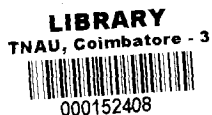


**STUDIES ON THE DIRECT AND RESIDUAL EFFECT OF
NON-CONVENTIONAL GREEN LEAF MANURES WITH N FOR
RICE - RICE CROPPING SYSTEM**

Thesis submitted in part fulfilment of the requirements for the award of the degree
of *Doctor of Philosophy (Agriculture) in Agronomy* to the
Tamil Nadu Agricultural University, Coimbatore

By

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1996

CERTIFICATE

This is to certify that the thesis entitled " **STUDIES ON THE DIRECT AND RESIDUAL EFFECT OF NON-CONVENTIONAL GREEN LEAF MANURES WITH N FOR RICE - RICE CROPPING SYSTEM**" submitted in part fulfilment of the requirements for the award of the degree of **Doctor of Philosophy (Agriculture)** in Agronomy to the Tamil Nadu Agricultural University, Coimbatore, is a record of bonafide research work carried out by **Mrs. V. Geethalakshmi** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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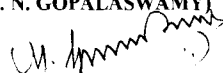
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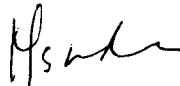
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ABSTRACT

STUDIES ON THE DIRECT AND RESIDUAL EFFECT OF NON-CONVENTIONAL GREEN LEAF MANURES WITH N FOR RICE - RICE CROPPING SYSTEM

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Investigations were carried out at Tamil Nadu Agricultural University, Coimbatore from June, 1993 to February, 1995 to evaluate the direct and residual effects of non-conventional green leaf manures applied with varying levels of N for lowland rice - rice cropping system in comparison with conventional green leaf manuring.

Experiment was laid out in split plot design, replicated thrice during Kharif season to study the direct effect of applied green leaf manures and different levels of N and in split-split plot design during Rabi season to study the residual effect of green leaf manures and applied N to Kharif rice. During Kharif season four non-conventional green leaf manures Viz., *Ipomoea reptans*, *Eichhornia crassipes*, *Calotropis gigantea* and *Leucaena leucocephala* were compared against the conventional green manure, *Sesbania aculeata* in addition to one control (no green leaf manure application). Four levels of N (0, 40, 80 and 120 kg N ha⁻¹) were also included along with different green leaf manures as treatments. During Rabi season, each sub plot of Kharif main treatment was divided into two to accommodate two extra treatments Viz., 0 and 100 kg N ha⁻¹.

This was done to study the residual effect. This cropping system experiment was done for two years i.e., Kharif - Rabi of 1993 - '94 and Kharif - Rabi of 1994 - '95.

Application of green leaf manures enhanced higher $\text{NH}_4\text{-N}$ as well as $\text{NO}_3\text{-N}$ content both during incubation as well as during main field study. *Sesbania aculeata* released $\text{NH}_4\text{-N}$ quickly and the release from *Calotropis gigantea* and *Ipomoea reptans* was little later. Higher N levels (80 and 120 Kg N ha^{-1}) applied to Kharif rice crop showed higher values of $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ over lower level of N (40 kg N ha^{-1}). Combined application of green leaf manures and fertilizer N recorded the highest $\text{NH}_4\text{-N}$ as well as $\text{NO}_3\text{-N}$.

Conjunctive use of *Sesbania aculeata* or *Calotropis gigantea* or *Ipomoea reptans* with 120 kg N ha^{-1} influenced positively the growth components, yield attributes, uptake of nutrients and grain as well as straw yields of rice.

Green leaf manures incorporation increased the Harvest Index (HI), Productivity Score (PS) and Relative Yield Index (RYI), while application of inorganic fertilizer influenced only PS and RYI but not HI.

Agronomic Efficiency (AE), Apparent N Recovery (ANR) and N Harvest Index (NHI) were improved by the application of *Sesbania aculeata* or *Calotropis gigantea* or *Ipomoea reptans*. However, Physiological Efficiency (PE) was not altered. AE, PE and ANR were higher in lower level of N tried (40 kg N ha^{-1}), in contrast, the NHI was the highest with the highest level of N tried (120 kg N ha^{-1}).

Ipomoea reptans, *Leucaena leucocephala* and *Calotropis gigantea* left significantly higher soil available N after the harvest of Kharif rice crop. The increase was 8.86, 8.19 and 7.01 per cent during 1993 and 13.26, 11.83 and 10.83 per cent during

1994 respectively over control. Increasing levels of N had increased the post Kharif harvest soil available N. Computed N balance for Kharif rice was positive when green leaf manure + inorganic fertilizer were combined.

Higher residual effect of *Leucaena leucocephala*, *Calotropis gigantea* and *Ipomoea reptans* applied to Kharif rice on Rabi rice growth attributes was noticed. Levels of N applied to Kharif rice had no effect on Rabi rice growth attributes. Application of 100 kg N ha⁻¹ to Rabi crop alone had increased the growth attributes as compared to no N application to Rabi rice.

Application of *Calotropis gigantea*, *Sesbania aculeata*, *Ipomoea reptans* and *Leucaena leucocephala* in order along with 120 kg N ha⁻¹ applied to Kharif rice significantly influenced the yield attributes of Rabi rice. Levels of N studied on Kharif rice did not have any influence on the yield attributes of Rabi rice. Recommended level of fertilizer application to Rabi crop improved the yield attributes.

N, P and K uptakes in Rabi rice crop were higher in *Ipomoea reptans*, *Leucaena leucocephala*, *Calotropis gigantea* and *Sesbania aculeata* applied plots. Application of 120 kg N ha⁻¹ to Kharif rice also had improved N, P and K uptakes in Rabi rice and this result was comparable with 80 kg N ha⁻¹.

Green leaf manures application to Kharif rice crop increased the Rabi rice grain yield from 12.9 to 78.8 per cent over control. Among them, application of *Leucaena leucocephala*, *Ipomoea reptans*, *Calotropis gigantea* and *Sesbania aculeata* increased the grain yield of Rabi rice. Carry over effect of fertiliser N applied to Kharif rice was absent in Rabi rice. Application of 100 kg N ha⁻¹ to Rabi rice alone significantly influenced the Rabi rice grain yield and produced 124 and 72 per cent increased grain yield during 1993 and 1994 respectively over no N application to Rabi rice.

Green leaf manuring applied to Kharif crop improved the soil fertility status after the harvest of Rabi rice crop also. Incorporation of green leaf manures increased the organic carbon, soil available N, P and K. *Calotropis gigantea*, *Leucaena leucocephala* and *Ipomoea reptans* left more soil N in the cropping system studied. Application of 100 kg N ha⁻¹ to Rabi rice improved the soil available N status but decreased the P and K status in the soil after rice - rice cropping system.

Application of green leaf manures in combination with fertilizer N to Kharif rice and fertilizer N to Rabi rice increased the net return. The BC ratio was the highest when *Ipomoea reptans* + 80 kg N ha⁻¹ were applied to Kharif rice with 100 kg N ha⁻¹ applied to Rabi rice. This treatment was comparable with the BC ratios obtained under *Calotropis gigantea* or *Sesbania aculeata* with the same inorganic fertilizer level to Kharif and Rabi rice.

Considering the productivity, soil fertility and economics, the summary goes to say that

- Application of *Ipomoea reptans*, a non-conventional green leaf manure at the rate of 8 t ha⁻¹ in combination with 80 kg N ha⁻¹ applied to Kharif rice in addition to 100 kg N ha⁻¹ applied to Rabi rice is recommended. This combined treatment had given higher BC ratio and also passed out from the partial budgeting. Further, this treatment had maintained positive soil nutrient balance after rice - rice cropping system.

- In the absence of *Ipomoea reptans*, the best bet alternative non-conventional green leaf manure would be *Calotropis gigantea* at the rate of 6.5 t ha⁻¹ with the same inorganic combination.

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Abbreviations used

AE	Agronomic Efficiency
ANR	Apparent N Recovery
AT	Active Tillering
BC ratio	Benefit - Cost ratio
DME	Dry Matter Efficiency
DMP	Dry Matter Production
g	gram
GLM	Green leaf manure
ha	hectare
HI	Harvest Index
K	Potassium
LAI	Leaf Area Index
Mha	Million hectares
Mt	Million tonnes
N	Nitrogen
NHI	Nitrogen Harvest Index
NS	Not Significant
NUE	Nitrogen Use Efficiency
P	Phosphorus
PE	Physiological Efficiency
PI	Panicle Initiation
PS	Productivity Score
RDME	Relative Dry Matter Efficiency
RYI	Relative Yield Index
Sig	Significant
t	tonnes
yr	year

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INTRODUCTION

CHAPTER 1

INTRODUCTION

Rice being the staple food of Asians, especially for Indians, its cultivation has spread over to 41 Mha with a total production of 75 Mt in India. Thus the productivity computes to 1720 kg ha⁻¹. Demographers fear that Indian population may cross one Billion by 2000 AD. To meet the food demand of the growing population, India has to produce 21 Mt of extra rice from the rice cultivated area of 41 Mha (Sampath, 1990). Unless the gap between production and consumption is so bridged, India has to face a social revolution in the coming years. Hence the immediate task of scientists engaged in crop production is to generate technologies to increase the productivity of rice from the present level, since the rice yield from one hectare could sustain 5.7 persons in a year as against 5.3 for maize and 4.1 for wheat (De Datta, 1981).

Because of the existing *Natural Endowments in India*, with obvious constraints, the rice crop is being cultivated as monocrop under upland situation and as well as in different cropping systems under irrigated condition. Among the rice based cropping systems in India, rice - rice is the most popular lowland cropping system under irrigated condition especially Sundarban delta of West Bengal, Krishna - Gothavari delta of Andra Pradesh, Mahanathi delta of Orissa and Cauvery delta of Tamil Nadu.

Sankaran (1988), during his endowment lecture at Coimbatore opined that 45 per cent of yield advantage from rice comes from introduction of modern technologies over traditional and among them fertilizer is the key point. Between major nutrients, nitrogen is the kingpin, since the masked yield potential of high yielding rice varieties is exploited by its various levels.

In India, 11.6 Mt of plant nutrients are annually applied to crop production and out of this, 40 per cent goes to rice production. Hence the quantity of fertilizer used per hectare of rice had remarkably increased in the last two decades. On the other hand, the fertilizer use efficiency has come down to 8.1 kg grain per kg of applied N in 1988 - '89 from 17.1 kg in 1970 - '71 (Kundu and Pillai, 1992).

Among the identified reasons for this low fertilizer use efficiency, meeting individual crop needs as compared to cropping system approach, practising inorganic fertilizer alone, improper technological adoption etc. are some of the known reasons. Nutrient prescription for individual rice crop is usually being made without any consideration on the system as a whole and as a result, the recommendation becomes uneconomical. Food and Agricultural Organisation has conceptualised the idea of system approach for plant nutrition, whose main concept is the integrated use of available resources of plant nutrients in the cropping system as a whole.

Indian soils are generally low in N. With continuing world energy crisis, the fertilizer cost has increased steadily. In addition with the policy on decontrol, the cost of fertilizer N still goes beyond the reach of farmers. At this context, the N hungry Indian soils can not be met with inorganic fertilizers, especially N fertilizer. Ukita *et al.* (1972) opined that chemical fertilizers are not only costly but also pollutants. The enumerated facts made the farmers with no option except to fully exploit the potential alternative source of plant nutrients atleast to partially substitute the fertiliser N for rice based cropping system so as to maintain the productivity. Through integrated nutrient management, by judicious combination of organic sources especially green manures and green leaf manures with fertilizer has a greater scope to increase the productivity by proper blending. This approach not only sustains soil fertility and productivity but also keeps the environment intact with reduced cost investments (Swaminathan, 1987). However, the practice of green manuring to rice is over looked after 1960s for many known reasons.

Presently green manuring in India is adopted only in a negligible extent due to two dimensions of time and water and non availability of larger quantities of green manure seeds. However, green leaf manuring is practised to second crop of rice in most of the deltaic region with out any scientific rationale. Green leaf manuring to rice has greater scope over green manuring because of its abundance availability in the nature. They don't require any management and also they come up with natural rain. These are all the added advantages of green leaf manures. Among them, the non-conventional green leaf manures like *Calotropis gigantea* and *Ipomoea reptans* come up very well under tropical waste lands with least care. The other green leaf manures like *Ipomoea reptans*, a problematic weed in water ponds and the *Leucaena leucocephala* were not effectively used for green leaf manuring practices. Application of the above non-conventional green leaf manures are not popularised with the farmers due to dearth of research information.

The system approach to research on nutrient management should have goal seeking orientation leading to problem solving, resulting in improved nutrient management practices. Research work on Integrated Nutrient Management in rice based cropping system to develop optimum management strategies has been well studied with green manuring, but not with green leaf manuring especially non-conventional green leaf manuring. In this context, the present research agenda was drawn for study with the following objectives :

- To study the effect of non-conventional green leaf manures application on the growth, yield attributes and yield of rice for a cropping system of rice - rice.
- To study the effect of full and partial substitution of chemical N fertilizer with non-conventional green leaf manures on the growth, yield attributes and yield of rice for a cropping system of rice - rice.

- To observe the N release pattern from full and partial substitution of fertiliser N with non-conventional green leaf manures.
- To study the residual effect of different non-conventional green leaf manures and fertilizer N applied to the previous crop to the succeeding rice crop.
- To study the change in soil fertility under the above practices.
- To evolve an integrated N management practice for rice - rice cropping system based on economics.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Rice is a unique among the major food crops because of its semi aquatic and grows best in a flooded soil. By the year 2020, the earth will be home to eight billion people and 40 per cent of them would be rice consumers. Thus the world's annual rice production must increase by 74 per cent from today's production of 519 Mt (Dedolph, 1993).

Fertilizer N played key role in increasing the yield of rice and response of rice to N was universal (Mc Cure and Strangel, 1982). About 75 per cent of leaf nitrogen was associated with chloroplast, which implied its physiological importance in dry matter production through the function of photosynthesis (Savant and De Datta, 1982). In the storage organs of many crops, the deposition of nitrogen was also closely related to the *sink capacity which inturn affected the potential yield performance (Dreyfus et al., 1985).*

Rice accounts for about 1/3 of the total N consumed in India. Most of the rice soils in the world were deficit in N and in India about 67 per cent of rice soils were estimated to be deficient in N (Mahapatra *et al.*, 1985). Unfortunately, the flooded rice ecosystem provided a picture in which efficiency of rice to utilize the native as well as applied N was very low, seldom exceeding 30-45 per cent (Vlek and Byrnes, 1986). To increase the N use efficiency as well as to keep the soil productivity intact and to certain extent reduce the quantity of N fertilizer used, integrated nutrient management concept has come in to existence (Morris *et al.*, 1987).

Application of split doses at basal and tillering in the presence of green manure increased the N use efficiency (Furoc *et al.*, 1988). Substituting atleast a part of chemical

fertilizer nitrogen with organic and biological sources will keep the ecology sound and help in sustainable agriculture

The research works carried out in India and other countries related to integrated N management through green manures and inorganic fertilizer for rice based cropping system are reviewed in this chapter.

2.1. SOURCES OF NITROGEN SUPPLY

Asia is now the largest and fastest growing market for nitrogen in the world. Among the Asian countries, annual consumption rates of China, India, Pakistan and Indonesia were more than 14 per cent of the fertilizer nitrogen already used (De Datta, 1985). But unless N losses are minimized, most of the potential benefits from increased N fertilizer use may be lost. Recent endeavors of several International Scientific Forums have been focused on this aspect leading to many viable recommendations for efficient use of N in rice soils. One of the promising techniques is the conjunctive use of chemical, organic and biological sources of N. Nitrogen transformation process and N management in low land rice had been adequately summarized in review papers (De Datta and Patrick, 1986 ; Haynes, 1986).

2.1.1. Contribution of soil nitrogen to rice productivity

Applied nitrogen and native nitrogen of the soil are the two important components of rice production system. Many chemical and biological process in the soil influence the availability of nitrogen to low land rice. By using ¹⁵N technique, measuring and accounting for the dynamic changes of mineralization - immobilization process have been made possible. The amount of N mineralized in a soil during the crop growing season varied with soil and environmental conditions and depends on the measurement techniques used. According to Ito and Watanabe (1981), mineralization

could be 5 times greater for biologically fixed N (23.4 per cent mineralized) than for the native soil N (4.6 per cent mineralization).

Mineralisation of organic nitrogen in flooded soils largely depends on the chemical and soil microbial environments. Koyama (1981) and Sahrawat (1983), found that 50 to 75 per cent of N was supplied by the soil to the crop. Keerthisinghe *et al.* (1984;1985), concluded that the exchangeable NH_4^+ and in some soils, the non-exchangeable NH_4^+ were the most important soil N fractions easily available to low land rice at early to mid tillering stages. Moreover organic soil nitrogen might contribute substantially to nitrogen supply at the spikelet filling stage. In soils rich in vermiculite, the non-exchangeable NH_4^+ should also be considered for N fertilizer recommendation to low land rice (Mengel *et al.*, 1986).

In many situations it is found that nitrogen from the soil alone is sufficient for sizable yield. Bouldin (1986), reported that upto 3 t ha^{-1} grain yield had been consistently obtained without N fertilizer, while the same 3 t ha^{-1} grain yield increase was shown in another situation under 100 kg N ha^{-1} using best splits of urea N. Inubushi and Watanabe (1988), reported that 79 to 83 per cent of N in the rice plant at harvest was derived from soil N.

