnightly intervals	32.42 q ha^{-1} (1.30 kg pit^{-1})	5.40 q ha^{-1} (0.22 kg pit^{-1}) - Basal 5.40+5.40+5.40+5.40+5.40 as 5 splits at fortnightly intervals	363.04 kg ha^{-1} (145.20g pit^{-1})	60.51 kg ha^{-1} (24.20 g pit^{-1}) - Basal 60.51+60.51+60.51+60.51+60.51 kg ha^{-1} as 5 splits at fortnightly intervals.

Treat-ment	MANURES				FERTILISER (UREA)	
	EXPERIMENT I (FARM YARD MANURE)		EXPERIMENT II	(POULTRY MANURE)		
T16	334.0 q ha^{-1} (13.36 kg pit^{-1})	- Full as basal	65.23 q ha^{-1} (2.61 kg pit^{-1})	- Full as basal	180.43 kg ha^{-1} (72.2 g pit^{-1})	30.07 kg ha^{-1} (12.0 g pit^{-1}) - Basal 30.07+30.07+30.07+30.07+30.07 kg ha^{-1} as 5 splits at fortnightly intervals.
T17	334.0 q ha^{-1} (13.36 kg pit^{-1})	111.33 q ha^{-1} (4.45 kg pit^{-1}) - Basal 111.33 q ha^{-1} (4.45 kg pit^{-1}) - On 40th Day 111.33 q ha^{-1} (4.45 kg pit^{-1}) - On 70th Day	65.23 q ha^{-1} (2.61 kg pit^{-1})	21.74 q ha^{-1} (0.87 kg pit^{-1}) - Basal 21.74 q ha^{-1} (0.87 kg pit^{-1}) - On 40th Day 21.74 q ha^{-1} (0.87 kg pit^{-1}) - On 70th Day	180.43 kg ha^{-1} (72.2 g pit^{-1})	30.07 kg ha^{-1} (12.00 g pit^{-1}) - Basal 30.07+30.07+30.07+30.07+30.07 kg ha^{-1} as 5 splits at fortnightly intervals
T18	334.0 q ha^{-1} (13.36 kg pit^{-1})	55.67 q ha^{-1} (2.23 kg pit^{-1}) - Basal 55.67+55.67+55.67+55.67+55.67 q ha^{-1} as 5 splits at fortnightly intervals	65.23 q ha^{-1} (2.61 kg pit^{-1})	10.87 q ha^{-1} (0.435 kg pit^{-1}) - Basal 10.87+10.87+10.87+10.87+10.87 q ha^{-1} as 5 splits at fortnightly intervals.	180.43 kg ha^{-1} (72.2 g pit^{-1})	30.07 kg ha^{-1} (12.0 g pit^{-1}) - Basal 30.07+30.07+30.07+30.07+30.07 kg ha^{-1} as 5 splits at fortnightly intervals
T19	300.0 q ha^{-1} (12.0 kg pit^{-1})	Full as basal	58.59 q ha^{-1} (2.34 kg pit^{-1})	- Full as basal	326.09 kg ha^{-1} (130.4 g pit^{-1})	54.35 kg ha^{-1} (21.7 g pit^{-1}) - Basal 54.35+54.35+54.35+54.35+54.35 kg ha^{-1} as 5 splits at fortnightly intervals
T20	300.0 q ha^{-1} (12.0 kg pit^{-1})	100.0 q ha^{-1} (4.0 kg pit^{-1}) - Basal 100.0 q ha^{-1} (4.0 kg pit^{-1}) - On 40th Day 100.0 q ha^{-1} (4.0 kg pit^{-1}) - On 70th Day	58.59 q ha^{-1} (2.34 kg pit^{-1})	19.53 q ha^{-1} (0.78 kg pit^{-1}) - Basal 19.53 q ha^{-1} (0.78 kg pit^{-1}) - On 40th Day 19.53 q ha^{-1} (0.78 kg pit^{-1}) - On 70th Day	326.09 kg ha^{-1} (130.4 g pit^{-1})	54.35 kg ha^{-1} (21.7 g pit^{-1}) - Basal 54.35+54.35+54.35+54.35+54.35 kg ha^{-1} as 5 splits at fortnightly intervals
T21	300.0 q ha^{-1} (12.0 kg pit^{-1})	50.0 q ha^{-1} (2.0 kg pit^{-1}) - Basal 50.0+50.0+50.0+50.0+50.0 q ha^{-1}) as 5 splits at fortnightly intervals	58.59 q ha^{-1} (2.34 kg pit^{-1})	9.77 q ha^{-1} (0.39 kg pit^{-1}) - Basal 9.77+9.77+9.77+9.77+9.77 q ha^{-1} as 5 splits at fortnightly intervals	326.09 kg ha^{-1} (130.4g pit^{-1})	54.35 kg ha^{-1} (21.7 g pit^{-1}) - Basal 54.35+54.35+54.35+54.35+54.35 kg ha^{-1} as 5 splits at fortnightly intervals
T22	200.0 q ha^{-1} (8.0 kg pit^{-1})	- Full as basal	39.06 q ha^{-1} (1.56 kg pit^{-1})	- Full as basal	434.78 kg ha^{-1} (173.9g pit^{-1})	72.46 kg ha^{-1} (29.0 g pit^{-1}) - Basal 72.46+72.46+72.46+72.46+72.46 kg ha^{-1} as 5 splits at fortnightly intervals
T23	200.0 q ha^{-1} (8.0 kg pit^{-1})	66.67 q ha^{-1} (2.67 kg pit^{-1}) - Basal 66.67 q ha^{-1} (2.67 kg pit^{-1}) - On 40th Day 66.67 q ha^{-1} (2.67 kg pit^{-1}) - On 70th Day	39.06 q ha^{-1} (1.56 kg pit^{-1})	13.02 q ha^{-1} (0.52 kg pit^{-1}) 13.02 q ha^{-1} (0.52 kg pit^{-1}) 13.02 q ha^{-1} (0.52 kg pit^{-1})	434.78 kg ha^{-1} (173.9 g pit^{-1})	72.46 kg ha^{-1} (29.0 g pit^{-1}) - Basal 72.46+72.46+72.46+72.46+72.46 kg ha^{-1} as 5 splits at fortnightly intervals