2.1.2. Contribution of organic manures to rice productivity

Increased use of fertilizer in improved varieties with meticulous irrigation program^{mt} are the key factors on the growth of rice production in Asia and elsewhere. Between the first and second halves of the 1970s, average fertilizer consumption grew by 50 per cent in south Asia, 39 per cent in south east Asia and 53 per cent in east Asia (Patnaik, 1978; David and Baliscan, 1981). But such impact hadn't come from organic manures. Organic manures may not replace the chemical fertilizers, but it can supplement / complement the inorganic fertilizers usage (Bin, 1983).

Organic fertilizers especially green manure crops, traditionally important source of nutrient, declined in relative importance with the rapid use of chemical fertilizers. However, interest in the potential for expanded use of green manure had been renewed due to the oil price shocks that resulted in sharp increase in fertilizer price during 1970 s (Rosegrant and Roumasset, 1985).

Concern also has been rising over possible long-term adverse effects of heavy use of chemical fertilizers on soil structure, crop productivity and off-farm pollution. Green manures and other organic fertilizers could maintain and improve soil structure. In sandy soils, increased organic matter improved water retention and reduced the leaching of nutrients. In clay soils, added organic matter could improve soil porosity, reducing water run-off and erosion losses (Repetto, 1986) and could provide a number of micronutrients not available from chemical fertilizers (Rosegrant and Roumasset, 1988; Ishikawa, 1988). Sharma and Mitra (1989), reported 28 per cent yield increase due to green manure application.

2.1.3. Contribution of fertilizer nitrogen to rice productivity

Unlike other cereals, nitrogen is required in large quantities by rice crop to produce one kg of photosynthates. Response of rice to nitrogen in flooded rice soil condition indicated the deficiency / low status of soil nitrogen. Tanaka (1961), stated that under favorable condition of rice cultivation, the uptake of nutrients was rapid during specific stages and therefore, the nutrients must be applied at those stages of maximum requirement to obtain increased grain yield. Ishizuka (1965), observed that uptake of N by rice followed a sigmoidal curve viz., initial lag with subsequent steady progress which leveled off at the end. Vlek *et al.* (1979), noted that application of

fertilizer N between two weeks after transplanting at maximum tillering influenced the grain yield. Yoshida (1981), noted that N utilization efficiency of rice for grain production was about 50 kg per kg of N used in the tropics.

2.2. FERTILIZER NITROGEN

2.2.1. Nitrogen transformation in rice soils

The transformation and availability of N in submerged soil are different from aerobic soil. Flooding the soil resulted in accumulation of $\text{NH}_4\text{-N}$ due to the instability of nitrate, coupled with low N released from organic matter decomposition (Savant and De Datta, 1982; Farroqui *et al.*, 1983). The biological, chemical and physical processes involved in the transformations of N in the flooded soils include

- (i) Mineralisation of organic nitrogen to inorganic compounds through ammonification, nitrification and denitrification.
- (ii) Immobilization of organic and inorganic nitrogen by micro organisms and
- (iii) Clay fixation.

The objective of good N management in rice should be to maximize the N uptake and to minimize the other transformations which compete with the plant for available N besides the transformation processes leading to losses.

2.2.1.1. Ammonification

The inorganic N fractions, more particularly $\text{NH}_4\text{-N}$ contributed an extremely dynamic N system in the soil and was the most influencing factor for rice production. Ammonification, the first step in mineralisation is defined as the biological conversion of organic forms of N into inorganic N, viz., $\text{NH}_4\text{-N}$. It is essentially a catabolism of amino acids and presumably includes several types of deamination reactions.

The ammonification process was affected by several factors including soil temperature, physical treatments like puddling, moisture level, wetting and drying, quality of organic matter in the soil, clay content etc. (Ponnamperuma, 1972). Broadbent (1978), found that the pH had little effect on the rate of ammonification while soil temperature had profound influence (Dei and Yamasaki, 1979; Savant and De Datta, 1982; Sahrawat, 1983; Marion and Black, 1987). Water logging had positively influenced the rate of ammonification as reported by Mahapatra and Khan (1987) and Sannigrahi and Mandel (1987).

2. 2.1.2. Nitrification and denitrification

Rice soil system consists of aerobic and anaerobic micro and macro sites. The aerobic sites constituting both the oxidised surface soil layer and the plant rhizosphere favoured nitrification process. The reduced soil layer lying below the oxidised zone was highly conducive for denitrification (Yoshida and Alexander, 1970). Nitrification, biological oxidation of NH_4 to NO_3 are common in rice soils, lead to the loss of nitrogen. This strict aerobic process occurred in the oxidised surface layer where the oxygen supply was not limited (Broadbent and Tusneem, 1971; Dancer *et al.*, 1973; Watanabe *et al.*, 1981). The nitrate formed in the oxidised layer diffused to anaerobic zone to undergo sequential reduction to NO_3 , NO_2 , N_2O and N_2 (Savant and De Datta, 1982; Mosier *et al.*, 1982).

Reddy *et al.* (1976), reported that nitrification reaction was a slow reaction followed zero order kinetics and was found to be influenced by factors like soil pH, organic matter, temperature, moisture, fertilizer management practices, stage of the rice crop etc. Katyal and Gadalla (1990), reported that besides soil properties regulating nitrification activity, flood water concentration of NH_4^+ -N seemed to play an important role in nitrification and subsequent denitrification.

2.2.1.3. Immobilization

Immobilization of N was caused by microbial fixation where the applied or native inorganic N was converted to an organic form in the soil leading to a decrease in fertilizer N availability to rice (Abichandani and Patnaik, 1958; De Datta, 1978; Kai and Wada, 1979). The relative magnitude of the availability of N was decided by both mineralization and immobilization processes which were continuous and simultaneous processes but the goal of these processes were opposed to each other. Immobilization of fertilizer N might not be considered as a loss because the N was not removed from the soil system and it might become available to rice in the course of time as a result of mineralisation.

The extent of immobilization depended upon the soil moisture regime and the chemical composition of soil organic matter. Under anaerobic decomposition, low mineral N was found to be immobilized compared to aerobic decomposition. Wide CN ratio of the added organic matter, the larger was the amount immobilized (Yoshida and Padre, 1975). The algal immobilized N could be remineralized. Recent experiments showed that 37 to 52 per cent of algal N was remineralised and utilised by single rice crop (Wilson *et al.*, 1980).

2.2.1.4. Clay fixation

The $\text{NH}_4\text{-N}$ not extractable from the soil by KCl is generally termed as fixed ammonia. The resultant product of mineralization of soil organic matter was subjected to chemical immobilization or lattice fixation (Bhattacharya, 1969; Broadbent, 1978). The fixation was increasing with increasing levels of added nitrogen (Rajue and Mukopadhyay, 1975; Ramanathan *et al.*, 1977; Doram and Evans, 1983)

2.2.2. Response of rice to N fertilizer

Most of the soils in south India are low in available N warranting judicious application of fertilizer N for sustained rice yields. The nitrogen use efficiency in rice is reported to be generally less than 40 per cent depending upon the rate and source of N used, method of application, soil characteristics, crop, variety, seasonal conditions, water management and cropping system.

Major breakthrough in rice production was brought about by the high yield dwarf and semi dwarf rice varieties with short stem, erect leaves and non lodging characters which helped to use solar energy very effectively and hence yielded more when N was applied (Subramanian and Thangamuthu, 1981).

Maximum rice grain yield was obtained with more than 120 kg N ha⁻¹ in most soils under high solar radiation, whereas a little dose was sufficient for lower solar radiation (Fagi and De Datta, 1981). In sandy loam soils, rice responded linearly upto 150 kg N ha⁻¹ and in clay loam / clay soils, 125 - 150 kg N ha⁻¹ was found to be optimum dose for maximum rice yields (Rana *et al.*, 1984 ;TRRI, 1986; Balasubramanian and Palaniappan, 1989), and the rate of response decreased with increasing levels of N application. Nitrogen application as high as 200 kg N ha⁻¹ or more had been tried for rice in different parts of India, particularly in Tamil Nadu (Dhanapalan Mosi *et al.*, 1987).

In the soils with low N status, rice cultivars responded significantly in terms of grain yield to N application up to 150 Kg ha⁻¹ (Maskina *et al.*, 1992). The short growth period, high demand of N by the crop to cope with the high production of grain and straw made rice cultivars respond significantly to higher N rates (Mahajan and Tripathi, 1992).

Application of N before flowering was very effective in increasing yield (Wopereis *et al.*, 1993). Thiyagarajan *et al.*(1993), reported that the N recommended for short (105 days) and long (150 days) duration crop ranged between 100 to 150 kg ha⁻¹ under Tamil Nadu conditions.

2.2.2.1. Growth character

Many workers reported the positive influence of N on growth parameters of rice, as indicated by increase in plant height (De Datta, 1981; Ramasamy and Dawood, 1985; Ramasamy, 1992; Rajeswari, 1990), tiller production (Chandrasekaran, 1984; Krishnakumar, 1986), leaf area index and dry matter production (Venkitaswamy, 1986; Srinivasulu Reddy, 1988).

In general, increased application of fertilizer N showed a beneficial effect on most of the growth components (Siddeswaran, 1992; Devasenapathy, 1994) of rice.

2.2.2.2. Yield attributes

Yield components of rice were favorably influenced by N application. Increased number of panicles per unit area (Subbiah *et al.*, 1983; Nachimuthu, 1985; Sivabal, 1989), longer panicles (Reddy, 1985; Rajeswari, 1990) and increased number of filled grains per panicle (Sankaranarayana, 1985; Balasubramanian, 1989) were observed at the enhanced level of application of N. Though the added N has not generally influenced the test weight of grains (Sivabal, 1989), in some studies, a slight increase was observed with higher levels of N (Srinivasulu Reddy, 1988; Singh *et al.*, 1990).

2.2.2.3. Yield

Enhanced rice yields to N supply have been reported by many rice researchers. However, there exists an optimum N requirement for each varieties, each ranges from

80 to 225 kg ha⁻¹ (Stangel, 1979). The positive response of high yielding rice varieties to N application as reflected by higher grain and straw yields had been demonstrated by several workers (Mongia *et al.*, 1989; Natarajan and Manickam, 1991; Singh *et al.*, 1990; Siddeswaran, 1992; Devasenapathy, 1994).

2.2.3. Nitrogen uptake

Nitrogen is absorbed rapidly during vegetative phase and the maximum rate of uptake was reached at flowering (Mikkelsen, 1970, Chaplin, 1972). Both field and laboratory studies revealed that N was taken by the rice crop continuously from seedling stage to physiological maturity (Kharg and Singh, 1973).

Uptake of fertilizer N by rice crop occurred mostly between 30 days after transplanting and panicle initiation stage. There was a rapid uptake of fertilizer N at these stages and slower uptake during the later period of growing season. Beyond panicle initiation N uptake was rather low (Obcema *et al.*, 1984).

Application of N invariably increased the uptake of N (Krishnakumar, 1986, Shukla *et al.*, 1989; Guindo *et al.*, 1994) with a corresponding increase in the uptake of P and K (Balasubramanian, 1989; Alagappan, 1990; Siddeswaran, 1992).

2.2.4. Residual effect of fertilizer N

Jansson (1963), reviewed the research on residual effect of N and concluded that fertilizer N, in general had a very little residual effect on the succeeding crops.

Soil retention of the applied ¹⁵N fertilizer as residual N ranged from 22 to 55 per cent with the inconsistent relationship to either the methods or times of N application. Band application usually maintained the highest residual N while the surface or

broadcast application with standing water registered the lowest retention in the soil (Mikkelsen, 1987). Soil retention of about 20 to 30 percent of the labeled ^{15}N was reported by Angayarkanni and Manickam (1990), in clay loam soils of Periyar Vaigai command area. Ilango *et al.* (1990), reported that in the residual crop of rice, the ^{15}N recovered was 3.75 to 3.95 per cent. Larger portion of the ^{15}N in the soil was not utilized by the residual crop and was retained in soil to aid the building up of soil fertility due to conversion into organic forms.

2.3. Use efficiency

2.3.1. Recovery of applied N

Fertilizer N recovery is calculated as the differential N uptake between fertilized and unfertilized crop per unit quantity of applied N. It had been reported that the upland crops generally used 40 to 60 per cent of the applied N (Mitsui, 1955; Prasad *et al.*, 1971) whereas the flooded rice crop used only 20 to 40 per cent (Prasad and De Datta, 1979; Krishnappa and Shinde, 1980; Rao and Shinde, 1985; Vlek and Byrnes, 1986; Manickam *et al.*, 1990) and it rarely exceeded 40 per cent of the applied N according to Asian farmers management practices (De Datta, 1981).

At International Rice Research Institute (IRRI) Savant and De Datta (1982), using labeled urea found that rice recovered only 25 to 30 per cent of the best split applied urea. The percentage recovery of applied N varied to greater extent with soil properties, fertilizer sources, application methods, rates and times of fertilizer N application and other crop management practices. The total N recovery usually fluctuated between 30 and 50 per cent in the tropics with higher values for deep placement of N in soil or topdressing of N at later growth stages at lower levels of N. Rekhi *et al.* (1982), reported a recovery of 58 to 72 and 66 to 83 per cent of applied N in the first and second year of experimentation respectively.

In a study on the N cycle of flooded rice ecosystem using tracer technique on silty loam soil of Loudiana, Reddy (1982), reported a recovery of 33 per cent of N. Mahapatra and Khan (1983), reported that the recovery of N ranged from 29.2 to 39.7 per cent for various sources of applied N. According to App *et al.* (1986), the yield potential of rice varieties would also decide the recovery per cent of applied N. A number of management practices such as split application of N fertilizer and placement of N in the reduced soil layer had been designed to improve the recovery of fertilizer N which resulted in low retention of the applied N in the soil (Angayarkanni and Manickam, 1990; Scholten, 1992).

The studies conducted by Natarajan and Manickam (1991), revealed that the quantity of N derived from the fertilizer was greater for the short duration varieties than medium duration varieties due to higher root densities in the early stages of the crop.

2.3.2. Nitrogen use efficiency

Asian farmers have not been able to effectively utilize fertilizer N to boost their yields because of excessive losses (Craswell and Vlek, 1979; De Datta and Patrick, 1986). The percentage N recovery by rice, in general, varied with the soil characteristics, rice varieties and management practices such as the types and sources of N, quantity, times and methods of application, use of biological inhibitors, management of weeds and water etc. (De Datta, 1986 ; Watanabe *et al.*, 1988).

Increasing fertilizer N application generally led to decreased N use efficiency. Escalating fertilizer prices have made it imperative for the rice scientists to develop techniques to increase the use efficiency of applied N fertilizers. Morris *et al.* (1986b), reported that N use efficiency values of 29 and 31 kg grain per kg N for green manure and fertilizer N respectively. Sharma and Mitra (1988), reported that the average grain

yield response was 32 kg grain per kg N for green manure. Saravanan *et al.* (1988), found higher N use efficiency (21.5 kg grain per kg N) with conjunctive use of green manure and prilled urea than with prilled urea alone (17.1).

Furoc and Morris (1989), found that the Physiological Efficiency of N recovered from green manure was a linear function of N uptake and decreased from 29 to 17 kg grain per kg N for 75 and 180 kg ha⁻¹ of N uptake respectively. Mahapatra *et al.* (1990), reported higher N use efficiency when *Sesbania aculeata* was applied along with prilled urea (21 kg grain per kg N) than with prilled urea alone (14 kg grain per kg N).

Schnier *et al.* (1990), stated that Agronomic Efficiency of applied N decreased with increasing N levels and it ranged from 60 to 24 kg grain per kg N for N levels of 30 to 150 kg ha⁻¹. Krishnakumar and Subramanian (1991), reported that Agronomic Efficiency was 30, 20 and 12 kg grain per kg N at 75, 150 and 220 kg N ha⁻¹ respectively. Thus, Agronomic Efficiency ranging from 17 to 25 kg grain per kg N resulted with different methods and kinds of N material used.

2.4. Rice-based cropping system

China to sustain intensive cropping with high inputs, used legumes in rotation with cereals. Organic and inorganic nutrient sources are integrated with management for rice-based cropping systems is the concept being used in "System approach to plant nutrition" (SAPN) by Food and Agricultural organization. The concept of SAPN integrated three systems. (i) Integrated plant nutrient systems (IPNS) (ii) Plant nutrition based on cropping system as a whole rather than component crop in the system and (iii) soil fertility conservation and enhancing soil management system (Roy and Brown, 1984). According to De Datta (1988), system results should provide basic information on the followings:

- (I) Technology that is within the management and resource limitation of small farmers.
- (ii) Technology with specific resource constraints.
- (iii) Technology which encounters problems that can not be solved or that can not be overcome by a program of resource augmentation, market support or extension activities.

The systems approach for nutrient use management should solve the problem resulting in improved fertilizer management practices for rice and rice - based cropping systems.

Most recently suitable rice-based cropping systems for different agroclimatic conditions had been identified. Rice-rice is the most dominant cropping system under deltaic irrigated condition in south and eastern India, whereas rice-wheat, rice-groundnut, rice-legume, rice-mustard and rice-potato are some of the dominant rice-based cropping systems in different parts of north India (AICARP, 1978). Rice-rice, rice-rice-pulse/cotton in south India, rice-wheat-green gram, rice-potato-rice/ groundnut in north India and Jute-rice-wheat in eastern India are some more examples of intensive rice-based cropping systems (Palaniappan, 1986).

Region specific rice-based systems followed in India had been listed by Pandey *et al.* (1986). Palaniappan and Thangamuthu (1987), reported various rice-based cropping systems prevalent in Tamil Nadu. Rice-rice-pulse (green gram/black gram) is the common cropping system for major rice growing areas in Tamil Nadu (Palaniappan, 1985).

2.4.1. Nutrient management in cropping system

Hitherto crop production research was focused on individual crops disregarding the fact that each crop is only a component of a cropping system. Hence the nutrient

dosage for the individual crop was calculated based on the response of individual crop but not considering the cropping system as a whole. This might even led to high and uneconomic recommendation of fertilizer dose. Hence fertilization should not be considered for individual crop but for the cropping system as a whole (Mahapatra *et al.*, 1974).

For increasing the fertilizer use efficiency and economising the use of mineral fertilizer, system approach of N supply was emphasized by Swaminathan (1981). Fertilizer use in high intensive cropping systems had been reviewed by Bhardwaj and Tandon (1981), Grewal and Sharma (1981), Mandel *et al.* (1981), Meelu and Rekhi (1981), Tandon (1983), Pillai *et al.* (1985) and Biswas *et al.* (1987). They opined that fertilizer prescription approach for the system as a whole was economical and more efficient.

For developing the fertilizer schedule for the cropping system, Biswas *et al.* (1987), observed that it was necessary to take into account the residual effect of fertilizers applied to the previous crop and the influence of the preceding crop on the succeeding crop.

In double crop systems, the Kharif rice recorded a mean grain yield of 4 to 5 t ha⁻¹ and the Rabi crop with 5 to 6 t ha⁻¹ with same straw yields, removed 225 to 275 kg N, 30 to 35 kg P₂O₅ and 325 to 375 kg K₂O ha⁻¹. The N uptake data indicated very high removal of N which often exceeded the recommended dose of N (Mahapatra *et al.*, 1990). They recommended a basal dose of 100 to 120 kg N ha⁻¹ for both the rice crops in the rotation.

2.4.2. Nitrogen requirement for rice-based cropping systems

Purushothaman (1979), reported that each of the rice crops should be fertilized with recommended level of N for higher productivity and net return for the rice - based multiple cropping systems studied at Coimbatore. Studies conducted at many locations in India with rice-rice system indicated that the response to N by the second crop of rice was uniformly wide spread, regardless of N dose to first crop of rice (AICARP, 1980).

Subbiah and Sachdev (1983), found that each crop of rice in the cropping system required N application at the recommended rate. Though considerable proportion of N applied to the crop was present in the soil after harvest, its availability to the following crop was less than three per cent.

2.4.3. Integrated nutrient management in rice-based cropping system

In soils with low N and organic carbon, combined application of green manure with 60 kg N ha⁻¹ through mineral fertilizer gave rice yields comparable with 100 kg fertilizer N ha⁻¹ and the residual effect of green manuring was negligible for the succeeding crop of wheat (Tiwari *et al.*, 1980; Mahapatra *et al.*, 1981; IRRI 1984). In general, N contribution could be 10 to 25 kg ha⁻¹ from grain legumes and 30 to 40 kg ha⁻¹ from green manures, raised preceding to rice in a rice-based cropping system (Mahapatra *et al.*, 1985).

Rice responds well to the mineral fertilizer applied but the efficiency of applied N was very low. Use of organic manure, biofertilizers and crop residues in rice-based cropping systems not only could substitute a portion of the costly fertilizer N but also could help to maintain fertility in intensively cultivated rice soils (Swaminathan, 1987). The practice of using green manures and biofertilizers and including pulses in the

cropping system and incorporating their haulms, integrated with inorganic N fertilizers received a great deal of attention for efficient and economic management of N for rice-based cropping systems (Meelu and Morris, 1987).

Several multilocation trials conducted to study the management of fertilizer in fixed single year rice-rice cropping system revealed that the total productivity, net returns and cost benefit ratio of the system as a whole were in favor of combined use of organic manures and/or biofertilizers with reduced dose of mineral fertilizers (Mahapatra *et al.*, 1990).

2.4.4. Nitrogen balance in cropping system

Sharma and Saxena (1970), found a negative nitrogen balance for four cropping sequences with out nitrogen and also with 35 kg N ha⁻¹ application, while the balance was positive with 70 kg N ha⁻¹. Nair *et al.* (1973), observed from rice based cropping system studies that removal of nitrogen was about 105 per cent against added fertilizer. This indicated that rice removed some quantity from soil resource also.

At coimbatore in rice based multiple cropping study, the nutrient balance was very much affected by fertilizer nitrogen levels. There was a positive balance when full dose of recommended level of N was applied to each rice crop and the balance was negative when only half the recommended N was applied to either of the rice crops (Purushothaman, 1979). Mahapatra *et al.* (1985), observed that N balance was negative even with 100 per cent of the recommended N for rice-rice system.

In lateritic soils, the nutrient balance study on N and P in rice-rice cropping system showed that removal was almost equal to the amount added at 50 per cent optimum level of NPK. With higher levels, there was increasing positive balance of both N and P. However, the K balance was negative at levels between 0 and 90 kg

N ha⁻¹ applied to each crop of rice in the cropping system (Panda and Sahoo, 1989). With adequate use of fertilizers under intensive rice cropping system there was no appreciable deterioration of the soil health as reported from the long term fertilizer experiments in wetland rice (Patnaik *et al.*, 1989).

The adoption of high yielding technologies for crop production was likely to deplete the soil nutrients until these were replenished adequately. Balance sheet of nutrients for six rice-based cropping systems after two complete cycles showed that nutrients added as fertilizer and removal by the crops had a deficit of N in all the rotations except rice-maize and rice-sorghum. Maximum N deficit was recorded under rice-greengram (25.1 kg ha⁻¹ yr⁻¹). Phosphorus balance was positive in all the rotations which varied from 14.2 to 31.9 kg ha⁻¹ yr⁻¹. Potassium balance was negative in all the rotations and the maximum deficit being 145.4 in rice- sorghum + cowpea rotation (Mongia *et al.*, 1989).

Balance sheet of N at two locations in Philippines and one location each in Japan and India revealed that there was positive balance in unfertilized control plots and negative balance in plots receiving N fertilizers (Patnaik *et al.*, 1989).

2.4.5. Soil fertility management in cropping system

The influence of cropping system on the dynamics of soil fertility could not be appraised with in a short period because of the contribution of native soil fertility, residual effect of previous crops and seasonal variations took a fairly longer period to assess.

Manurial experiments conducted at Indian Agricultural Research Institute, New Delhi, indicated the cumulative effect of organic manuring in various cropping systems (Ghosh, 1981). Mahapatra *et al.* (1981), reviewed the rice-rice sequence experiments

under AICARP (1988) and All India Coordinated Rice Improvement Project (AICRIP) and reported higher cumulative effect of organic manuring. The addition of organic manure in different cropping systems built up the soil fertility over a period of time and the nutrient supply was increased.

2.4.5.1. Soil nutrient status

Inubushi and Watanabe (1988), considered that the microbial biomass is a small but most active pool of bioelements. When green plants and crop residues were ploughed in to the soil, considerable quantities of nutrients would be added to the soil, which gradually became available to the subsequent crops on decomposition (Srinivasulu Reddy, 1988). Legumes grown solely for incorporation as green manure could increase the soil N pool provided the legumes effectively fix N_2 and losses of legume N were minimized (Buresh and De Datta, 1991; Joshi *et al* 1994).

2.4.5.2. Organic matter status of the soil

Tropical soils are normally low in organic matter, which contributes much to the productivity of soils through mineralisation of nutrients and improvement in soil physical and biological conditions. The variation in the quantity of plant residues added and varying N content of different crops involved in the crop sequence affect the organic matter content in the soil.

Increased organic matter status of soil due to incorporation of green manure and pulses residue in a crop sequence had been reported by many authors (Purushothaman, 1979; Chaudhary and Bathla, 1985; Rajeswari, 1990).

2.4.6. Residual effect of N in a cropping system

Regardless of the quantity of fertilizer N applied, its residual value for the succeeding crop hardly exceeded three per cent of the original application (Reddy and Patrick, 1978).

Singh and Sharma (1979), studied the response of N application to rice in the rice-wheat rotation. The results indicated that 180 kg N ha⁻¹ applied to rice showed significant residual effect on wheat in the second year. However, application of organic and biological sources of N and incorporation of crop residues enriched the soil. Beri and Meelu (1981), did not observe any residual effect by green manure applied to rice on succeeding wheat crop in light soils.

Singh and Rao (1983), reported that N applied as sulphur coated urea to Kharif left a significant residual effect for the succeeding wheat at Karagpur. Shinde *et al.* (1985), observed through ¹⁵N studies that when 80 kg N was applied to a field, the first crop of wheat took only 22 kg N from the applied N. If the first crop was rice, it took only 19 kg. If the second crop was wheat 6.7 per cent of the residual N was taken by the crop. If it was rice, it was only 22 per cent.

Rao and Shinde (1985), conducted a field experiment with four successive wetland rice with ¹⁵N labeled urea application at 100 kg N ha⁻¹ to first crop of rice. They found that recovery of ¹⁵N labeled urea in four successive wetland rice crops was 27 to 36 per cent, 7.6 per cent, 4.5 per cent and 3.2 per cent respectively. Westcott and Mikkelsen (1987), found that a mere quantity of 7.5 to 8.7 per cent of N found in green manure was available to the second crop of rice.

2.5. GREEN MANURING

Green manure is no novelty and the value of this ancient farm practice was understood by Chinese, Greek and Romans for an unknown time prior to birth of Christ (Pieters, 1927). There are records showing that some 3000 years ago in China, green crops, generally legumes were grown and ploughed as a manure for rice. The importance of green manuring had been recognized as early as 500 BC in India (Kadke, 1965) and since then it has been traditionally practiced by rice farmers. Sanyasi Raju (1952), studied the relative merits of some green manures like sunhemp (*Crotalaria juncea*), daincha (*Sesbania aculeata*), pillipesara (*Phaseolus trilobus*) and cowpea (*Vigna unguiculata*). Vanchani and Murthy (1964), reported that among 100 leguminous green manures surveyed, only *Crotalaria juncea* and *Sesbania aculeata* were acceptable to farmers of India.

The improvement on physical and biological properties of soil and their persistence under tropical conditions had been investigated extensively in a number of short and long term studies (Singh, 1984). *Sesbania aculeata* is widely grown as green manure in view of its high N fixing capacity and its ability to withstand a wide range of soil conditions like salinity (Dargan *et al.*, 1982), drought (Brewbaker and Glover, 1987), alkalinity and water logging (Ghai *et al.*, 1988). On an average *Sesbania aculeata* could produce about 20 t ha⁻¹ green matter at 45 days of growth condition, the optimum age of turning could be 60 days (Sivabal, 1989).

Nitrogen requirement of rice crop could be reduced to 40 or 80 kg N ha⁻¹ through incorporation of weeds like Eichhornia and Ipomoea as green manure at the rate of 5 or 10 t ha⁻¹ (Jha *et al.*, 1989; Narsa Reddy *et al.*, 1987). Shi *et al.* (1980), reported that incorporation of 5 t either Eichhornia or Ipomoea per hectare recorded yield levels comparable with that of 40 kg N ha⁻¹. The yield level of rice crop with Subabul was significantly higher than application of urea at 50 kg N ha⁻¹ on equal N basis (Bottenberg and Harry, 1981; Purushothaman *et al.*, 1990). Incorporation of

Subabul at the rate of 8 t ha⁻¹ increased the uptake of N and yield of rice (Zoyza *et al.*, 1990). Subba Reddy *et al.* (1991), proved that incorporation of Subabul in the soil led to higher dry matter production, leaf area, N uptake and yield of sorghum compared with equivalent amount of N as urea. Application of different green leaf manures and prilled urea significantly influenced the uptake of N and P in grain and straw of rice compared with control (Bijan k Mandal *et al.*, 1992; Ventura and Watanabe, 1993).

2.5.1. Decomposition and transformation of green manure nitrogen in low land rice soil

Broadbent (1978) and Savant and De Datta (1982), observed that mineralisation of complex organic nitrogen to ammoniacal nitrogen was the vital process in the nutrition of low land rice. The two process Viz., immobilization and mineralisation occurred simultaneously in the wetland and quantity of nitrogen released or fixed was influenced by soil and environmental factors. The organic matter on decomposition released various substances including humic substances which appreciably influenced the soil fertility and also resulted in a significant change in the total microbial population during the active decomposition period.

The ammoniacal nitrogen released from green manure was absorbed rapidly on to the anion exchange complex of the soil, with the balance of unabsorbed ammoniacal nitrogen in the soil solution. The two forms of ammoniacal nitrogen were in equilibrium and could be represented by ammoniacal nitrogen (exchangeable) \rightleftharpoons ammoniacal nitrogen (solution).

The relative proportions of the two forms were influenced by CEC and presence of exchangeable cations (Keethisinghe *et al.*, 1985) and some became as non-exchangeable in vermiculite and illite (Reddy and Patrick, 1986).

2.5.2. Release of green manure nitrogen

Unlike the inorganic N fertilizers, green manure N underwent microbial decomposition and mineralisation before N became available to the crop (Meelu and Rekhi, 1981; Swaminathan, 1984; Nagarajah, 1987; Biswas and De Datta, 1988). It generally decomposed rapidly and released N quickly for the first crop following incorporation. According to Bouldin (1988), green manure contained two fractions, one which decomposes immediately upon incorporation (Fast N) and second fraction which decomposes slowly over several years (slow N). Thus, if a green manure decomposition was rapid and released N quickly, it could be an excellent source of N to the following crop, but it would have little impact on the organic matter content in the soil and could result in low residual effect in the form of organic matter build up.

Studies indicated that much of mineralized N in a flooded soil was released as NH_4^+ -N within 2 weeks of flooding (Aspiras, 1966; Ponnampuruma, 1972; Khind *et al.*, 1985). A peak in the formation of KCl extractable NH_4^+ -N from the soils applied with green manure was observed between 7 and 15 days period (Bhardwaj and Dev, 1985; Khind *et al.*, 1987; Beri *et al.*, 1989). Moreover, it was noted that there was not much difference in the mineralisation of N among different green manures. Mian and Stewart (1985 b), reported that about 45 per cent of azolla N was released in 60 days. Nagarajah *et al.* (1986), studied the incorporation of rice straw, *Sesbania rostrata* and azolla in lowland rice and found that *S. rostrata* released NH_4^+ -N at a higher rate than azolla and reached maximum in 16 days after incorporation and decreased after 30 days, while rice straw caused net immobilization.

Nagarajah *et al.* (1989), noted that when *Sesbania rostrata* and *Azolla microphylla* were added at same N equivalents, there was increase in soil solution and exchangeable NH_4^+ -N upto 40 to 80 days after flooding and then leveled off in the absence of rice plants, while in the presence of rice plant, the soil solution NH_4^+ -N

peaked around 15 and 30 days after flooding and was almost exhausted at 55 days after flooding. Thangaraju and Kannaiyan (1990), noted that ammoniacal and nitrate nitrogen increased upto 5 to 6 weeks and higher amount of release was noticed with *Seshama* sp. than *Azolla* sp. and they further noted that rapid decomposition of azolla incorporated in the flooded condition formed a potential nitrogen source for rice.

2.5.3. Factors influencing the green manure N release

Release of NH_4^+ -N from the green manures was influenced by many factors including its chemical composition, soil type, method of application, applied mineral N etc. The concentration of N, polyphenol and lignin in plant material were generally recognized plant factors controlling the N mineralisation rate of plant materials added to soil (Vallis and Jones, 1973; Alexander, 1977; Haynes, 1986). The N concentration or the CN ratio of the incorporated plant material was often the best indicator of the rate of N mineralisation and the N concentration had to be greater than a critical level between 15 and 25 g kg^{-1} before net mineralisation would occur (Shi *et al.*, 1980; Stevenson, 1986). However, when the plant materials contained high concentration of lignin or polyphenols, there might be little mineralisation of plant N in spite of higher N concentration than the critical level (Shivaraj, 1981; Maskina *et al.*, 1984; Bouldin, 1987; Palm and Sanchez, 1990).

Frankenberger and Abdelmagid (1985), reported that plant N concentration was mostly correlated with N mineralisation, but lignin concentration influenced its rate. Haynes (1986), believed that lignins and polyphenols reduced N mineralisation rate because lignin degraded to phenolic compounds and these compounds as well as polyphenols already present combine with plant protein and amino acid to form humic polymers that resist decay.

Nagarajah *et al.* (1986), studied the release pattern of N from *S. aculeata* and *Crotalaria juncea* incorporated at different periods of 15, 35 and 45 days after sowing and observed that $\text{NH}_4\text{-N}$ release was maximum at 45 days old plant and lowest with 35 days old. However, the release pattern was more or less similar. It was noted that with advancement of maturity of green manure, there was corresponding increase in lignin, CN ratio, fiber content which adversely affected the decomposition and mineralisation.

In another study Nagarajah (1987), found that N released from several green manures and crop residue was related to lignin and N content of green manure crop. Sesbania, cowpea, pigeonpea, mung bean and peanut with similar N content and CN ratio released almost similar amount of $\text{NH}_4\text{-N}$. The initial rate of N release was fastest in sesbania, azolla released less N than sesbania, cowpea, pigeonpea, mungbean, peanut despite it had much higher N content. This was due to its higher lignin content (20 per cent in azolla Vs 6.13 per cent sesbania).

Muller *et al.* (1988), found that the lignin concentration of plant material was much better predictor of plant decomposition rate than N concentration. Chemical composition other than N also affect the mineralisation of green manure N. Nagarajah *et al.* (1989), noted that N release was more under *S. rostrata* than *Azolla microphylla* inspite of N added at same equivalents. This because although azolla had low CN ratio, the lignin content of azolla was 20 per cent where as 9 per cent for sesbania, which was known to retard degradation of organic constituents of plant materials. Higher lignin content was considered the reason for lower N availability in azolla than in milk vetch.