Treatment	MANURES: EXPERIMENT I (FARM YARD MANURE)		EXPERIMENT II (POULTRY MANURE)		FERTILISER (UREA)	
T24	200.0 q ha^{-1} (8.0 kg pit^{-1})	33.33 q ha^{-1} (1.33 kg pit^{-1}) - Basal 33.33+33.33+33.33+33.33+33.33 q ha^{-1} as 5 splits at fortnightly intervals	39.06 q ha^{-1} (1.56 kg pit^{-1})	6.51 q ha^{-1} (0.26 kg pit^{-1}) - Basal 6.51+6.51+6.51+6.51+6.51 as 5 splits at fortnightly intervals	434.78 kg ha^{-1} (173.9 g pit^{-1})	72.46 kg ha^{-1} (29.0 g pit^{-1}) - Basal 72.46+72.46+72.46+72.46+72.46 kg ha^{-1} as 5 splits at fortnightly intervals
T25	400.0 q ha^{-1} (16.0 kg pit^{-1})	- Foll as basal	78.13 q ha^{-1} (3.13 kg pit^{-1})	- Full as basal	217.39 kg ha^{-1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5 g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T26	400.0 q ha^{-1} (16.0 kg pit^{-1})	133.33 q ha^{-1} (5.33 kg pit^{-1}) - Basal 133.33 q ha^{-1} (5.33 kg pit^{-1}) - On 40th Day 133.33 q ha^{-1} (5.33 kg pit^{-1}) - On 70th Day	78.13 q ha^{-1} (3.13 kg pit^{-1})	26.04 q ha^{-1} (1.04 kg pit^{-1}) - Basal 26.04 q ha^{-1} (1.04 kg pit^{-1}) - On 40th Day 26.04 q ha^{-1} (1.04 kg pit^{-1}) - On 70th Day	217.39 kg ha^{-1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T27	400.0 q ha^{-1} (16.0 kg pit^{-1})	66.67 q ha^{-1} (2.67 kg pit^{-1}) - Basal 66.67+66.67+66.67+66.67+66.67q ha^{-1} as 5 splits at fortnightly intervals	78.13 q ha^{-1} (3.13 kg pit^{-1})	13.02 q ha^{-1} (0.52 kg pit^{-1}) - Basal 13.02+13.02+13.02+13.02+13.02 q ha^{-1} as 5 splits at fortnightly intervals	217.39 kg ha^{-1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals

* Organic : chemical nitrogen combinations of treatments are as follow

T1	100:100	T4	67:133	T7	133:67	T10	125:125	T13	83:167	T16	167:83	T19	150:150	T22	100:200	T25	200:200
T2	100:100	T5	67:133	T8	133:67	T11	125:125	T14	83:167	T17	167:83	T20	150:150	T23	100:200	T26	200:200
T3	100:100	T6	67:133	T9	133:67	T12	125:125	T15	83:167	T18	167:83	T21	150:150	T24	100:200	T27	200:200

Nitrogen content of farm yard manure - 0.50 per cent   25 kg P_2O_5 ha^{-1} - applied through 125.0 kg Mussoriephos

Nitrogen content of poultry manure - 2.56 per cent   25 kg K_2O ha^{-1} - applied through 41.67 kg Muriate of potash

APPENDIX IIb

Actual quantity of manures and fertilisers applied, their frequency/time of application and ratio of substitution