Fox *et al.* (1990), in their study with different legume residues observed that (lignin + polypenol) : N ratio appeared to be good predictor of N mineralisation rate of incorporated legumes. Palm and Sanchez (1990), reported that the best predictor for

N mineralised in 8 weeks from ten tropical legumes and rice straw was polyphenol : N ratio in the residue. They found that N and lignin concentration in the plant materials were not correlated with the amount of N mineralised.

2.5.4. Green manuring on availability of nutrients

Organic sources of nitrogen markedly increased the soil available nitrogen compared to combination of organic and fertilizer N (Debnath and Hajra, 1972). Ramaswamy and Raj (1976), reported that green manure application increased the availability of N through reduction in nitrogen loss by leaching and denitrification. Bronson (1983), reported increased availability of nitrogen in the soil after green manuring. Duraisamy *et al.* (1986), reported that incorporation of 25 t ha⁻¹ of *Sesbania aculeata* was found to increase available N content.

Swarup (1987), observed that in sodic soil incorporation of 50 days old sesbania provided substantial improvement in soil available N over initial status. Shukla and Pandey (1987) and Abrol and Palaniappan (1988), observed that application of green manure increased available nitrogen due to production of organic acids in the soil. Jeyaraman (1988), reported that soil available N increased substantially on application of leucaena over control. Combined application of leucaena leaf and fertilizer N gave higher available N content than N alone.

2.5.5. Green manuring on nutrient uptake

Mahapatra *et al.* (1981), observed that bio-organics in combination with chemical fertilizers resulted in higher N uptake. Bouldin *et al.* (1984), noted that application of 20 kg N ha⁻¹ in the form of farm yard manure at puddling and 30 kg N ha⁻¹ as urea at planting provided adequate N uptake in comparison with application of entire

amount of N as urea in three splits. An invariable increase in the N uptake was noticed with combination of inorganic N and green manure N (Ventura *et al.*, 1987; Singh *et al.*, 1988; Rabindra *et al.*, 1989). The N, P, K contents in rice were more in the treatments receiving 60 kg N ha⁻¹ and daincha compared to the application of 60 kg N ha⁻¹ alone and that of 120 kg N ha⁻¹ as urea (Swarup, 1987).

Sharma and Mittra (1988), noted that uptake of N and K increased with application of organic materials upto 15 t ha⁻¹ and they indicated that nutritional requirement of the crop was met by mineralized nutrients from organic matter and the effect was greater when FYM and water hyacinth were applied together. Sharma and Mahapatra (1990) and Pushpavalli *et al.* (1994), revealed that better supply of N was made to the crop through combination of inorganic and organic source of N than through inorganic source alone. Similar results were also reported by Balasubramanian and Veerabadran (1994) and Lency Thomas (1995).

2.5.6. Green manure on growth attributes

Application of N through green manure promoted the growth of rice by increasing the plant height (Srinivasulu Reddy, 1988; Syed Nazeer Peeran, 1988; Sharma and Mittra, 1988; Sivabal, 1989; Singh *et al.*, 1990), tiller production (Shanmugam, 1983; Sankaranarayana, 1985; Krishnakumar, 1986), leaf area index (Vinaya Rai and Murthy 1979; Sharma *et al.*, 1987) and dry matter production (Venkitaswamy, 1986; Srinivasulu Reddy, 1988).

2.5.7. Green manure on yield attributes

Most of the yield components of the rice were favorably influenced by green manure application. Green manure gave significantly more effective tillers, number of filled grains per panicle, fertilized grains per panicle, 1000 grains weight, panicle length (Dargan *et al.*, 1975, Joseph 1986; Shukla and Pandey, 1987; Srinivasulu Reddy, 1988;

Singh *et al.*, 1990; Budhar *et al.*, 1994). Syed Nazeer Peeran (1988), noted that combined application of nitrogen with organic manure, azospirillum increased dry matter production, panicle length, number of filled grains per panicle, 1000 grains weight over the fertilizer N applied treatment. Mahapatra and Sharma (1989), noted that combined application of sesbania and prilled urea gave maximum number of panicles m^{-2} , number of filled grains $panicle^{-1}$, 1000 grains weight compared to azolla and prilled urea or combination of sesbania and azolla. Sharma and Mitra (1989) and Saravana Pandian (1990), noted that combined application of farm yard manure or water hyacinth with paddy straw increased the yield attributes of rice.

2.5.8. Green manuring on grain yield

Bronson (1983), recorded significantly higher yield with green manures and grain yields were related to the contribution of N by different green manures. Bhardwaj and Dev (1985) and Singh *et al.* (1987a), obtained rice grain yield of $4.8 t ha^{-1}$ without sesbania and N fertilizer, $7.6 t ha^{-1}$ with sesbania and $9 t ha^{-1}$ with sesbania + $120 kg N ha^{-1}$. Ranvir Singh *et al.* (1988), reported that ploughing insitu of *Sesbania rostrata* before transplanting rice increased yield by $3.7 t ha^{-1}$ while $60 kg N ha^{-1}$ increased by only $1.7 t ha^{-1}$. Sharma and Mitra (1989), noted that application of farm yard manure or water hyacinth compost at $10 t ha^{-1}$ along with paddy straw at $25 t ha^{-1}$ increased grain yield by 28 per cent, similar to the increase given by $30 kg N ha^{-1}$ as fertilizer and Beri *et al.* (1989), observed that rice yield with green manure alone was comparable to $120 kg N ha^{-1}$ and green manure with $60 kg N ha^{-1}$ resulted in yields equivalent to $180 kg N ha^{-1}$. Singh *et al.* (1990) and Purushothaman and Padmavathi (1994), observed substantial increase in grain yield, when green manure, fertilizer and blue green algae were used together in the rice ecosystem.

2.5.9. Green manuring on N economy of fertilizer N

It is difficult to compare the relative efficiency of green manure with chemical fertilizers, even on equivalent nutrient basis. A more rational way is to discover the extent to which green manure could substitute for nutrient elements derived from fertilizers to obtain crop yield (Singh, 1984). The combined effect of inorganic N fertilizer and green manure was significantly higher than that with either of them alone (Dreyfus *et al.*, 1985).

Experimental evidences showed that green manure could substitute 20 to 80 kg N ha⁻¹ (Hege 1952, Dargan, *et al.*, 1975; Chatterjee *et al.*, 1979, Tiwari *et al.*, 1980, Bhardwaj *et al.*, 1981, De *et al.*, 1983). The response of rice to green manures mainly depended upon the type of green manure used and the time of its application, since the succulence and CN ratio might vary.

Singh *et al.* (1980), tried with *Sesbania aculeata*, *Crotalaria juncea* and *Vigna unguiculata* and with 4 levels of inorganic N viz. 0, 60, 120, 180 kg ha⁻¹ and found that incorporation of *Sesbania aculeata* along with 120 kg N ha⁻¹ produced the highest grain and straw yields as compared to 180 kg N alone.

Burying of daincha (*S. aculeata*) immediately before transplanting caused adverse effect on the crop growth because of N immobilization, low Eh value and formation of organic acids on higher partial pressure (Beri and Meelu, 1979). They also reported that burying of daincha 10 to 20 days before transplanting at 12 t ha⁻¹ saved 60 kg N ha⁻¹.

Khind *et al.* (1983), in their study on 120 kg N ha⁻¹ found that 60 days old daincha could replace 90 kg N ha⁻¹. Shukla *et al.* (1984), conducted a trial with *S. rostrata* and *S. aculeata* applied at 10 t and 12 t ha⁻¹ respectively and they were applied

one week before transplanting. They found that 10 t of *S. rostrata* and 12 t of *S. aculeata* ha⁻¹ would be equal to 90 kg N ha⁻¹ as prilled urea.

Ramasamy and Dawood (1985), reported that daincha applied at 12.5 t ha⁻¹ gave better yield than 40 kg fertilizer N, daincha at 12.5 t ha⁻¹ with 40 kg N ha⁻¹ gave 4.6 t ha⁻¹ of grain yield as compared to 80 kg N as urea (4.1 t ha⁻¹). Several experiments showed that *S. aculeata* could replace 60 to 120 kg N ha⁻¹ (Watanabe, 1984; Khind *et al.*, 1985; Khind and Maskina 1986; Palaniappan *et al.*, 1987; Meelu and Morris, 1987; Singh *et al.*, 1987; Sivabal, 1989; Saravana Pandian, 1990).

Substitution of N by green manure equivalent to 45 to 120 kg fertilizer N ha⁻¹ with sesbania was reported by several workers (Tiwari *et al.*, 1980; Bhardwaj and Dev, 1985; Morris *et al.*, 1986a; Khind *et al.*, 1985; Khind and Maskina 1986; Singh *et al.*, 1987a, 1988). Singh *et al.* (1990), studied the relative effect of green manure N and inorganic N on the rice grain yield. Green manure crops *S. aculeata*, sunhemp and cowpea were sown and incorporated at 50 and 60 days in sandy loam soil. Green manure N was equal or better than urea in increasing the grain yield (Urkurkar *et al.*, 1994). The N equivalence was 35 per cent higher than urea for cowpea, 20 per cent for sunhemp and 15 per cent for sesbania.

2.5.10. Residual effect of green manure

The practice of green manure integrated with N fertilizer received a great deal of attention for efficient and economic management of N for rice based cropping systems. Mahapatra *et al.* (1981), reported that green manure with 60 kg N ha⁻¹ through mineral fertilizer gave rice yields comparable with 100 kg fertilizer N ha⁻¹ in rice-wheat cropping system. Experiments conducted at Ludhiana, showed that green manuring increased rice yields with significant carry over effect on succeeding wheat crop (Meelu and Rekhi, 1981). This was further confirmed by Meelu and Rekhi (1983), with wheat -

summer mung-rice cropping system, where 60 kg fertilizer N ha⁻¹ was replaced by mung straw. Mahapatra *et al.* (1985), observed that N contribution would be 10 to 25 kg ha⁻¹ from grain legumes and 30 to 40 kg ha⁻¹ from green manure raised prior to rice in rice based cropping system.

Meelu and Morris (1987), observed that green manuring in intensive cropping system resulted in saving of 60 to 80 kg N ha⁻¹ in rice. It produced a residual effect on the succeeding wheat crop. Malathi (1989), also reported that incorporation of FYM and *Sesbania aculeata* each at 12.5 t ha⁻¹ to the rice crop, resulted in increased grain yield of rice and residual effect was higher with *Sesbania aculeata* than FYM. In rice - rice crop sequence studies conducted under AICARP and AICRIP, the cumulative response of organic manuring was found to be very high.

From the review of green manure research in India by Sethi *et al.* (1952), it was observed that the residual effect of green manure applied to rice crop was negligible. Wilson *et al.* (1980), found that only two to three per cent of green manure N could be used by the second crop. The amount of residual N from one application of green manure was very small. But continued application of green manure was likely to have measurable effect, because of the accumulation of modest quantities of organic N over years (Bouldin *et al.*, 1984). It was observed by Westcott and Mikkelson (1987), that upto 8.7 per cent of N was available to the second crop of rice.

2.6. Integrated nutrient management concept

The seminar organized by the Fertilizer Association of India (FAI) in 1974, advocated an integrated nutrient supply approach to crops involving organic, inorganic and biological sources to take care of soil health besides improving the crop yields. Ramaswamy and Raj (1976), reported that the green manure application was beneficial in increasing the ammonifying power of the soil. The green manure N would only

partially meet the N requirement of the rice crop. In a survey of current green manure management practices in south, south east and east Asia, Garrity and Flinn (1988), found that green manuring in no case substituted entirely the chemical N. Therefore, use of legume as an N source for lowland rice would typically require integrated use of N fertilizer for sustained high rice yields.

Rajkumar Bhajan Singh and Brar (1988), observed that incorporation of 60 days old daincha one day before transplanting along with 110 kg N ha⁻¹ applied in three splits were found to give higher yields.

Patel *et al.* (1989), studied the integrated effect of organic and inorganic sources of N on grain yield of rice var. Gr II in sandy loam soil. He found that grain yield with *S. aculeata* @ 10 t ha⁻¹ + 40:20:20 kg NPK ha⁻¹ was highest over other treatments.

Shukla *et al.* (1989), studied the integrated effect of organic and inorganic N on rice yield and noted that yield with sesbania alone equaled with yield obtained under 90 kg N ha⁻¹ as prilled urea. Sesbania with 30 kg N ha⁻¹ as prilled urea increased the grain yield (9 per cent) which was significantly higher than with 90 kg N ha⁻¹ as prilled urea alone and equaled with 120 kg N ha⁻¹ as urea super granule.

Kalidurai and Kannaiyan (1990) and Rao and Moorthy (1994), evaluated *S. rostrata*, *S. aculeate* and *Azolla microphylla* as N sources for rice both in dry season and wet season in clay soil and noted that *Sesbania rostrata* and *S. aculeata* with 60 kg N ha⁻¹ significantly increased grain yield. Thangaraju and Kannaiyan (1990) and Hedge and Dwivedi (1994), studied the effect of azolla and sesbania on the yield of IR 50 in dry and wet seasons. Yields were higher with the application of USG at 100 kg N ha⁻¹ along with *Sesbania rostrata*.

From the foregoing review, it could be inferred that voluminous research work has been carried out on the influence of organic manures and fertilizer N on rice with varying levels of response. Possibility of integrating both the sources for successful and profitable rice production is evident. In the recent past, fertilizer research focused mainly on the nutrient demand of individual crop. Hence fertilizer N economy has to be achieved in rice culture by proper and judicious use of alternative N sources. Many researchers have studied the effect of organic, inorganic and integrated N sources on the growth and yield of rice. However, due to limited availability of green manures, the traditional practice of green leaf manuring may be intensified in rice cultivating areas. But only limited information are available on the effect of these green leaf manures on N release pattern, N uptake and utilization and yield of the rice crop. Similarly, there is a lacuna in the current state of knowledge on the integrated use of green leaf manures, extent of substitution of inorganic N by green leaf manure N, the residual effect of applied green leaf manures on the succeeding rice crop and the yield and the extend of fertilizer N economy. In this context, present investigation was taken to study the effect of application of non-conventional green leaf manures on the lowland rice, it's N release pattern and their residual effect on the succeeding rice in rice - rice cropping system.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

Field experiments were conducted in the wetlands of Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore with the objective of evaluating the direct and their residual effect of applied non-conventional green manures in lowland rice in comparison with the conventional green manures under different levels of fertilizer N from June, 1993 to February, 1995 in two repeated rice cropping system study of rice - rice. The materials used and the methods employed during the course of investigations are described in this chapter.

3.1. MATERIALS

3.1.1. Field location

During first year of the experimentation (1993 - '94), both main (Kharif) and residual (Rabi) rice crops were grown in field No. F of the wetlands of Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, while during second year, main and residual rice crops were grown in field No. M. The location of these fields in wetlands is geographically situated at 11⁰ N latitude and 77⁰ E longitude at an altitude of 426.7 m above MSL.

3.1.2. Weather and Climate

The normal (50 years) climatic condition of the location is as follows: A mean annual rainfall of 674.2 mm is received in 45.8 rainy days. The mean maximum and minimum temperatures are 31.5⁰C and 21.0⁰C respectively.

Relative Humidity ranges from 61 to 91 per cent and 14 to 68 per cent during forenoon and afternoon respectively. The mean bright sunshine hours per day is 7.3 hours with a mean solar radiation of $429 \text{ cal}^{-1} \text{ cm}^{-2} \text{ day}^{-1}$.

The minimum required agrometeorological variables recommended by the World Meteorological Organisation and International Rice Research Institute (IRRI, 1980) for fundamental research in rice have been considered in the present study. The weather conditions that prevailed during the experimental period are furnished in annexure I_A and II_A and depicted in Fig. 1.

The amount of rainfall received during the cropping period was 104.0 mm and 506.6 mm distributed over 13 and 30 rainy days during Kharif season and Rabi seasons of 1993-'94 and 170.8 and 467.0 mm distributed over 10 and 28 rainy days during Kharif season and Rabi seasons of 1994 - '95 respectively.

3.1.3. Seasons

During 1993 - '94, the first sequence experiment was initiated with a main crop (Kharif crop) during June - September followed by a residual crop (Rabi crop) raised during October - February. Similarly the second sequence experiment was conducted with a main crop (June - September) and a residual crop (October - February) during 1994 - '95.

3.1.4. Soil

The soils of the experimental fields were moderately drained, deep clayey classified taxonomically as Typic haplustalf, medium in available N (270 and 254.3

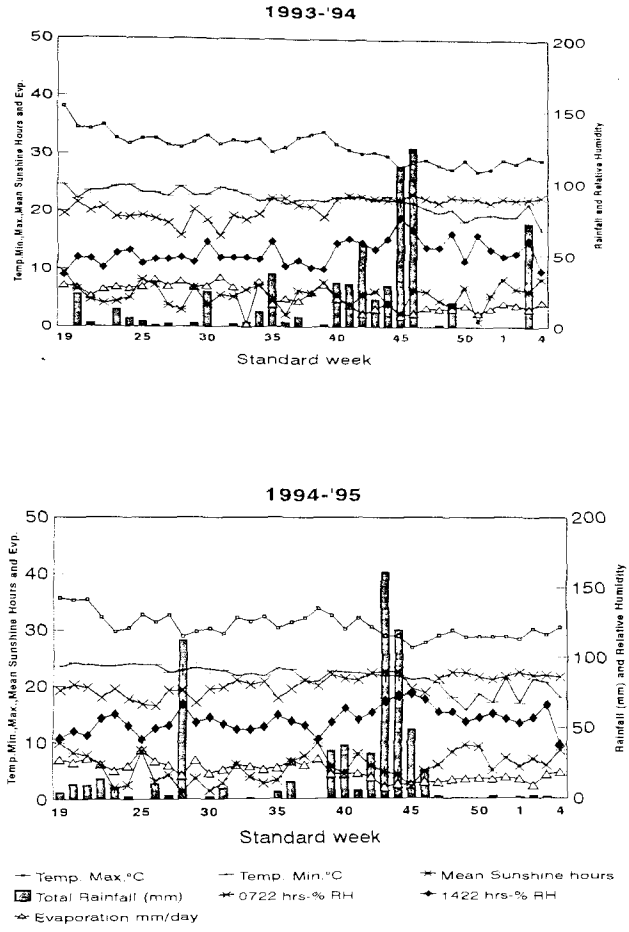


Fig.1 Weather during cropping season

kg ha⁻¹ in F and M block respectively) and P (16.2 and 18.6 Kg ha⁻¹) and high in available K(563 and 465.3 kg ha⁻¹). The details on physico-chemical characteristics of the soil are given in Table 1.