1996-97

Treatment	MANURES: EXPERIMENT I (FARM YARD MANURE)		MANURES: EXPERIMENT II (POULTRY MANURE)		FERTILISER (UREA)	
T1	192.31q ha^{-1} (7.69 kg pit^{-1}) - Full as basal		38.17 q ha^{-1} (1.53 kg pit^{-1}) - Full as basal		217.39 kg ha^{-1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T2	192.31 q ha^{-1} (7.69 kg pit^{-1})	64.10 q ha^{-1} (2.56 kg pit^{-1}) - Basal 64.10 q ha^{-1} (2.56 kg pit^{-1}) - On 40th Day 64.10 q ha^{-1} (2.56 kg pit^{-1}) - On 70th Day	38.17 q ha^{-1} (1.53 kg pit^{-1})	12.72 q ha^{-1} (0.51 kg pit^{-1} - Basal 12.72 q ha^{-1} (0.51 kg pit^{-1} - On 40th Day 12.72 q ha^{-1} (0.51 kg pit^{-1}) - On 70th Day	217.39 kg ha^{1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5 g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T3	192.31 q ha^{-1} (7.69 kg pit^{-1})	32.05 q ha^{-1} (1.28 kg pit^{-1}) - Basal 32.05+32.05+32.05+32.05+32.05 q ha^{-1} as 5 splits at fortnightly intervals	38.17 q ha^{-1} (1.53 kg pit^{-1})	6.36 q ha^{-1} (0.26 kg pit^{-1}) - Basal 6.36+6.36+6.36+6.36+6.36 q ha^{-1} as 5 splits at fortnightly intervals	217.39 kg ha^{-1} (87.0 g pit^{-1}	36.23 kg ha^{-1} (14.5 g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T4	128.85 q ha^{-1} (5.15 kg pit^{-1})	Full as basal	25.57 q ha^{-1} (1.02 kg pit^{-1})	Full as basal	289.13 kg ha^{-1} (115.7 g pit^{-1})	48.19 kg ha^{-1} (19.3 g pit^{-1} - Basal 48.19+48.19+48.19+48.19+48.19 kg ha^{-1} as 5 splits at fortnightly intervals
T5	128.85 q ha^{-1} (5.15 kg pit^{-1})	42.95 q ha^{-1} (1.72 kg pit^{-1}) - Basal 42.95 q ha^{-1} (1.79 kg pit^{-1}) - On 40th Day 42.95 q ha^{-1} (1.79 kg pit^{-1}) - On 70th Day	25.57 q ha^{-1} (1.05 kg pit^{-1})	8.52 q ha^{-1} (0.34 kg pit^{-1}) - Basal 8.52 q ha^{-1} (0.34 kg pit^{-1}) - On 40th Day 8.52 q ha^{-1} (0.34 kg pit^{-1}) - On 70th Day	289.13 kg ha^{-1} (115.7 g pit^{-1})	48.19 kg ha^{-1} (19.3 g pit^{-1}) - Basal 48.19+48.19+48.19+48.19+48.19 kg ha^{-1} as 5 splits at fortnightly intervals
T6	128.85 q ha^{-1} (5.15 kg pit^{-1})	21.48 q ha^{-1} (0.86 kg pit^{-1}) - Basal 21.48+21.48+21.48+21.48+21.48 q ha^{-1} as 5 splits at fornightly intervals	25.57 q ha^{-1} (1.02 kg pit^{-1})	4.26 q ha^{-1} (0.17 kg pit^{-1}) - Basal 4.26+4.26+4.26+4.26+4.26 q ha^{-1} as 5 splits at fortnightly intervals	289.13 kg ha^{-1} (115.7 g pit^{-1})	48.19 kg ha^{-1} (19.3 g pit^{-1}) - Basal 48.19+48.19+48.19+48.19+48.19 kg ha^{-1} as 5 splits at fortnightly intervals
T7	255.77 q ha^{-1} (10.23 kg pit^{-1})	Full as basal	50.76 q ha^{-1} (2.03 kg pit^{-1})	Full as basal	145.65 kg ha^{-1} (58.3 g pit^{-1})	24.28 kg ha^{-1} (9.7 g pit^{-1}) - Basal 24.28+24.28+24.28+24.28+24.28 kg ha^{-1} as 5 splits at fornightly intervals

Treatment	MANURES: EXPERIMENT I (FARM YARD MANURE)		MANURES: EXPERIMENT II (POULTRY MANURE)		FERTILISER (UREA)	
T8	255.77 q ha^{-1} (10.23 kg pit^{-1})	85.26 q ha^{-1} (3.41 kg pit^{-1}) - Basal 85.26 q ha^{-1} (3.41 kg pit^{-1}) - On 40th Day 85.26 q ha^{-1} (3.41 kg pit^{-1}) - On 70th Day	50.76 q ha^{-1} (2.08) kg pit^{-1})	16.92 q ha^{-1} (0.68 kg pit^{-1}) - Basal 16.92 q ha^{-1} (0.68 kg pit^{-1}) - On 40th Day 16.92 q ha^{-1} (0.68 kg pit^{-1}) - On 70th Day	145.65 kg ha^{-1} (58.3 g pit^{-1})	24.28 kg ha^{-1} (9.7 g pit^{-1}) - Basal 24.28+24.28+24.28+24.28+24.28 kg ha^{-1} as 5 splits at fortnightly intervals
T9	255.77 q ha^{-1} (10.23 kg pit^{-1})	42.63 q ha^{-1} (1.71 kg pit^{-1}) - Basal 42.63+42.63+42.63+42.63+42.63 q ha^{-1} as 5 splits at fortnightly intervals	50.76 q ha^{-1} (2.03 kg pit^{-1})	8.46 q ha^{-1} (0.34 kg pit^{-1}) - Basal 8.46+8.46+8.46+8.46+8.46 q ha^{-1} as 5 splits at fortnightly intervals	145.65 kg ha^{-1} (58.3 g pit^{-1})	24.28 kg ha^{-1} (9.7 g pit^{-1}) - Basal 24.28+24.28+24.28+24.28+24.28 kg ha^{-1} as 5 splits at fortnightly intervals
T10	240.38q ha^{-1} (9.62kg pit^{-1})	Full as basal	47.71 q ha^{-1} (1.91 kg pit^{-1})	Full as basal	271.74 kg ha^{-1} (108.7 g pit^{-1})	45.29 kg ha^{-1} (18.10 g pit^{-1}) - Basal 45.29+45.29+45.29+45.29+45.29 kg ha^{-1} as 5 splits at fortnightly intervals
T11	240.38 q ha^{-1} (9.62 kg pit^{-1})	80.13 q ha^{-1} (3.21 kg pit^{-1}) - Basal 80.13 q ha^{-1} (3.21 kg pit^{-1}) - On 40th Day 80.13 q ha^{-1} (3.21 kg pit^{-1}) - On 70th Day	47.71 q ha^{-1} (1.91 kg pit^{-1})	15.90 q ha^{-1} (0.64 kg pit^{-1}) - Basal 15.90 q ha^{-1} (0.64 kg pit^{-1} - On 40th day 15.90 q ha^{-1} (0.64 kg pit^{-1}) - On 70th day	271.74 kg ha^{-1} (108.7 g pit^{-1})	45.29 kg ha^{-1} (18.10 g pit^{-1}) - Basal 45.29+45.29+45.29+45.29+45.29 kg ha^{-1} as 5 splits at fortnightly intervals
T12	240.38 q ha^{-1} (9.62 kg pit^{-1})	40.06 q ha^{-1} (1.60 kg pit^{-1}) - Basal 40.06+40.06+40.06+40.06+40.06 q ha^{-1} as 5 splits at fortnightly intervals	47.71 q ha^{-1} (1.91 kg pit^{-1})	7.95 q ha^{-1} (0.32 kg pit^{-1}) - Basal 7.95+7.95+7.95+7.95+7.95 q ha^{-1} as 5 splits at fortnightly intervals	271.74 kg ha^{-1} (108.7 g pit^{-1})	45.29 kg ha^{-1} (18.10 g pit^{-1}) - Basal 45.29+45.29+45.29+45.29+45.29 kg ha^{-1} as 5 splits at fortnightly intervals.
T13	159.62 q ha^{-1} (6.38 kg pit^{-1})	Full as basal	31.68 q ha^{-1} (1.27 kg pit^{-1})	Full as basal	363.04 kg ha^{-1} (145.20g pit^{-1})	60.51 kg ha^{-1} (24.20 g pit^{-1}) - Basal 60.51+60.51+60.51+60.51+60.51 kg ha^{-1} as 5 splits at fortnightly intervals
T14	159.62 q ha^{-1} (6.38 kg pit^{-1})	53.21 q ha^{-1} (2.13 kg pit^{-1}) - Basal 53.21 q ha^{-1} (2.13 kg pit^{-1}) - On 40th Day 53.21 q ha^{-1} (2.13 kg pit^{-1}) - On 70th Day	31.68 q ha^{-1} (1.27 kg pit^{-1})	10.56 q ha^{-1} (0.42 kg pit^{-1}) - Basal 10.56 q ha^{-1} (0.42 kg pit^{-1}) - On 40th Day 10.56 q ha^{-1} (0.42 kg pit^{-1}) - On 70th Day	363.04 kg ha^{-1} (145.20g pit^{-1})	60.51 kg ha^{-1} (24.20 g pit^{-1}) - Basal 60.51+60.51+60.51+60.51+60.51 kg ha^{-1} as 5 splits at fortnightly intervals.
T15	159.62 q ha^{-1} (6.38 kg pit^{-1})	26.60 q ha^{-1} (1.06 kg pit^{-1}) - Basal 26.60+26.60+26.60+26.60+26.60 q ha^{-1} as a splits at fortnightly intervals	31.68 q ha^{-1} (1.27 kg pit^{-1})	5.28 q ha^{-1} (0.21 kg pit^{-1}) - Basal 5.28+5.28+5.28+5.28+5.28 q ha^{-1} as 5 splits at fortnightly intervals	363.04 kg ha^{-1} (145.20g pit^{-1})	60.51 kg ha^{-1} (24.20 g pit^{-1}) - Basal 60.51+60.51+60.51+60.51+60.51 kg ha^{-1} as 5 splits at fortnightly intervals.