3.1.5. Crops and varieties

Two rice varieties Viz., IR 50 and IR 20 were used during first season (June - September) and second season (October - February) respectively both in the first as well as in the second year of the study. The details on the varieties tested are given in Table 2.

3.1.6. Green manure

In the present study, the non-conventional green leaf manures Viz., *Calotropis gigantea*, *Ipomoea reptans*, *Eichhornia crassipes* and *Leucaena leucocephala* were used. The effect of the above green leaf manures were compared with the conventional green manure Viz., *Sesbania aculeata* which is reported to be the most acceptable green manure among the farmers of India and can able to withstand a wide range of soil conditions like salinity (Dargan *et al.*, 1982), alkalinity and water logging (Ghai *et al.*, 1988). The nutrients content of non-conventional green leaf manures are given in the Tables 4 along with the nutrients content of *Sesbania aculeata*.

Green leaf manures Viz., *Calotropis gigantea*, *Ipomoea reptans*, *Eichhornia crassipes* and *Leucaena leucocephala* were applied on N equivalent basis on par with green manure *Sesbania aculeata* which was applied at the rate of 6.25 t ha⁻¹

Table 1. Physico - Chemical properties of the experimental field soil

Particulars	Composition	
	F block	M block
I. Mechanical Analysis		
Clay (%)	45.8	43.6
Silt (%)	12.2	19.3
Fine sand (%)	19.9	20.8
Coarse sand(%)	22.1	16.3
II. Chemical Analysis		
Organic carbon (%)	0.61	0.63
Available Nitrogen (kg ha ⁻¹)	270.0	254.3
Available Phosphorus (kg ha ⁻¹)	16.2	18.6
Available potassium (kg ha ⁻¹)	563.0	465.3
pH (1:2 soil water suspension)	8.1	7.8
EC (dsm ⁻¹)	0.5	0.62
CEC (g. mol. l ⁻¹)	22.7	35.2
III. Physical properties		
Bulk density (g cc ⁻¹)	1.28	1.3
Maximum WHC (%)	47.6	47.9
Infiltration rate (cm hr ⁻¹)	1.58	1.52

Table 2. Important characteristics of the varieties used

Characters	Rice	
	IR 50	IR 20
Parantage	IR 2153 - 14 X IR 28 X IR 36	IR 262 X TKM 6
Duration (days)	105 (Summer) 130 (Winter)	130 -135
Habit	Erect	Semi - dwarf
Panicle	Long and drooping	Medium compact
Rice colour	White	White
Average yield (Kg ha ⁻¹)	6000	5000
1000 grain weight (g)	20.35	19.00
Grain type	Long slender	Medium slender

3.2. METHODS

3.2.1. Experimental details

Experiment I and II were conducted in Kharif and Rabi season respectively in the same plots . Experiment I was conducted to study the direct effect of applied green leaf manures on Kharif rice crop and the experiment II was conducted to study the residual effect of applied green leaf manures on the Rabi rice crop. This sequence was studied in two years from June, 1993 to February, 1995.

3.2.2. Treatment details

The treatments followed for the two experiments during the investigation are given below:

Experiment I. Effect of applied green leaf manures on first season rice variety IR 50.

This experiment was conducted during Kharif season (June - September) with short duration rice variety IR 50.

Treatment No

Main plots

M ₁	control
M ₂	<i>Sesbania aculeata</i>
M ₃	<i>Ipomoea reptans</i>
M ₄	<i>Eichhornia crassipes</i>
M ₅	<i>Calotropis gigantea</i>
M ₆	<i>Leucaena leucocephala</i>

Sub plots

S ₁	No nitrogen
S ₂	40 kg N ha ⁻¹
S ₃	80 kg N ha ⁻¹
S ₄	120 kg N ha ⁻¹

The experiment was conducted in a split plot design replicated thrice with a gross plot size of 8.5 x 5 m. Phosphorus at 50 kg ha⁻¹ and potassium at 50 kg ha⁻¹ were applied uniformly to all treatments.

Experiment II. Study on residual effect of applied green leaf manures to first season rice on second season rice variety IR 20.

This experiment was a continuation of the Experiment I. The layout of experiment I was kept undisturbed after the harvest of the crop and each plot of experiment I was sub divided into two plots. Experiment II was conducted in split - split plot design, replicated thrice and the following treatments were allotted.

Treatment No

Main plots

M ₁	control	
M ₂	<i>Sesbania aculeata</i>	Introduced
M ₃	<i>Ipomoea reptans</i>	in the
M ₄	<i>Eichhornia crassipes</i>	experiment I
M ₅	<i>Calotropis gigantea</i>	
M ₆	<i>Leucaena leucocephala</i>	

Sub plots

S ₁	No nitrogen
S ₂	40 kg N ha ⁻¹
S ₃	80 kg N ha ⁻¹
S ₄	120 kg N ha ⁻¹

Sub- sub plot

F ₀	No N fertilizer	Introduced in
F ₁	Recommended N fertilizer (100 kg N ha ⁻¹)	experiment II.

Table 3. Summary of the experimental lay out

Particulars	1993 - '94		1994 - '95	
	Experiment I	Experiment II	Experiment I	Experiment II
Season	Jun . - Sep	Oct . - Feb .	Jun - Sep.	Oct. - Feb
Variety	IR 50	IR 20	IR 50	IR 20
Gross plot size (m ²)	8.5 x 5.0	4.0 x 5.0	8.5 x 5.0	4.0 x 5.0
Net plot size (m ²)	7.5 x 4.0	3.0 x 4.0	7.5 x 4.0	3.0 x 4.0
Design	split plot	split - split plot	split plot	split - split plot
Number of treatments				
Main plot	6	6	6	6
Sub plot	4	4	4	4
Sub - sub plot	-	2	-	2
Numer of replications	3	3	3	3
Total number of plots	72	144	72	144
Amount of P ₂ O ₅ and K ₂ O applied	50 kg ha ⁻¹ each in P ₂ O ₅ and K ₂ O in all the experiments			
Date of sowing	30.5.1993	18.9.1993	3.6.1994	15.9.1994
Date of transplanting	21.6.1993	15.10.1993	24.6.1994	12.10.1994
Date of harvesting	15.9.1993	4.2.1994	20.9.1994	2.2.1995

This experiment was conducted during Rabi season (Oct- Jan) with medium duration rice variety IR 20.

3.2.3. Preparation of main fields (Common to both the years)

The selected main fields were ploughed with tractor mounted cage wheel and levelled with bullock pairs. Plots of the required size were laid out and bunds and channels were formed all around. For the experiment I, the main plots were made with a size of 36 x 5 m. The green manure and green leaf manures were applied 10 days prior to transplanting, trampled well into the soil with trampler followed by flooding. Then each main plot was divided into four sub plots with a size of 8.5 x 5 m and levelling was done sub plotwise just one day before transplanting. The experimentwise details are presented in Table 3 with lay-out plan in Fig.2a and 2b.

3.2.4. Seeds and sowing (Common to both the years)

Rice seedlings were raised in wet nurseries and transplanted in the main field at the rate of two seedlings per hill with a spacing of 15 x 10 cm in both the seasons. The age of seedlings at transplanting was 21 days for IR 50 and 27 days for IR 20. In each crop, gap filling was done within a week of transplanting. Plant population was maintained uniformly in all the plots.

3.2.5. Application of manures and fertilizers

3.2.5.1. Green leaf manures (Common to both the years)

Nutrient content and CN ratio of the green leaf manures used in the present investigation are given in the Tables 4 and 5. After collecting the GLMs, the representative samples were drawn, analysed for its N content and the quantity to

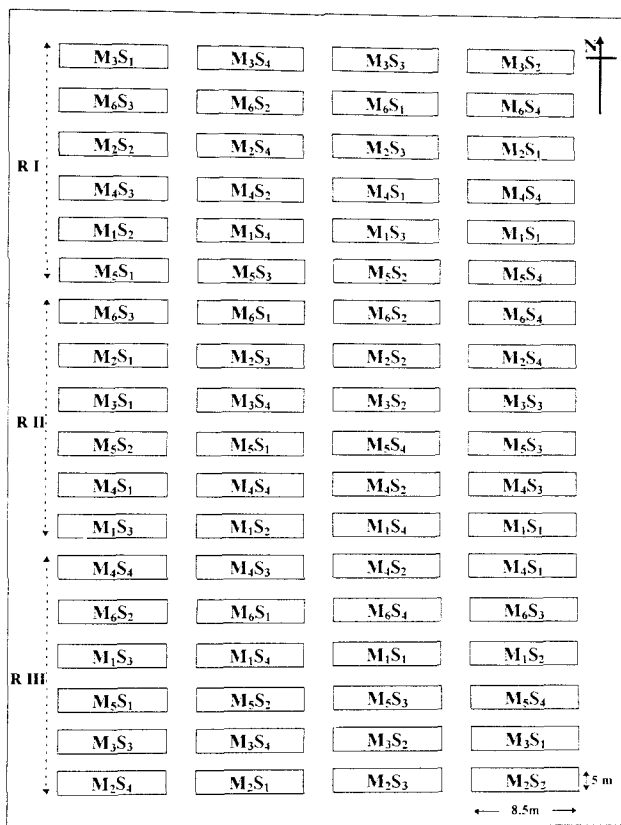


Fig. 2a. Field Layout for Kharif season rice

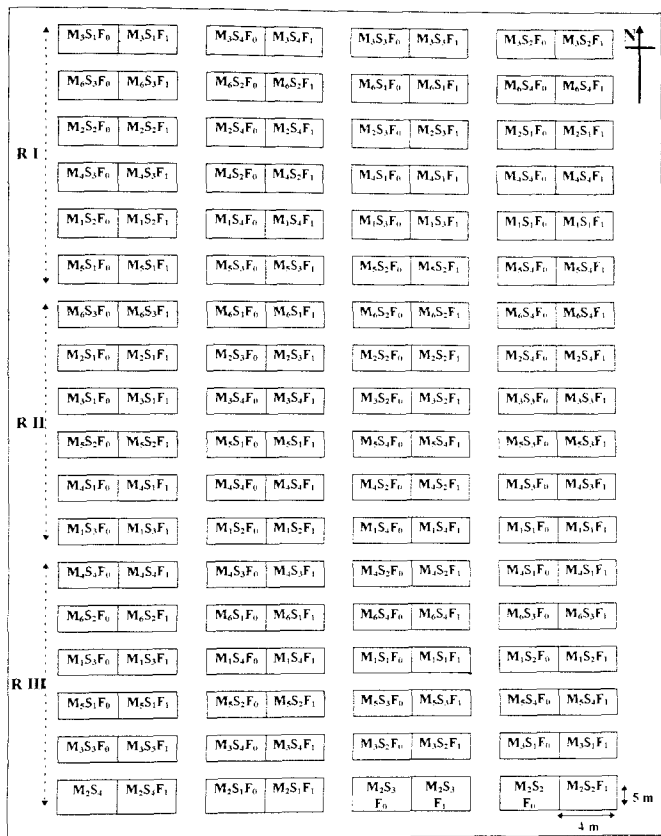


Fig.2b. Field layout for Rabi season rice

Table 4. Nutrient content of GLMs used at the time of incorporation (1993 - '94)

GLMs	Moisture content (%)	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)	Carbon content (%)	CN ratio	Lignin content (%)
<i>Sesbania aculeata</i>	77.2	3.16	0.41	3.93	50.5	16:1	9.2
<i>Ipomoea reptans</i>	73.0	2.02	0.36	1.66	58.4	29:1	14.2
<i>Eichhornia crassipes</i>	89.5	1.90	0.38	0.90	68.0	36:1	22.0
<i>Calotropis gigantea</i>	67.0	2.25	0.61	1.26	54.6	24:1	17.4
<i>Leucaena leucocephala</i>	65.5	2.06	0.41	1.41	65.0	32:1	18.0

* Data statistically not analysed.

Table 5. Nutrient content of GLMs used at the time of incorporation (1994 - '95)

GLMs	Moisture content (%)	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)	Carbon content (%)	CN ratio	Lignin content (%)
<i>Sesbania aculeata</i>	70.6	2.97	0.43	3.89	43.8	15:1	9.0
<i>Ipomoea reptans</i>	65.4	2.24	0.34	1.65	58.5	26:1	13.6
<i>Eichhornia crassipes</i>	90.2	1.86	0.33	0.94	67.4	36:1	22.0
<i>Calotropis gigantea</i>	64.2	2.30	0.65	1.20	60.8	26:1	16.7
<i>Leucaena leucocephala</i>	60.5	2.02	0.44	1.35	67.2	33:1	18.3

* Data statistically not analysed

be applied was calculated at equal N basis of *Sesbania aculeata* and the quantities of green leaf manures applied are given in the Table 6.

3.2.5.2. Fertilizer (Common to both the years)

The entire dose of P_2O_5 (50 kg ha^{-1}) and 50 per cent of N as per treatment schedule and 50 per cent of K_2O (25 kg ha^{-1}) were applied as basal just before transplanting. The remaining 50 per cent N and K_2O (25 kg ha^{-1}) were topdressed in two equal splits at active tillering and panicle initiation stages. The N source was prilled urea (46 % N). Single super phosphate (16 % P_2O_5) and Muriate of potash (60 % K_2O) were used for P and K respectively.

3.2.6. Irrigation (Common to both the years)

The rice crops were irrigated to maintain five cm water level through out the crop growth period from 10 days after transplanting to 10 days before harvest.

3.2.7. Weed control and plant protection (Common to both the years)

The rice crops were given two hand weedings at tillering and panicle initiation stage respectively. Adequate prophylactic plant protection measures were given as per the recommendation of crop production guide, jointly published by Tamil Nadu Agricultural University and State Department of Agriculture.

3.2.8. Harvest (Common to both the years)

Border rows all around the plots were harvested first and the net plots were then harvested and thrashed. The individual plot yield was recorded at 14 per cent seed moisture. Straw was sun dried and weight was recorded subsequently.

3.3. N release pattern

N release pattern from green leaf manures as well as from applied chemical fertilizer plots were studied by observing changes in soil $\text{NH}_4^+ \text{-N}$ and $\text{NO}_3^- \text{-N}$ contents. For this, after the incorporation of green leaf manures, soil samples were collected from each plot daily for the first five days and then on eighth day also. After transplanting, the soil samples were drawn daily for the first five days and then once in four days, thereafter upto one month after transplanting. These wet samples were immediately analysed for $\text{NH}_4^+ \text{-N}$ and $\text{NO}_3^- \text{-N}$ contents by employing modified method as reported by Bremner and Keeney (1966). The amount of $\text{NH}_4^+ \text{-N}$ and $\text{NO}_3^- \text{-N}$ present per hectare was then computed by the method suggested by Buresh (1991), after working out the bulk density of the soil at each stage.

3.4. Biometric observations (Common to both the years)

Five plants from each net plot were chosen by random and tagged. These plants were used for recording all biometric observations at different stages of crop growth as given below :

3.4.1. Growth components

3.4.1.1. Plant height (Common to both the years)

Plant height was measured in cm during maximum tillering, panicle initiation, flowering and at harvest.

3.4.1.2. Leaf Area Index (LAI) (Common to both the years)

The leaf area index was worked out at flowering as per the method suggested by Palanisamy and Gomez(1974) by using the following formula :

$$LAI = \frac{L \times W \times K \times \text{No. of leaves per hill}}{\text{Spacing (cm}^2\text{)}}$$

where, L - Length of third leaf from top (cm)

W - Width of the same leaf blade (cm)

K - Constant factor of 0.75 for Kharif rice and 0.73 for Rabi rice.

3.4.1.3. Dry Matter Production (DMP) (Common to both the years)

Leaving the terminal two rows on both the sides of each treatment, from third and fourth rows with in borders, five plants were removed at maximum tillering, panicle initiation, flowering and harvest stages. These samples were first air dried in the shade and then oven dried at 60°C to a constant weight and dry weight was recorded and expressed in kg ha⁻¹.

3.4.1.4. Dry Matter Efficiency (DME)

The relative DME was computed using the formula suggested by Krishnamoorthy *et al.* (1973).

$$\text{DME} = \frac{\text{Grain Yield}}{\text{Grain yield} + \text{straw yield}} \times \frac{100}{\text{Duration of the crop in the field (days)}}$$

3.4.2. Yield components (Common to both the years)

The following yield components were recorded at harvest from the tagged plants:

- (i) Number of panicles m⁻²
- (ii) Panicle length (cm)
- (iii) Number of mature grains per panicle
- (iv) Thousand grains weight (g)

3.4.3. Yield

3.4.3.1. Grain yield (Common to both the years)

Grain yield was recorded from the net plot and expressed in kg ha⁻¹ at 14 per cent seed moisture level.

3.4.3.2. Straw yield (Common to both the years)

Straw yield was recorded from the net plot after enough sun drying and expressed in kg ha⁻¹.

3.4.3.3. Harvest Index (HI)

The HI or the Partial Efficiency was computed using the formula

$$\text{HI} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.4.3.4. Productivity Score (PS)

Productivity score is often used for assessing the biological efficiency of plants, because it gives a single rating on the effect or reaction of different treatments on grain yield, biological yield and the harvest index. The productivity score was obtained by summing up the grain yield, biological yield and the harvest index for each treatment, as suggested by Singh and Stoskopf (1971).

3.4.3.5. Relative Yield Index (RYI)

The relative yield index was computed using the formula

$$RYI = \frac{\text{Grain yield for each treatment (kg ha}^{-1}\text{)}}{\text{10 years mean grain yield of the Central farm (kg ha}^{-1}\text{)}} \times 100$$

3.5. Chemical analysis

3.5.1. Plant analysis (Common to both the years)

The plant samples removed for dry matter estimation were ground into a fine powder in a wiley mill and used for chemical analysis to find out the content of N at maximum tillering, panicle initiation, flowering and harvest stages. The nutrient content of the samples was multiplied with the respective dry matter produced to calculate nutrient uptake and expressed in kg ha⁻¹. For calculating nutrient uptake of N, P and K at harvest, nutrient contents of grain and straw were analysed separately and multiplied with the respective dry weights of grain and straw where ever necessary, those have been summed up and reported.

3.5.2. Soil analysis (Common to 4 both the years)

Soil samples were taken before the start of the experiment and composite samples were collected by using screw auger at 30 cm depth and analysed for mechanical and chemical properties (Table 7). Similarly after the harvest of the crops, plotwise samples were taken from the same depth of 0 - 30 cm.

3.5.3. Methods used for soil and plant analysis (Common to both the years)

The details of analytical methods employed for soil and plant analysis are presented in Table 6.

3.6. Nitrogen use efficiency (Common to both the years)

Various parameters used to study the use efficiency of N are as follows:

3.6.1. Agronomic Efficiency (AE)

The agronomic efficiency i.e., the response in yield per unit input as indicated by kg of grain per kg of applied N was computed by the following formula (Yoshida, 1981) :

$$AE = \frac{\text{Grain yield in fertilised plot (kg ha}^{-1}\text{)} - \text{Grain yield in unfertilised plot (kg ha}^{-1}\text{)}}{\text{Quantity of fertilizer N applied (kg ha}^{-1}\text{)}}$$

Table 6. Amount of GLMs applied to each main plot of Experiment I

GLMs	1993 - '94		1994 - '95	
	Quantity applied (t ha ⁻¹)	Added N (kg ha ⁻¹)	Quantity applied (t ha ⁻¹)	Added N (kg ha ⁻¹)
<i>Sesbania aculeata</i>	6.25	45.03	6.25	54.57
<i>Ipomoea reptans</i>	8.25	45.03	7.04	54.57
<i>Eichhornia crassipes</i>	22.57	45.03	29.93	54.57
<i>Calotropis gigantea</i>	6.07	45.03	6.62	54.57
<i>Leucaena leucocephala</i>	6.34	45.03	6.83	54.57

Table 7. Methods used for soil and plant analysis

Name of estimation	Authors	Methodology
I. Soil		
Textural analysis	Piper (1966)	International pipette method
Organic Carbon	Walkley and Black (1934)	Wet digestion method
Total nitrogen	Bremner (1965)	Kjeldahl's method
NH ₄ ⁺ -N and NO ₃ ⁻ -N	Bremner (1965) and Buresh (1991)	Extraction distillation method
Available nitrogen	Subbiah and Asija (1956)	Alkaline permanganate method
Available phosphorus	Olsen et al., (1954)	0.5 M sodium bi carbonate extraction
Available potassium	Stanford and English (1949)	Flame Photometry
pH	Jackson (1973)	1:2 soil water suspension
EC	Jackson (1973)	Conductivity bridge
CEC	Chapman (1965)	Neutral normal ammonium acetate method
II. Plant		
Nitrogen	Bremner (1965)	Kjeldahl's method
Phosphorus	Jackson (1973)	Triacid digestion with calorimetric estimation
Potassium	Jackson (1973)	Triacid digestion with flame photometric method

3.6.2. Physiological Efficiency (PE)

The physiological efficiency, also known as efficiency of utilisation as indicated by kg of grain per kg of absorbed N (Yoshida, 1981) was computed as follows:

$$PE = \frac{\text{Grain yield in fertilised plot (kg ha}^{-1}\text{)} - \text{Grain yield in unfertilised plot (kg ha}^{-1}\text{)}}{\text{N uptake in fertilised plot (kg ha}^{-1}\text{)} - \text{N uptake in unfertilised plot (kg ha}^{-1}\text{)}}$$

3.6.3. Apparent N Recovery (ANR)

Apparent N Recovery, also known as recovery fraction was computed as per the formula suggested by Pillai and Vamadevan (1978):

$$AR \text{ of N (\%)} = \frac{y^1 - y^0}{N^1} \times 100$$

Where y^1 = uptake of N in particular treatment (kg ha⁻¹)

y^0 = uptake of N in unfertilised plot (kg ha⁻¹) and

N^1 = quantity of N applied for the treatment (kg ha⁻¹)

3.6.4. Nitrogen Harvest Index (NHI)

The NHI was computed as per the formula suggested by Spiretz (1977).

$$NHI = \frac{\text{N uptake in economic yield}}{\text{N uptake in biological yield}} \times 100$$

3.7. Nitrogen balance in the cropping system

Soil available N balance in the cropping system (annual cropping cycle) was computed for different treatments as per the procedure suggested by Sadanandan and Mahapatra (1973). This was done for two years and reported.

3.8. Economic analysis

Gross and net returns per hectare were computed for the cropping system as a whole, considering the prevailing market price of the inputs and produces. Benefit - cost (BC) ratio was worked out for different treatments by dividing the gross returns by cost of cultivation.

3.8.1 Partial budgeting

Partial budgeting is one of the planning economic tools used to asses the viability of a proposed component technology. Based on this tool, as suggested by Gonzales and Van Der Veen (1986), the economic advantages of different treatments were worked out and the derived benefits or losses are expressed in Rs ha⁻¹.

3.9. Statistical analysis

The data on various characters studied during the investigations were statistically analysed as suggested by Gomez and Gomez (1984). Where ever the treatment differences were found significant (F test), critical differences were worked out at five per cent probability level and the values were furnished. Treatment differences which were not significant are denoted as "NS".

RESULTS

CHAPTER IV

RESULTS

Four field experiments were carried out at wetlands of Tamil Nadu Agricultural University, Coimbatore, from June, 1993 to February, 1995 to evaluate the conventional and non conventional green leaf manures (GLMs) in economising the fertilizer N for low land rice based cropping system. The experimental results are presented in this chapter.

Experiment I

Experiment I was conducted during Kharif, 1993 as well as during Kharif, 1994 with an objective of evaluating selected non-conventional green leaf manures under low land rice.

4.1. Effect of GLMs and levels of N on Kharif rice

4.1.1. NH_4^+ -N and NO_3^- -N contents in the soil

4.1.1.1. Change in soil NH_4^+ -N content as influenced by GLMs incorporation during the incubation period (0 - 8 days after GLMs incorporation) (Tables 8 and 9)

The data on NH_4^+ -N content in the soil supplied with green leaf manures indicated that in all the plots applied with green leaf manures irrespective of different GLMs crops, there was increase in NH_4^+ -N in soil throughout the incubation period of eight days from the date of incorporation. But, in the case of control (no GLMs), the trend was different. The NH_4^+ -N content increased up to second day and there after

Table 8. Change in the soil NH_4^+ -N content (ppm) as influenced by GLMs incorporation during the incubation period (1993)

Treatment	Days after application of GLMs					
	1	2	3	4	5	8
Control	10.13	10.47 (3.36)	9.96 (-4.87)	7.98 (-19.88)	7.98 (0)	7.37 (-7.64)
<i>Sesbania aculeata</i>	16.47	21.53 (30.72)	26.63 (23.69)	31.83 (19.53)	35.82 (12.54)	40.09 (11.92)
<i>Ipomoea reptans</i>	14.17	15.72 (10.94)	16.73 (6.42)	23.17 (38.49)	23.29 (0.52)	24.70 (6.05)
<i>Eichhornia crassipes</i>	10.27	11.24 (9.44)	12.00 (6.76)	13.14 (9.5)	13.77 (4.79)	15.67 (13.79)
<i>Calotropis gigantea</i>	14.84	16.30 (9.84)	18.45 (13.19)	24.16 (30.95)	24.67 (2.11)	26.00 (5.39)
<i>Leucaena leucocephala</i>	14.14	14.28 (0.99)	15.43 (8.05)	17.30 (12.12)	20.72 (19.77)	22.43 (8.25)
SEd	0.38	0.35	0.49	0.74	0.53	1.34
CD (P = 0.05)	0.85	0.79	1.09	1.64	1.18	2.99

Table 9. Change in the soil NH_4^+ -N content (ppm) as influenced by GLMs incorporation during the incubation period (1994)

Treatment	Days after application of GLMs					
	1	2	3	4	5	8
Control	9.78	10.21 (4.39)	10.14 (-0.69)	9.83 (-3.05)	9.52 (-3.15)	9.02 (-5.25)
<i>Sesbania aculeata</i>	14.32	18.63 (30.09)	21.12 (13.36)	27.45 (29.97)	34.51 (25.72)	36.37 (5.38)
<i>Ipomoea reptans</i>	13.87	17.33 (24.95)	19.51 (12.52)	22.26 (14.10)	24.83 (11.55)	28.32 (14.06)
<i>Eichhornia crassipes</i>	11.91	12.44 (4.45)	14.20 (14.15)	15.44 (8.73)	15.80 (2.33)	20.41 (29.18)
<i>Calotropis gigantea</i>	15.22	18.91 (24.24)	22.77 (20.41)	25.36 (11.37)	29.48 (16.25)	32.63 (10.68)
<i>Leucaena leucocephala</i>	13.13	17.35 (32.14)	18.41 (6.11)	22.62 (22.87)	25.34 (12.02)	29.83 (17.72)
SEd	0.34	0.36	0.51	0.71	0.67	1.22
CD (P = 0.05)	0.76	0.81	1.14	1.58	1.49	2.73

Figures in paranthesis indicate the percentage change of NH_4^+ -N content over previous day

decline observed. In general, between different green leaf manures evaluated for soil $\text{NH}_4^+\text{-N}$, the contribution from *Sesbania aculeata* was significantly higher over other green leaf manures. The next one was *Calotropis gigantea* which was at par with *Ipomoea reptans*. This was seen in both the years of study during Kharif season.

Further, it was interesting to note during 1993 Kharif that the release of $\text{NH}_4^+\text{-N}$ from *Sesbania aculeata* was quicker and the rate of release when compared to the previous day was comparatively lesser and this was observed from the third day after incorporation. In *Ipomoea reptans* and *Calotropis gigantea*, the highest rate of release was observed on fourth day and there after the rate of increase in $\text{NH}_4^+\text{-N}$ was in declining trend. During 1994 Kharif, when $\text{NH}_4^+\text{-N}$ release between different days were compared, the release of $\text{NH}_4^+\text{-N}$ from *Sesbania aculeata* increased up to second day followed by a critical decline at the third day and again peaks and troughs noticed on the release of $\text{NH}_4^+\text{-N}$. The rate of release from *Calotropis gigantea* and *Ipomoea reptans* was higher on the second day and there after it gradually decreased. The release of $\text{NH}_4^+\text{-N}$ from *Eichhornia crassipes* was minimum in both the years and the release was delayed till eighth day after application.

4.1.1.2. Change in soil $\text{NO}_3^-\text{-N}$ content as influenced by GLMs incorporation during the incubation period (0 - 8 days after GLMs incorporation)
(Tables 10 and 11)

During initial days, release of $\text{NO}_3^-\text{-N}$ from control plot was higher when compared to GLMs applied plots. In the case of control, $\text{NO}_3^-\text{-N}$ content increased upto second day and then from third day onwards, the reverse trend was observed. The $\text{NO}_3^-\text{-N}$ content in GLMs applied plots got increased from first day after application. This increasing trend was observed upto fourth day and after this period, the trend found declined. Among the different green leaf manures, the release of $\text{NO}_3^-\text{-N}$ was highest with *Sesbania aculeata* in both the years of study.

Table10. Change in the soil NO₃⁻ - N content (ppm) as influenced by GLMs incorporation during the incubation period (1993)

Treatment	Days after application of GLMs					
	1	2	3	4	5	8
Control	2.02	2.97 (47.03)	2.87 (- 33.67)	2.11 (- 26.48)	1.86 (-11.85)	1.39 (- 25.27)
<i>Sesbania aculeata</i>	1.91 (28.80)	2.46 (21.14)	2.98 (19.80)	3.57 (-9.24)	3.24 (-5.03)	3.03 (-2.47)
<i>Ipomoea reptans</i>	1.78 (25.28)	2.23 (16.59)	2.60 (14.62)	2.98 (-5.03)	2.83 (-2.47)	2.76 (-2.47)
<i>Eichhornia crassipes</i>	1.93 (31.61)	2.54 (0.79)	2.56 (17.97)	3.02 (-6.62)	2.82 (-25.89)	2.09 (-25.89)
<i>Calotropis gigantea</i>	1.85 (18.92)	2.20 (6.36)	2.34 (6.36)	2.98 (27.35)	2.86 (-4.03)	2.68 (-6.29)
<i>Leucaena leucocephala</i>	1.91 (11.52)	2.13 (3.76)	2.21 (3.76)	2.85 (28.96)	2.59 (-9.12)	2.12 (-18.15)
SEd	0.049	0.07	0.078	0.150	0.105	0.146
CD (P = 0.05)	0.109	0.156	0.174	0.330	0.234	0.325

Table11. Change in the soil NO₃⁻ - N content (ppm) as influenced by GLMs incorporation during the incubation period (1994)

Treatment	Days after application of GLMs					
	1	2	3	4	5	8
Control	3.21	3.73 (16.20)	3.50 (-6.58)	3.02 (- 13.71)	2.33 (-22.85)	1.51 (- 35.65)
<i>Sesbania aculeata</i>	2.52 (12.30)	2.83 (16.96)	3.31 (7.55)	3.56 (5.89)	3.77 (-1.86)	3.70 (-1.86)
<i>Ipomoea reptans</i>	1.97 (12.69)	2.22 (11.26)	2.47 (11.26)	2.81 (13.77)	3.13 (11.39)	3.52 (12.46)
<i>Eichhornia crassipes</i>	2.32 (9.48)	2.54 (18.89)	3.02 (14.90)	3.47 (1.73)	3.53 (3.14)	3.33 (-5.67)
<i>Calotropis gigantea</i>	2.08 (11.06)	2.31 (10.82)	2.57 (14.39)	2.94 (6.84)	3.14 (3.82)	3.26 (3.82)
<i>Leucaena leucocephala</i>	2.44 (1.63)	2.48 (5.34)	2.62 (8.78)	2.85 (8.78)	3.04 (6.67)	3.09 (1.65)
SEd	0.063	0.31	0.126	0.139	0.175	0.193
CD (P = 0.05)	0.140	NS	0.28	0.310	0.390	0.43

Figures in paranthesis indicate the percentage change of NO₃⁻ - N content over previous day

NS = Not significant

Between the days of observation, as compared to the first day after application of GLMs in 1993, the NO_3^- -N content was higher in the fourth day and there after, there was no appreciable increase over the previous days of observation. During 1994, soil NO_3^- -N content from *Sesbania aculeata* applied plot got increased upto fifth day after application and then it started declining. The same trend was observed for *Eichhornia crassipes* applied plot also. In *Ipomoea reptans*, *Calotropis gigantea* and *Leucaena leucocephala* applied plots, the NO_3^- -N content steadily increased till eighth day after their application, eventhough the increasing trend followed decreasing order.