Treatment	MANURES: EXPERIMENT I (FARM YARD MANURE)		MANURES: EXPERIMENT II (POULTRY MANURE)		FERTILISER (UREA)	
T16	321.15 q ha^{-1} (12.85 kg pit^{-1})	- Full as basal	63.74 q ha^{-1} (2.55 kg pit^{-1})	- Full as basal	180.43 kg ha^{-1} (72.2 g pit^{-1})	30.07 kg ha^{-1} (12.0 g pit^{-1}) - Basal 30.07+30.07+30.07+30.07+30.07 kg ha^{-1} as 5 splits at fortnightly intervals.
T17	321.15 q ha^{-1} (12.85 kg pit^{-1})	107.05 q ha^{-1} (4.28 kg pit^{-1}) - Basal 107.05 q ha^{-1} (4.28 kg pit^{-1}) - On 40th Day 107.05 q ha^{-1} (4.28 kg pit^{-1}) - On 70th Day	63.74 q ha^{-1} (2.55 kg pit^{-1})	21.25 q ha^{-1} (0.85 kg pit^{-1}) - Basal 21.25 q ha^{-1} (0.85 kg pit^{-1}) - On 40th Day 21.25 q ha^{-1} (0.85 kg pit^{-1}) - On 70th Day	180.43 kg ha^{-1} (72.2 g pit^{-1})	30.07 kg ha^{-1} (12.0 g pit^{-1}) - Basal 30.07+30.07+30.07+30.07+30.07 kg ha^{-1} as 5 splits at fortnightly intervals
T18	321.15 q ha^{-1} (12.85 kg pit^{-1})	53.53 q ha^{-1} (2.14 kg pit^{-1}) - Basal 53.53+53.53+53.53+53.53+53.53 q ha^{-1} as 5 splits at fortnightly intervals	63.74 q ha^{-1} (2.55 kg pit^{-1})	10.62 q ha^{-1} (0.43 kg pit^{-1}) - Basal 10.62+10.62+10.62+10.62+10.62 q ha^{-1} as 5 splits at fortnightly intervals.	180.43 kg ha^{-1} (72.2 g pit^{-1})	30.07 kg ha^{-1} (12.0 g pit^{-1}) - Basal 30.07+30.07+30.07+30.07+30.07 kg ha^{-1} as 5 splits at fortnightly intervals
T19	288.46 q ha^{-1} (11.54 kg pit^{-1})	Full as basal	57.25 q ha^{-1} (2.29 kg pit^{-1})	- Full as basal	326.09 kg ha^{-1} (130.4 g pit^{-1})	54.35 kg ha^{-1} (21.7 g pit^{-1}) - Basal 54.35+54.35+54.35+54.35+54.35 kg ha^{-1} as 5 splits at fortnightly intervals
T20	288.46q ha^{-1} (11.54 kg pit^{-1})	96.15 q ha^{-1} (3.85 kg pit^{-1}) - Basal 96.15 q ha^{-1} (3.85 kg pit^{-1}) - On 40th Day 96.15 q ha^{-1} (3.85 kg pit^{-1}) - On 70th Day	57.25 q ha^{-1} (2.29 kg pit^{-1})	19.08 q ha^{-1} (0.76 kg pit^{-1}) - Basal 19.08 q ha^{-1} (0.76 kg pit^{-1}) - On 40th Day 19.08 q ha^{-1} (0.76 kg pit^{-1}) - On 70th Day	326.09 kg ha^{-1} (130.4 g pit^{-1})	54.35 kg ha^{-1} (21.7 g pit^{-1}) - Basal 54.35+54.35+54.35+54.35+54.35 kg ha^{-1} as 5 splits at fortnightly intervals
T21	288.46 q ha^{-1} (11.54 kg pit^{-1})	48.08 q ha^{-1} (1.92 kg pit^{-1}) - Basal 58.08+48.08+48.08+48.08+48.08 qha^{-1} as 5 splits at fortnightly intervals	57.25 q ha^{-1} (2.29 kg pit^{-1})	9.54 q ha^{-1} (0.38 kg pit^{-1}) - Basal 9.54+9.54+9.54+9.54+9.54 q ha^{-1} as 5 splits at fortnightly intervals	326.09 kg ha^{-1} (130.4g pit^{-1})	54.35 kg ha^{-1} (21.7 g pit^{-1}) - Basal 54.35+54.35+54.35+54.35+54.35 kg ha^{-1} as 5 splits at fortnightly intervals

Treatment	MANURES				FERTILISER (UREA)	
	EXPERIMENT I (FARM YARD MANURE)		EXPERIMENT II (POULTRY MANURE)			
T22	192.31 q ha^{-1} (7.69 kg pit^{-1})	- Full as basal	38.17 q ha^{-1} (1.53 kg pit^{-1})	- Full as basal	434.78 kg ha^{-1} (173.9g pit^{-1})	72.46 kg ha^{-1} (29.0 g pit^{-1}) - Basal 72.46+72.46+72.46+72.46+72.46 kg ha^{-1} as 5 splits at fortnightly intervals
T23	192.31 q ha^{-1} (7.69 kg pit^{-1})	64.10 q ha^{-1} (2.56 kg pit^{-1}) - Basal 64.10 q ha^{-1} (2.56 kg pit^{-1}) - On 40th Day 64.10 q ha^{-1} (2.56 kg pit^{-1}) - On 70th Day	38.17 q ha^{-1} (1.53 kg pit^{-1})	12.72 q ha^{-1} (0.51 kg pit^{-1}) - Basal 12.72 q ha^{-1} (0.51 kg pit^{-1}) - On 40th Day 12.72 q ha^{-1} (0.51 kg pit^{-1}) - On 70th Day	434.78 kg ha^{-1} (173.9 g pit^{-1})	72.46 kg ha^{-1} (29.0 g pit^{-1}) - Basal 72.46+72.46+72.46+72.46+72.46 kg ha^{-1} as 5 splits at fortnightly intervals
T24	192.31 q ha^{-1} (7.69 kg pit^{-1})	32.05 q ha^{-1} (1.28 kg pit^{-1}) - Basal 32.05+32.05+32.05+32.05+32.05 q ha^{-1} as 5 splits at fortnightly intervals	38.17 q ha^{-1} (1.53 kg pit^{-1})	6.36 q ha^{-1} (0.26 kg pit^{-1}) - Basal 6.36+6.36+6.36+6.36+6.36 q ha^{-1} as 5 splits at fortnightly intervals	434.78 kg ha^{-1} (173.9 g pit^{-1})	72.46 kg ha^{-1} (29.0 g pit^{-1}) - Basal 72.46+72.46+72.46+72.46+72.46 kg ha^{-1} as 5 splits at fortnightly intervals