4.1.1.3. Change in soil NH_4^+ -N content as influenced by GLMs and levels of N after rice transplantation (Tables 12 and 13)

Application of GLMs and levels of N had significant influence on soil NH_4^+ -N at all the days of observation in both the years of study in the present investigation. Application of green leaf manures irrespective of their genus increased NH_4^+ -N significantly over control. Among the green leaf manures, during 1993, *Sesbania aculeata* registered highest NH_4^+ -N upto 17 days after transplanting and it was significantly higher than all the other green leaf manures studied upto 13 days, but comparable with *Calotropis gigantea* and *Ipomoea reptans* on 17 th day. After 17 th day *Calotropis gigantea* recorded the maximum NH_4^+ -N content which was significantly superior over *Leucaena leucocephala* and *Eichhornia crassipes*, but comparable with *Ipomoea reptans* and *Sesbania aculeata* upto 21 days. After 21 days *Calotropis gigantea* and *Ipomoea reptans* were significantly higher than all the other green leaf manures (Table 12). In 1994, *Sesbania aculeata* found superior upto ninth day after transplanting and from 13th day onwards *Calotropis gigantea* registered the maximum NH_4^+ -N content but it was at par with *Ipomoea reptans* and *Sesbania aculeata* and significantly superior to *Leucaena leucocephala* and *Eichhornia crassipes* (Table 13)

Table 12. Change in the soil NH_4^+ - N content (ppm) as influenced by GLM s incorporation after transplanting of rice crop (1993)

Treatment	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21*	25	29
Main plot											
M ₁	10.95	15.19	17.92	19.82	20.72	16.46	8.95	5.92	14.49	11.98	10.01
M ₂	51.88	54.81	64.91	57.28	71.63	73.26	72.44	65.32	75.28	63.29	60.79
M ₃	32.31	41.12	47.59	50.47	52.38	58.72	62.20	63.85	76.67	69.96	65.14
M ₄	24.52	27.64	37.05	39.32	41.02	43.28	45.01	43.25	54.89	49.44	44.35
M ₅	34.86	42.01	47.91	52.18	53.75	58.95	61.08	65.06	77.19	73.63	65.92
M ₆	28.85	34.69	42.98	45.83	47.64	50.18	51.90	52.14	65.1	56.03	54.08
SEd	1.55	1.42	0.96	1.85	1.55	1.50	1.01	0.96	0.87	1.05	0.81
CD(p=0.05)	3.43	3.16	2.14	4.13	3.45	3.34	2.25	2.14	1.94	2.34	1.80
Sub plot											
S ₁	26.61	29.44	31.23	33.75	36.99	40.88	43.94	45.70	45.92	43.42	41.43
S ₂	28.42	34.14	41.87	36.73	47.03	56.89	48.91	48.73	60.47	54.17	49.40
S ₃	31.62	37.77	47.43	50.91	51.72	53.41	52.48	50.30	65.99	56.71	53.33
S ₄	35.58	42.30	51.75	55.07	55.67	56.45	45.73	52.28	70.02	61.91	56.05
SEd	1.30	1.19	0.88	0.63	0.90	0.80	0.51	0.55	0.91	0.90	0.76
CD(p=0.05)	2.64	2.42	1.78	1.28	1.83	1.62	1.04	1.12	1.85	1.83	1.54
Interaction	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

Sig - Significant at 5 per cent level

M₁ = Control

M₂ = *Sesbania aculeata*

M₃ = *Ipomoea reptans*

M₄ = *Eichhornia crassipes*

M₅ = *Calotropis gigantea*

M₆ = *Leucaena leucocephala*

S₁ = 0 kg N ha⁻¹

S₂ = 40 kg N ha⁻¹

S₃ = 80 kg N ha⁻¹

S₄ = 120 kg N ha⁻¹

M x S Interaction table

Treatment	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21 *	25	29
M ₁ S ₁	7.11	6.93	6.85	6.73	6.69	4.77	3.08	2.97	2.90	2.89	2.89
M ₁ S ₂	8.65	13.59	18.03	20.06	22.12	16.84	8.76	5.28	15.03	12.94	10.27
M ₁ S ₃	12.35	17.97	20.07	23.01	23.94	19.41	10.55	6.75	18.07	14.19	12.59
M ₁ S ₄	15.70	22.28	26.71	29.48	30.13	24.82	13.44	8.67	21.97	17.89	14.29
M ₂ S ₁	47.80	49.33	52.97	57.08	59.47	62.41	63.63	61.33	57.93	54.77	52.73
M ₂ S ₂	49.80	53.09	63.16	16.15	70.55	73.93	72.46	64.37	75.45	66.16	60.09
M ₂ S ₃	52.79	56.21	69.72	75.93	76.41	77.68	75.39	66.69	81.51	59.56	63.35
M ₂ S ₄	57.16	60.64	73.77	79.77	80.11	79.02	78.29	68.90	86.21	72.69	66.99
M ₃ S ₁	28.41	33.93	35.14	39.74	45.38	53.26	58.36	60.44	59.91	57.78	55.68
M ₃ S ₂	30.16	39.95	46.75	48.27	49.75	58.51	60.53	63.70	75.65	69.78	64.29
M ₃ S ₃	33.39	43.01	52.12	54.94	55.12	60.98	63.75	64.33	82.53	74.63	68.89
M ₃ S ₄	37.00	47.58	56.36	58.93	59.28	62.15	66.17	66.95	88.60	77.67	71.71
M ₄ S ₁	20.44	22.24	22.68	23.69	28.32	33.49	37.95	39.49	40.44	38.17	37.00
M ₄ S ₂	22.24	25.39	35.34	38.81	39.60	42.48	43.71	42.32	54.49	48.16	44.14
M ₄ S ₃	25.46	29.02	43.03	45.64	46.34	46.95	47.71	44.87	60.99	54.32	46.61
M ₄ S ₄	29.92	33.90	47.14	49.15	49.82	50.20	50.94	46.30	63.66	57.11	49.66
M ₅ S ₁	30.68	34.60	37.37	40.46	43.54	49.03	55.26	61.73	63.53	60.29	55.92
M ₅ S ₂	32.92	39.80	45.62	51.83	53.09	58.50	59.47	64.82	77.12	72.86	65.49
M ₅ S ₃	35.86	44.26	52.84	56.45	57.97	62.50	62.66	65.79	82.02	78.31	69.95
M ₅ S ₄	40.01	49.38	55.80	59.67	60.40	65.78	66.93	67.91	86.10	83.07	72.32
M ₆ S ₁	25.22	29.62	32.37	34.81	38.56	42.37	45.85	48.25	50.84	46.65	44.39
M ₆ S ₂	26.77	33.00	41.97	45.57	47.07	48.60	48.26	51.94	65.13	55.16	52.17
M ₆ S ₃	29.88	36.20	46.83	49.49	50.58	52.97	54.83	53.37	70.83	59.26	58.44
M ₆ S ₄	33.55	40.06	50.75	53.43	54.33	56.77	58.66	54.98	73.61	63.08	61.33
M SEd	1.55	1.42	0.96	1.85	1.55	1.50	1.01	0.96	0.87	1.05	0.81
CD	3.43	3.16	2.14	4.13	3.45	3.34	2.25	2.14	1.94	2.34	1.80
S SEd	1.30	1.19	0.88	0.63	0.90	0.80	0.51	0.55	0.91	0.90	0.76
CD	2.64	2.42	1.78	1.28	1.83	1.62	1.04	1.12	1.85	1.83	1.54
MxS SEd	2.43	1.81	2.88	3.23	1.55	2.36	1.26	0.94	2.23	2.20	1.87
CD	4.93	3.68	5.85	6.56	3.15	4.80	2.56	1.91	4.53	4.47	3.80
SxM SEd	2.51	1.94	3.07	2.73	1.83	1.96	1.66	0.98	2.15	2.23	1.86
CD	5.10	3.94	6.23	5.54	3.72	3.98	3.37	2.00	4.37	4.53	3.77

* Top dressing of urea was done

Table 13. Change in the soil NH_4^+ - N content (ppm) as influenced GLMs incorporation after transplanting of rice crop (1994)

Treatment	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21*	25	29
Main plot											
M ₁	12.77	17.31	18.00	21.48	22.50	18.64	10.81	6.93	15.30	11.13	9.09
M ₂	46.91	51.82	54.15	71.30	74.62	76.48	73.40	69.01	79.05	69.62	62.47
M ₃	37.63	39.71	42.95	60.68	63.82	66.42	68.81	68.98	81.70	72.91	63.12
M ₄	28.60	33.47	36.44	42.55	45.20	49.42	49.95	48.91	58.98	54.67	43.81
M ₅	36.35	41.28	44.51	67.85	70.94	73.09	74.68	74.33	82.45	73.25	63.28
M ₆	35.43	39.25	42.75	51.86	54.34	57.98	60.27	62.00	74.53	63.61	52.27
SEd	1.01	1.62	1.45	1.04	1.57	0.88	1.12	1.28	1.88	1.40	1.26
CD(p=0.05)	2.25	3.61	3.23	2.32	3.49	1.96	2.50	2.85	4.19	3.12	2.81
Sub plot											
S ₁	28.49	30.58	33.06	39.33	44.26	48.13	50.41	51.82	50.07	45.16	42.51
S ₂	30.50	34.99	37.55	51.43	53.65	56.16	54.14	53.83	63.53	55.88	47.71
S ₃	34.58	39.59	42.22	57.85	59.27	60.16	58.03	56.18	71.83	62.39	50.87
S ₄	38.20	43.39	46.35	61.87	63.76	64.39	62.69	58.28	75.89	66.68	54.93
SEd	1.01	1.40	1.56	1.00	1.42	0.86	1.05	1.31	1.91	1.39	1.28
CD(p=0.05)	2.05	2.84	3.17	2.04	2.88	1.74	2.14	2.66	3.88	2.83	2.59
Interaction	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

Sig - Significant at 5 per cent level

M x S Interaction table

Treatment	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21 *	25	29
M ₁ S ₁	8.40	8.23	8.01	7.22	7.04	5.41	4.22	3.85	3.12	2.98	2.92
M ₁ S ₂	9.89	15.68	17.56	22.35	24.20	20.24	9.71	6.38	15.16	11.07	8.13
M ₁ S ₃	14.45	20.55	21.24	27.21	28.87	23.33	13.31	8.23	20.71	14.26	11.94
M ₁ S ₄	18.35	24.76	25.17	29.15	29.88	25.56	15.98	9.26	22.19	16.22	13.38
M ₂ S ₁	42.82	45.31	48.23	56.97	60.03	64.16	66.25	65.21	60.36	54.37	53.06
M ₂ S ₂	43.49	49.93	51.39	70.33	74.82	76.45	71.42	68.27	75.29	68.39	63.26
M ₂ S ₃	48.05	54.19	56.37	76.25	80.40	81.13	76.56	70.83	87.67	75.31	65.45
M ₂ S ₄	53.27	57.85	60.62	81.63	83.23	84.18	79.36	71.72	92.86	80.40	68.09
M ₃ S ₁	33.41	34.54	37.61	42.08	50.62	57.87	61.14	65.94	66.27	61.78	57.52
M ₃ S ₂	35.07	36.26	39.56	58.17	60.31	63.89	65.20	67.23	79.29	69.75	60.14
M ₃ S ₃	39.79	41.21	45.42	67.48	68.21	69.31	70.18	69.83	89.40	77.25	63.39
M ₃ S ₄	42.22	46.81	49.22	75.00	76.13	74.59	78.71	72.93	91.82	82.86	71.41
M ₄ S ₁	23.62	27.02	29.94	32.20	38.06	44.14	46.42	47.15	46.32	42.41	36.96
M ₄ S ₂	26.40	30.32	33.38	43.24	44.32	48.26	48.90	48.03	58.50	54.17	42.35
M ₄ S ₃	29.99	36.38	38.29	47.31	47.72	51.45	50.78	49.11	63.81	59.87	45.52
M ₄ S ₄	34.37	40.15	44.16	47.45	50.69	53.84	53.69	51.35	67.27	62.23	50.39
M ₅ S ₁	31.90	35.14	37.60	59.27	63.90	65.27	68.00	69.53	66.65	60.08	57.49
M ₅ S ₂	34.32	40.18	43.27	66.22	68.90	69.29	72.23	72.36	82.12	73.71	62.20
M ₅ S ₃	37.53	43.54	46.57	72.32	74.25	76.90	77.14	76.26	88.26	77.33	64.07
M ₅ S ₄	41.63	46.24	50.57	73.57	76.74	80.89	81.33	79.18	92.75	81.88	69.34
M ₆ S ₁	30.84	33.23	36.99	38.26	45.93	51.94	56.42	59.21	57.70	49.36	47.13
M ₆ S ₂	33.85	37.58	40.22	48.27	49.34	53.84	57.39	60.72	70.85	58.21	50.16
M ₆ S ₃	37.65	41.67	45.43	56.50	56.18	58.84	60.19	62.82	81.10	70.31	54.83
M ₆ S ₄	39.38	44.50	48.37	64.40	65.90	67.28	67.08	65.25	88.46	76.57	56.95
M SEd	1.01	1.62	1.45	1.04	1.57	0.88	1.12	1.28	1.88	1.40	1.26
CD	2.25	3.61	3.23	2.32	3.49	1.96	2.50	2.85	4.19	3.12	2.81
S SEd	1.01	1.40	1.56	1.00	1.42	0.86	1.05	1.31	1.91	1.39	1.28
CD	2.05	2.84	3.17	2.04	2.88	1.74	2.14	2.66	3.88	2.83	2.59
MxS SEd	1.88	2.52	3.31	1.82	1.73	1.26	1.53	1.75	2.84	2.04	1.65
CD	3.82	5.12	6.72	3.71	3.52	2.56	3.11	3.55	5.76	4.14	3.33
SxM SEd	1.95	2.68	2.98	2.04	1.86	1.40	1.57	1.88	3.12	2.23	1.70
CD	3.96	5.44	6.05	4.14	3.77	2.84	3.18	3.82	6.33	4.52	3.45

* Top dressing of urea was done

Significant at 5 per cent level

NH_4^+ -N content between different days were compared and presented in Tables 14 and 15. NH_4^+ -N content increased upto 21 days after transplanting in *Ipomoea reptans*, *Calotropis gigantea* and *Leucaena leucocephala* applied plots, where as in *Sesbania aculeata* the increase was observed upto nine days, then it was static upto 13 days and there after it started declining. In *Eichhornia crassipes*, increase was noticed upto 13 days and then declined.

NH_4^+ -N content in the soil increased with the increase in levels of N. The highest NH_4^+ -N was recorded at 120 kg N ha⁻¹. Interaction between green leaf manures and the levels of N was significant. Irrespective of green leaf manures applied, NH_4^+ -N content increased with N levels. Combined application of 120 kg N ha⁻¹ and GLMs recorded the highest NH_4^+ -N content. Among the green leaf manures, *Sesbania aculeata*, *Calotropis gigantea* and *Ipomoea reptans* were comparable at all the N levels with reference to NH_4^+ -N release.

4.1.1.4. Change in soil NO_3^- -N content as influenced by GLMs and levels of N after rice transplantation (Tables 16 and 17)

Different green leaf manures and levels of N application had influenced the NO_3^- -N at all the days of observation in both the years. Among the different green leaf manures, highest NO_3^- -N content was observed in *Sesbania aculeata* up to second day after application. From third day to 21st day the maximum NO_3^- -N content was seen with *Calotropis gigantea*. This was followed by *Sesbania aculeata* which was comparable with *Ipomoea reptans* (Table 16). The same trend was noticed in both the years.

Nitrogen levels also significantly influenced the soil NO_3^- -N content and the maximum was seen with 120 kg N ha⁻¹. The interaction effect between green leaf

Table 14. Percentage change of soil $\text{NH}_4^+ - \text{N}$ over previous day (1993)

Treatment	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21*	25	29
M ₁ S ₁	-	-2.53	-1.15	-1.75	-0.59	-28.70	-35.43	-3.57	-2.36	-0.35	0
M ₁ S ₂	-	57.11	32.67	11.26	10.27	-23.87	-47.98	-39.73	18.47	-13.91	-20.63
M ₁ S ₃	-	45.51	11.69	14.65	4.04	-23.34	-45.65	-36.02	16.77	-21.47	-11.28
M ₁ S ₄	-	41.91	19.88	10.37	-2.20	-17.62	-45.85	-35.49	15.34	-18.57	-20.12
M ₂ S ₁	-	-3.20	7.38	7.76	4.19	4.94	1.95	-3.61	-5.54	-5.45	-3.72
M ₂ S ₂	-	6.61	18.97	9.48	2.02	4.79	-1.99	11.16	17.21	-12.31	-9.17
M ₂ S ₃	-	-6.48	24.03	8.91	0.63	1.66	-2.95	-11.54	22.22	-14.66	-8.93
M ₂ S ₄	-	6.09	21.65	8.13	0.43	-1.36	-0.92	-11.99	25.12	-15.68	-7.84
M ₃ S ₁	-	19.43	3.57	13.09	14.19	17.36	9.58	3.56	-0.88	-3.56	-3.63
M ₃ S ₂	-	32.46	17.02	3.25	3.07	17.61	3.47	5.24	18.76	-7.76	-7.87
M ₃ S ₃	-	28.81	21.18	5.41	0.33	10.63	4.54	0.91	28.29	-9.57	-7.69
M ₃ S ₄	-	28.59	18.45	4.56	0.59	4.84	6.47	1.18	32.34	-12.34	-7.67
M ₄ S ₁	-	8.81	1.98	4.45	19.54	18.26	13.32	4.06	2.41	-5.61	-3.07
M ₄ S ₂	-	14.16	39.18	9.80	2.03	7.27	2.89	-3.18	28.56	-11.61	-8.30
M ₄ S ₃	-	13.98	48.27	6.06	1.50	1.31	1.61	-5.95	35.92	-10.93	-14.11
M ₄ S ₄	-	13.60	39.05	4.26	1.36	-0.76	1.47	-9.10	37.49	-10.28	-13.05
M ₅ S ₁	-	12.77	8.00	8.26	7.61	12.60	12.57	11.70	2.91	-5.09	-7.25
M ₅ S ₂	-	20.89	14.62	13.61	2.43	10.19	1.65	8.99	18.17	-5.52	-10.11
M ₅ S ₃	-	23.99	19.38	6.83	2.69	7.81	0.25	4.99	24.66	-4.53	-10.67
M ₅ S ₄	-	23.41	13.03	6.93	1.22	8.90	1.75	1.46	26.78	-3.51	-12.94
M ₆ S ₁	-	17.44	9.28	7.53	10.77	9.88	8.23	5.23	5.36	-8.24	-4.84
M ₆ S ₂	-	23.27	27.18	8.57	3.29	3.40	-0.69	7.62	25.39	-15.30	-5.40
M ₆ S ₃	-	21.51	22.69	5.68	2.20	4.72	3.51	-2.26	32.79	-16.33	-1.38
M ₆ S ₄	-	19.40	26.68	5.28	1.68	4.44	3.32	-6.25	33.88	-14.30	-2.77

* Top dressing of urea was done

Table 15. Percentage change of soil $\text{NH}_4^+ - \text{N}$ over previous day (1994)