Treatment	MANURES: EXPERIMENT I (FARM YARD MANURE)		MANURES: EXPERIMENT II (POULTRY MANURE)		FERTILISER (UREA)	
T25	382.62 q ha^{-1} (15.38 kg pit^{-1})	- Full as basal	76.34 q ha^{-1} (3.05 kg pit^{-1})	- Full basal	217.39 kg ha^{-1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5 g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T26	382.62 q ha^{-1} (15.38 kg pit^{-1})	128.21 q ha^{-1} (5.13 kg pit^{-1}) - Basal 128.21 q ha^{-1} (5.13 kg pit^{-1}) - On 40th Day 128.21 q ha^{-1} (5.13 kg pit^{-1}) - On 70th Day	76.34 q ha^{-1} (3.05 kg pit^{-1})	25.45 q ha^{-1} (1.02 kg pit^{-1}) - Basal 25.45 q ha^{-1} (1.02 kg pit^{-1}) - On 40th Day 25.45 q ha^{-1} (1.02 kg pit^{-1}) - On 70th Day	217.39 kg ha^{-1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals
T27	382.62 q ha^{-1} (15.38 kg pit^{-1})	64.10 q ha^{-1} (2.56 kg pit^{-1}) - Basal 64.10+64.10+64.10+64.10+64.10q ha^{-1} as 5 splits at fortnightly intervals	76.34 q ha^{-1} (3.05 kg pit^{-1})	12.72 q ha^{-1} (0.51 kg pit^{-1}) - Basal 12.72+12.72+12.72+12.72+12.72 q ha^{-1} as 5 splits at fortnightly intervals	217.39 kg ha^{-1} (87.0 g pit^{-1})	36.23 kg ha^{-1} (14.5g pit^{-1}) - Basal 36.23+36.23+36.23+36.23+36.23 kg ha^{-1} as 5 splits at fortnightly intervals

* Organic : chemical nitrogen combinations of treatments are as follow

T1	100:100	T4	67:133	T7	133:67	T10	125:125	T13	83:167	T16	167:83	T19	150:150	T22	100:200	T25	200:200
T2	100:100	T5	67:133	T8	133:67	T11	125:125	T14	83:167	T17	167:83	T20	150:150	T23	100:200	T26	200:200
T3	100:100	T6	67:133	T9	133:67	T12	125:125	T15	83:167	T18	167:83	T21	150:150	T24	100:200	T27	200:200

Nitrogen content of farm yard manure - 0.52 per cent   25 kg P_2O_5 ha^{-1} - applied through 125.0 kg Mussoriephos

Nitrogen content of poultry manure - 2.62 per cent   25 kg K_2O ha^{-1} - applied through 41.67 kg Muriate of potash

APPENDIX III

Basic data used for calculating the cost of cultivation of crop ha^{-1} and working out the net returns in rupees and B/C ratio

A. Inputs

a. **Cost of labour**

1. Man labourer @ Rs.100.23 day^{-1}
2. Women labourer @ Rs.100.23 day^{-1}

b. **Cost of manures and fertilisers**

1.	Cost of farm yard manure	- Rs.340 t^{-1} (fresh) or Rs.680 t^{-1} (dry)
2.	Cost of poultry manure	- Rs.1.25 kg^{-1}
3.	Cost of urea	- Rs.4.80 kg^{-1}
4.	Cost of mussoriephos	- Rs.1.75 kg^{-1}
5.	Cost of muriate of potash	- Rs.4.40 kg^{-1}

c. **Cost of seeds**

Cost of bitter gourd seeds - Rs.650 kg^{-1}

d. **Other inputs**

1.	Choodi coir for pandal making	- Rs.20 kg^{-1}
2.	Galvanised iron wire for pandal making	- Rs.32.5 kg^{-1}
3.	Wooden poles for pandal making	
	(a) Heavy poles	- @ Rs. 70 per pole
	(b) Medium lean poles	- @ Rs. 20 per pole

B. Output

Fruits - Rs. 9 kg^{-1}

APPENDIX IV

TOTAL COST OF CULTIVATION* (Rs. ha^{-1})

Treatment	EXPERIMENT I	EXPERIEMNT II
T1	48508.00	39783.00
T2	50011.45	41286.45
T3	56025.25	47300.25
T4	44368.00	38537.25
T5	45871.45	40040.70
T6	51885.25	46054.50
T7	52648.00	41028.75
T8	54151.45	42532.20
T9	60165.25	48546.00
T10	52172.00	41265.75
T11	53675,00	42769.20
T12	59689.25	48783.00
T13	46892.00	39635.25
T14	48395.45	41138.70
T15	54409.25	47152.50
T16	57440.00	42853.00
T17	58943.45	44356.45
T18	64957.25	50370.25
T19	55824.00	42736.50
T20	57327.45	44239.95
T21	63341.25	50253.75
T22	49552.00	40827.00
T23	51055.45	42330.45
T24	57069.25	48344.25
T25	62108.00	44626.75
T26	63611.45	46130.20
T27	69625.25	52144.00

* Inclusive of treatment cost

APPENDIX V

ENERGY EQUIVALENTS (MJ)

Name	Energy equivalent per unit of input or output (MJ)
A. Input	
1. Bitter gourd seeds	0.8 MJ per kg of harvested produce (32 MJ per kg of seed)
2. Farm yard manure	0.3 MJ per kg of dry matter
3. Poultry manure	60.60 MJ per kg of nitrogen content
4. Urea	60.60 MJ per kg of nitrogen content
5. Plant protection chemicals	
a. Fungicides	120 MJ per kg.
b. Insecticides	120 MJ per kg or litre
6. Mussoriephos	11.1 MJ per kg of P_2O_5 content
7. Muriate of potash	6.7 MJ per kg of K_2O content
8. Labour	
a. Man	15.68 MJ per man day
b. Women	12.56 MJ per women day
B. Output	
1. Plant biomass	10.00 MJ kg^{-1} of drymatter
2. Fruits	0.8 MJ kg^{-1} of harvested mass

APPENDIX VI

TOTAL ENERGY - INPUT* (MJ ha^{-1})

	1995-'96		1996-'97	
Treat-ment	Experiment I	Experiment II	Experiment I	Experiment II
T1	14885.96	15665.96	14798.36	15665.96
T2	15121.16	15901.16	15033.56	15901.16
T3	16061.96	16841.96	15974.36	16841.96
T4	15143.36	15665.96	15084.86	15665.96
T5	15378.56	15901.16	15320.06	15901.16
T6	16319.36	16841.96	16260.86	16841.96
T7	14628.56	15665.96	14511.86	15665.96
T8	14863.76	15901.16	14747.06	15901.16
T9	15804.56	16841.96	15687.86	16841.96
T10	17720.96	18695.96	17611.16	18695.96
T11	17956.16	18931.16	17846.36	18931.16
T12	18896.96	19871.96	18787.16	19871.96
T13	18048.56	18695.96	17975.96	18695.96
T14	18283.76	18931.16	18211.16	18931.16
T15	19224.56	19871.96	19151.96	19871.96
T16	17393.36	18695.96	17246.96	18695.96
T17	17628.56	18931.16	17482.16	18931.16
T18	18569.36	19871.96	18422.96	19871.96
T19	20555.96	21725.96	20424.26	21725.96
T20	20791.16	21961.16	20659.46	21961.16
T21	21731.96	22901.96	21600.26	22901.96
T22	20945.96	21725.96	20858.36	21725.96
T23	21181.16	21961.16	21093.56	21961.16
T24	22121.96	22901.96	22034.36	22901.96
T25	20165.96	21725.96	19936.76	21725.96
T26	20401.16	21961.16	20171.96	21961.16
T27	21341.96	22901.96	21112.76	22901.96

* Treatment inputs + Non treatment inputs

APPENDIX VIIa

Amount of Nitrogen added during cropping period (kg ha^{-1})

	1995-'96		1996-'97	
Treatment	Experiment I	Experiment II	Experiment I	Experiment II
T1	200	200	200	200
T2	200	200	200	200
T3	200	200	200	200
T4	200	200	200	200
T5	200	200	200	200
T6	200	200	200	200
T7	200	200	200	200
T8	200	200	200	200
T9	200	200	200	200
T10	250	250	250	250
T11	250	250	250	250
T12	250	250	250	250
T13	250	250	250	250
T14	250	250	250	250
T15	250	250	250	250
T16	250	250	250	250
T17	250	250	250	250
T18	250	250	250	250
T19	300	300	300	300
T20	300	300	300	300
T21	300	300	300	300
T22	300	300	300	300
T23	300	300	300	300
T24	300	300	300	300
T25	300	300	300	300
T26	300	300	300	300
T27	300	300	300	300

APPENDIX VIIb

Amount of P_2O_5 added during cropping period (kg ha^{-1})

	1995-'96		1996-'97	
Treat- ment	Experiment I	Experiment II	Experiment I	Experiment II
T1	85.00	107.03	88.46	107.83
T2	85.00	107.03	88.46	107.83
T3	85.00	107.03	88.46	107.83
T4	65.20	79.96	67.52	80.49
T5	65.20	79.96	67.52	80.49
T6	65.20	79.96	67.52	80.49
T7	104.80	134.10	109.40	135.15
T8	104.80	134.10	109.40	135.15
T9	104.80	134.10	109.40	135.15
T10	100.00	127.54	104.33	128.53
T11	100.00	127.54	104.33	128.53
T12	100.00	127.54	104.33	128.53
T13	74.80	93.08	77.67	93.75
T14	74.80	93.08	77.67	93.75
T15	74.80	93.08	77.67	93.75
T16	125.20	161.98	130.98	163.32
T17	125.20	161.98	130.98	163.32
T18	125.20	161.98	130.98	163.32
T19	115.00	148.04	120.19	149.23
T20	115.00	148.04	120.19	149.23
T21	115.00	148.04	120.19	149.23
T22	85.00	107.03	88.46	107.83
T23	85.00	107.03	88.46	107.83
T24	85.00	107.03	88.46	107.83
T25	145.00	189.07	151.26	190.66
T26	145.00	189.07	151.26	190.66
T27	145.00	189.07	151.26	190.66

APPENDIX VIIc

Amount of K_2O added during cropping period (kg ha^{-1})

	1995-'96		1996-'97	
Treat-ment	Experiment I	Experiment II	Experiment I	Experiment II
T1	125	83.59	121.16	76.53
T2	125	83.59	121.16	76.53
T3	125	83.59	121.16	76.53
T4	92	64.26	89.43	59.52
T5	92	64.26	89.43	59.52
T6	92	64.26	89.43	59.52
T7	158	102.93	152.89	93.53
T8	158	102.93	152.89	93.53
T9	158	102.93	152.89	93.53
T10	150	98.25	145.19	89.41
T11	150	98.25	145.19	89.41
T12	150	98.25	145.19	89.41
T13	108	73.63	104.81	67.77
T14	108	76.63	104.81	67.77
T15	108	73.63	104.81	67.77
T16	192	122.85	185.58	111.05
T17	192	122.85	185.58	111.05
T18	192	122.85	185.58	111.05
T19	175	112.89	169.23	102.29
T20	175	112.89	169.23	102.29
T21	175	112.89	169.23	102.29
T22	125	83.59	121.16	76.53
T23	125	83.59	121.16	76.53
T24	125	83.59	121.16	76.53
T25	225	142.20	216.31	128.06
T26	225	142.20	216.31	128.06
T27	225	142.20	216.31	128.06

STANDARDISATION OF ORGANIC AND INORGANIC FERTILISER COMBINATIONS FOR MAXIMISING PRODUCTIVITY IN BITTER GOURD (*Momordica charantia* L.)

BY

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ABSTRACT OF A THESIS
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COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

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ABSTRACT

An investigation was carried out during 1995-96 and 1996-97 at the Instructional Farm attached to College of Agriculture, Vellayani to study the efficacy of different levels of N applications (200, 250 and 300 kg N ha^{-1}) in different ratios of organic - chemical N substitutions (1:1, 1:2 or 2:1) at different frequencies (F_1 - full quantity of organic source as basal, F_2 - organic source at basal and at 40th and 70th DAS, F_3 - organic source as basal + fortnightly equal splits and chemical N source as basal + fortnightly intervals in equal splits in all the frequencies) of application. Two different organic sources ie. farm yard manure and poultry manure were used in two simultaneous experiments viz. Experiment I and II. The experiments were separately and simultaneously laid out as confounded 3^3 design in 9 plot blocks with 2 replications, confounding LR^2F in RI and LRF^2 in R II.

Higher levels of N nutrition was found to reduce days taken to flower in farm yard manure applied trial while sex ratio was narrowed at 90 DAS in poultry manure applied experiment. Higher jassid population was noticed at 60 DAS when higher levels of N was supplied predominantly through organic source as farm yard manure. Fungal leaf spot infestation was higher with the application of 200 kg N at 90 DAS and was also more with split applications of both farm yard manure and chemical N source at early stages of growth.

Full basal application of poultry manure was found to promote the per hectare yield of fruits, fruit yield $plant^{-1}$ and number of fruits $plant^{-1}$ compared to its split applications. When highest level of N (300 kg) was supplied through 2:1 ratio of organic - chemical N substitution using poultry manure as organic source, it effectively increased the fruit yield and number of fruits $plant^{-1}$.

Shelf life of fruits at room temperature was more when nutrient N was supplied through 2:1 ratio of organic - chemical N substitution using farm yard manure or poultry manure as an organic source. When N level was increased beyond 200 kg, shelf life of fruits at room temperature slightly decreased even when it was predominantly supplied through organic source of farm yard manure or poultry manure. Similar trend was noticed at refrigeratory condition too.

Nitrogen nutrition showed depressing effect on ascorbic acid or vitamin-C content of fruits in Experiment I. Iron content in fruits was more with the application of 200 or 300 kg N level in Experiment II. When 300 kg N was applied through a major source of poultry manure (2:1 ratio) it produced higher iron content in fruits.

Higher nitrogen levels or nitrogen nutrition through 2:1 ratio of substitution promoted the soil bacterial population in both Experiment I and II. Full basal application of farm yard manure or poultry manure favourably influenced the soil bacterial population. Nitrogen nutrition showed depressing effect on fungal population of soil in Experiment I while it stimulated the fungal growth in Experiment II. Soil actinomycetes population was higher with 2:1 substitution ratio using farm yard manure as organic source of N.

When farm yard manure or poultry manure as organic source was used in equal or higher proportion with chemical N source, it showed moderating effect on the soil acidity. Full basal application of farm yard manure also enhanced the soil pH from the acidic range and the organic carbon content.

Application of higher levels of N increased the net loss of N, P and K of soil in both the Experiment I and II. Net loss of N was higher with 1:2 ratio of N substitution or few or more split applications of organic source (farm yard manure) in Experiment I. Net loss of nutrients was moderated during the second year of field experimentation. Nitrogen nutrition in 1:2 ratio of substitution enhanced the net loss of N in Experiment II. Nitrogen nutrition through 2:1 ratio of N substitution or basal + 2 split doses of farm yard manure increased the net loss of P in soil. The net loss of K in soil was more when farm yard manure and chemical N sources were applied in 2:1 or 1:1 ratio of substitution. Net gain of K was observed in Experiment II, when chemical N source was substituted in higher proportion compared to poultry manure or when full dose of poultry manure was applied as basal dressing.

Higher levels of N application have resulted in negative net energy returns or energy loss in both the experiments. The 1:1 or 1:2 ratio of N substitution caused higher net energy losses in Experiment I while split applications of poultry manure resulted in more energy loss in Experiment II. Total energy output was higher with full basal application of poultry manure in Experiment I. Energy ratios registered a negative value and was higher with low level of N application in Experiment I and II.

Higher gross returns were obtained when full quantity of poultry manure was applied as basal dose in Experiment II. Application of 300 kg N through 2 : 1 ratio of organic - chemical N substitution registered higher gross returns in Experiment II. Net returns was higher when 200 kg N ha^{-1} was applied. Increasing N level beyond 200 kg was not economic in Experiment I using farm yard manure as organic source. When full quantity of poultry manure was applied completely as basal dose, higher net returns was obtained in Experiment II. Benefit-cost ratio decreased when N level was enhanced beyond 200 kg ha^{-1} in Experiment I. Higher benefit - cost ratio was recorded when poultry manure was applied in full dose as basal dressing.

Study revealed the favourable influence of organic sources; farm yard manure and poultry manure on fruit quality, shelf life and soil properties. The suitability of poultry manure as organic source for vegetable cultivation was also established by this study.