Treat.	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21 *	25	29
M ₁ S ₁	-	-2.00	-2.67	-9.86	-2.49	-23.15	-21.99	-8.76	-18.96	-4.49	-2.01
M ₁ S ₂	-	58.54	11.99	27.28	8.28	-16.36	-52.03	-34.29	137.61	-26.98	-26.56
M ₁ S ₃	-	41.23	3.36	28.1	6.10	-19.19	-42.95	-38.17	151.64	-31.14	-16.27
M ₁ S ₄	-	34.93	1.66	15.81	2.50	-14.46	-37.48	-42.05	139.63	-26.90	-17.50
M ₂ S ₁	-	5.81	6.44	18.12	5.37	6.88	-3.26	-1.57	-7.44	-9.92	-2.41
M ₂ S ₂	-	14.81	2.92	36.86	6.38	2.18	-6.58	-4.41	10.28	-9.16	-7.50
M ₂ S ₃	-	12.78	4.02	35.27	5.44	0.91	-5.63	-7.48	23.77	-14.09	-13.09
M ₂ S ₄	-	8.59	4.79	34.66	1.96	1.14	-5.73	-9.62	29.45	-13.42	-15.31
M ₃ S ₁	-	3.38	8.88	11.88	20.29	14.34	5.65	7.85	0.50	-6.77	-6.89
M ₃ S ₂	-	3.39	9.10	47.04	3.67	5.93	2.05	3.11	-17.94	-12.03	-13.78
M ₃ S ₃	-	3.57	10.22	48.57	1.10	1.61	1.26	-0.49	28.02	-13.59	-17.94
M ₃ S ₄	-	10.87	5.15	52.38	1.51	-2.02	5.52	-7.62	25.90	-9.75	-13.81
M ₄ S ₁	-	14.39	10.81	7.55	18.19	15.97	5.16	1.57	-1.76	-8.44	-12.85
M ₄ S ₂	-	14.85	10.09	29.53	2.49	8.88	1.33	-1.78	21.79	-7.40	-21.87
M ₄ S ₃	-	21.31	5.25	23.56	0.80	7.80	-1.30	-3.29	29.93	-6.17	-23.97
M ₄ S ₄	-	16.82	9.99	7.45	6.83	6.21	-0.3	-4.35	31.00	-7.49	-19.03
M ₅ S ₁	-	10.16	7.00	57.63	7.81	2.14	4.18	2.25	-4.14	-9.85	-4.31
M ₅ S ₂	-	17.07	7.69	53.04	4.05	0.56	4.24	0.18	13.49	-10.24	-15.62
M ₅ S ₃	-	16.01	6.96	55.29	2.67	3.56	0.31	-1.14	15.73	-12.38	-17.15
M ₅ S ₄	-	11.07	9.36	45.48	1.82	5.40	0.54	-2.64	17.14	-11.72	-15.32
M ₆ S ₁	-	7.75	11.32	3.43	20.05	13.09	8.63	4.95	-2.55	-16.04	-4.50
M ₆ S ₂	-	11.02	7.03	20.01	20.22	9.06	6.59	5.80	16.68	-17.84	-13.83
M ₆ S ₃	-	10.68	9.02	24.34	-0.57	4.73	3.17	4.37	29.10	-13.30	-22.02
M ₆ S ₄	-	13.00	8.69	33.14	2.33	2.09	-0.79	-2.72	35.57	-13.44	-25.62

* Topdressing of urea was done

Table 16. Change in the soil NO₃ - N content (ppm) as influenced by GLMs incorporation after transplanting of rice crop (1993)

Treat.	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21*	25	29
Main plot											
M ₁	8.81	11.85	13.99	12.45	10.63	7.34	5.03	3.33	12.70	8.60	4.63
M ₂	12.28	18.57	17.77	16.12	14.29	11.49	8.98	5.45	16.29	12.61	8.55
M ₃	11.76	16.25	17.57	15.77	13.62	9.93	8.45	4.65	14.77	11.88	8.39
M ₄	10.79	13.18	14.96	14.95	13.16	8.42	6.27	4.19	12.82	9.34	6.38
M ₅	11.42	17.48	19.63	20.38	18.01	14.04	11.23	6.91	17.12	12.03	8.30
M ₆	9.93	14.64	16.34	17.28	16.77	10.05	6.86	5.56	12.24	8.21	6.14
SEd	0.15	0.21	0.15	0.16	0.23	0.13	0.09	0.13	0.13	0.07	0.10
CD(p=0.05)	0.33	0.47	0.34	0.36	0.51	0.29	0.21	0.28	0.28	0.17	0.23
Sub plot											
S ₁	2.33	2.30	2.28	2.25	2.22	2.14	2.00	2.01	1.98	1.94	1.93
S ₂	9.49	14.84	16.60	16.42	14.76	9.98	7.38	4.63	14.44	10.30	6.67
S ₃	13.92	19.70	21.58	20.99	18.37	12.80	9.81	6.25	17.76	13.05	8.77
S ₄	16.77	24.46	26.38	24.97	22.31	15.92	12.03	7.17	23.12	16.50	10.90
SEd	0.20	0.19	0.03	0.19	0.14	0.17	0.08	0.13	0.16	0.06	0.06
CD(p=0.05)	0.41	0.38	0.06	0.39	0.28	0.35	0.16	0.25	0.33	0.12	0.13
Interaction	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig

Sig - Significant at 5 per cent level

M x S Interaction table

Treatment	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21 *	25	29
M ₁ S ₁	1.30	1.30	1.29	1.28	1.28	1.25	1.24	1.22	1.22	1.20	1.20
M ₁ S ₂	7.99	10.50	12.55	11.21	9.18	6.29	4.49	3.07	12.53	8.42	4.42
M ₁ S ₃	11.50	14.86	17.61	15.12	13.99	9.37	6.49	4.06	15.82	10.50	5.51
M ₁ S ₄	14.43	20.73	24.54	22.20	18.07	12.45	8.01	4.95	21.23	14.27	7.40
M ₂ S ₁	3.00	2.96	2.95	2.91	2.85	2.73	2.26	2.53	2.45	2.33	2.30
M ₂ S ₂	10.88	18.52	18.03	17.11	15.89	12.91	8.01	4.92	16.49	11.95	8.25
M ₂ S ₃	15.91	23.48	22.17	20.53	18.19	14.34	11.89	6.93	19.88	15.43	10.41
M ₂ S ₄	19.34	29.33	27.94	23.93	20.21	15.98	13.74	7.42	26.32	20.74	13.23
M ₃ S ₁	2.76	2.75	2.72	2.66	2.63	2.52	2.45	2.38	2.35	2.31	2.31
M ₃ S ₂	9.04	15.92	17.94	16.88	14.91	10.10	8.22	4.89	13.64	10.22	7.24
M ₃ S ₃	13.46	20.65	22.81	20.33	15.33	11.47	10.55	5.11	18.41	15.56	10.28
M ₃ S ₄	16.42	25.68	26.82	23.21	21.60	15.61	12.56	6.22	24.69	19.41	13.71
M ₄ S ₁	2.09	2.05	2.02	2.00	1.95	1.86	1.79	1.73	1.70	1.68	1.66
M ₄ S ₂	8.56	13.18	14.32	14.32	12.08	7.76	5.55	3.44	13.63	10.46	6.39
M ₄ S ₃	15.29	17.36	20.29	21.36	17.93	10.78	7.17	4.95	15.71	11.10	8.26
M ₄ S ₄	17.22	20.11	23.21	22.11	20.69	13.27	10.58	6.65	20.25	14.11	9.22
M ₅ S ₁	2.68	2.66	2.61	2.58	2.52	2.44	2.32	2.30	2.29	2.28	2.27
M ₅ S ₂	10.47	16.66	19.93	20.85	18.26	13.47	11.66	6.93	17.85	12.26	7.31
M ₅ S ₃	15.29	22.15	25.28	26.03	23.24	18.41	14.13	8.97	21.52	15.40	10.93
M ₅ S ₄	17.66	28.43	30.71	32.06	28.01	21.83	16.80	9.43	26.81	18.19	12.70
M ₆ S ₁	2.12	2.10	2.09	2.09	2.07	2.02	1.93	1.89	1.85	1.84	1.82
M ₆ S ₂	9.97	14.28	16.85	18.13	18.23	9.35	6.37	4.50	12.49	8.46	6.39
M ₆ S ₃	12.08	19.69	21.33	22.56	21.52	12.44	8.65	7.48	15.23	10.28	7.24
M ₆ S ₄	15.56	22.48	25.08	26.33	25.25	16.39	10.49	8.35	19.39	12.25	9.12
M SEd	0.15	0.21	0.15	0.16	0.23	0.13	0.09	0.13	0.13	0.07	0.10
CD	0.33	0.47	0.34	0.36	0.51	0.29	0.21	0.28	0.28	0.17	0.23
S SEd	0.20	0.19	0.03	0.19	0.14	0.17	0.08	0.13	0.16	0.06	0.06
CD	0.41	0.38	0.06	0.39	0.28	0.35	0.16	0.25	0.33	0.12	0.13
MxS SEd	0.38	0.45	0.69	0.47	0.35	0.43	0.19	0.31	0.40	0.15	0.15
CD	0.77	0.92	1.40	0.95	0.70	0.85	0.39	0.62	0.81	0.30	0.31
SxM SEd	0.35	0.43	0.62	0.45	0.33	0.38	0.19	0.29	0.37	0.15	0.17
CD	0.72	0.87	1.26	0.91	0.67	0.78	0.39	0.61	0.76	0.30	0.35

* Top dressing of urea was done Significant at 5 per cent level

M x S Interaction table

Treatment	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21 *	25	29
M ₁ S ₁	1.44	1.46	1.43	1.42	1.41	1.39	1.37	1.35	1.31	1.25	1.21
M ₁ S ₂	9.67	12.70	15.19	13.57	11.11	7.61	5.43	3.71	15.17	10.19	5.35
M ₁ S ₃	13.02	16.82	19.99	17.16	15.88	10.64	7.37	4.61	17.96	11.92	6.30
M ₁ S ₄	16.30	23.42	27.70	25.07	20.41	14.06	9.07	5.60	24.03	16.15	8.38
M ₂ S ₁	3.69	3.65	3.64	3.58	3.51	3.36	3.28	3.12	3.02	2.87	2.83
M ₂ S ₂	13.08	22.26	21.68	20.57	19.11	15.53	9.62	5.92	17.35	14.36	9.92
M ₂ S ₃	19.03	28.09	26.52	24.56	21.57	17.51	14.22	8.82	23.67	18.54	12.54
M ₂ S ₄	22.87	34.07	32.13	28.89	23.07	18.24	16.85	8.41	31.04	24.43	14.48
M ₃ S ₁	3.42	3.41	3.32	3.21	3.11	2.89	2.65	2.59	2.44	2.40	2.38
M ₃ S ₂	10.98	18.43	21.17	20.95	17.32	13.65	11.11	5.94	15.26	11.73	9.83
M ₃ S ₃	17.70	26.81	32.16	29.61	25.29	16.73	13.32	7.64	27.54	22.44	10.98
M ₃ S ₄	19.46	30.43	31.87	27.53	24.96	18.97	14.38	7.73	29.76	22.08	14.40
M ₄ S ₁	2.40	2.36	2.33	2.23	2.14	2.13	2.06	1.99	1.85	1.73	1.66
M ₄ S ₂	9.87	14.61	16.08	16.00	14.29	9.69	6.23	4.85	15.16	12.32	8.91
M ₄ S ₃	16.81	19.96	22.19	23.56	18.53	11.45	8.36	5.44	22.56	14.11	9.50
M ₄ S ₄	18.79	21.99	25.38	24.99	22.21	14.64	11.25	7.85	25.07	15.97	10.9
M ₅ S ₁	3.04	2.96	2.65	2.50	2.44	2.40	2.35	2.33	2.31	2.28	2.20
M ₅ S ₂	12.78	17.82	23.41	25.06	22.82	15.84	12.26	6.32	16.63	14.12	7.40
M ₅ S ₃	17.86	25.42	28.64	29.30	26.84	16.57	14.24	8.87	22.17	17.34	10.38
M ₅ S ₄	20.14	28.36	32.17	32.40	27.84	25.51	18.44	10.34	26.58	19.94	13.19
M ₆ S ₁	2.84	2.77	2.65	2.54	2.50	2.44	2.32	1.99	1.89	1.86	1.85
M ₆ S ₂	10.26	16.32	20.12	21.44	20.96	11.44	8.42	4.30	14.56	9.20	6.84
M ₆ S ₃	14.85	18.18	25.61	27.65	23.17	14.56	11.77	6.98	17.46	10.80	7.99
M ₆ S ₄	17.03	24.24	28.70	29.64	26.52	17.93	12.94	8.53	20.93	12.62	9.21
M SEd	0.07	0.09	0.15	0.13	0.21	0.27	0.31	0.42	0.44	0.36	0.37
CD	0.16	0.20	0.33	0.29	0.47	0.60	0.69	0.94	0.98	0.80	0.83
S SEd	0.13	0.13	0.17	0.16	0.47	0.32	0.58	0.55	0.68	0.51	0.62
CD	0.26	0.26	0.35	0.32	0.95	0.65	1.18	1.12	1.38	1.04	1.26
MxS SEd	0.35	0.31	0.35	0.38	0.62	0.81	0.79	0.74	0.81	0.76	0.81
CD	0.70	0.62	0.72	0.77	1.26	1.64	1.60	1.50	1.64	1.54	1.64
SxM SEd	0.38	0.37	0.43	0.40	0.69	0.87	0.83	0.81	0.88	0.81	0.83
CD	0.78	0.76	0.87	0.81	1.40	1.77	1.68	1.64	1.78	1.64	1.69

* Topdressing of urea was done

Significant at 5 per cent level.

manures and levels of N was significant at all the days of observation in both the years. Irrespective of green leaf manures application, NO_3^- -N content increased with the levels of N studied.

Change in NO_3^- -N content between different days were compared and presented in Tables 18 and 19. NO_3^- -N content increased upto fourth day in *Eichhornia crassipes*, *Calotropis gigantea* and *Leucaena leucocephala* applied plots, upto third day in *Ipomoea reptans* and control and only upto second day in *Sesbania aculeata*. There after in all the treatments, there was a steady decline in NO_3^- -N content till the topdressing with urea was done on 21 st day. When the levels of N and days of observation were analysed, the increase in NO_3^- -N content was observed upto third day and there was a steady decline in all the N levels.

4.1.2. Biometric observations

4.1.2.1. Plant height (Tables 20 and 21)

The plant height increased with the advancement of crop growth and it was the highest at harvest. During 1993 Kharif, plants grew taller when GLMs was incorporated. Among the green leaf manures, *Sesbania aculeata* (M_2) produced taller plants at all the four stages of study. However, this was statistically at par with *Calotropis gigantea* (M_5) in all the stages except at panicle initiation (PI) stage. The other green leaf manures were in the order of *Ipomoea reptans* (M_3) > *Leucaena leucocephala* (M_6) > *Eichhornia crassipes* (M_4).

Application of N at all the stages had increased the plant height significantly over absolute control (S_1). Taller plants were produced under S_4 (120 kg N ha⁻¹) followed by S_3 (80 kg N ha⁻¹) and S_2 (40 kg N ha⁻¹).

Table 18. Percentage change of soil NO₃ - N over previous day (1993)

Treat	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21 *	25	29
M ₁ S ₁	-	0.00	-0.77	-0.78	0.00	-2.34	-0.81	-3.61	0.00	-1.64	0.00
M ₁ S ₂	-	31.41	19.52	-10.68	-18.11	-31.48	-28.62	-31.63	308.1	-32.80	-47.50
M ₁ S ₃	-	29.22	18.51	14.14	-7.47	-33.02	-30.73	-37.44	289.6	-33.63	-47.62
M ₁ S ₄	-	43.66	18.38	-9.54	-18.60	-31.10	-35.66	-38.20	328.9	-32.78	-48.14
M ₂ S ₁	-	-1.33	-0.34	-1.36	-2.10	-4.21	-17.22	11.95	-3.16	-4.89	-1.29
M ₂ S ₂	-	70.22	-2.65	-5.10	-7.13	-18.75	-37.96	-38.58	235.1	-27.53	-30.96
M ₂ S ₃	-	47.58	5.58	-7.39	-11.39	-21.17	-17.09	-41.72	186.9	-22.38	-32.53
M ₂ S ₄	-	51.65	-4.73	-14.35	-15.55	-20.93	-14.02	-45.99	254.7	-21.20	-36.2
M ₃ S ₁	-	-0.36	-1.10	-2.20	-1.13	-4.19	-2.77	-2.85	-1.30	-1.70	0.00
M ₃ S ₂	-	76.10	12.69	-5.91	-11.68	-32.26	-18.61	-40.51	178.9	-25.07	-29.16
M ₃ S ₃	-	53.42	10.46	-10.87	-24.59	-25.18	-8.02	-51.56	260.3	-15.48	-33.93
M ₃ S ₄	-	56.39	4.43	-13.46	-6.93	-27.73	-19.54	-50.48	296.9	-21.38	-29.37
M ₄ S ₁	-	-1.91	-1.46	-0.99	-2.50	-4.60	-3.76	-3.35	-1.73	-1.18	-1.19
M ₄ S ₂	-	53.97	8.65	0.00	-15.64	-35.76	-28.48	-38.02	296.2	-23.26	-38.91
M ₄ S ₃	-	13.54	16.88	5.28	-16.06	-39.88	-33.49	-30.96	217.4	-29.34	-25.59
M ₄ S ₄	-	16.78	15.42	-4.74	-6.42	-35.86	-20.27	-37.15	204.5	-30.32	-34.66
M ₅ S ₁	-	-0.75	-1.87	-1.15	-2.32	-3.12	-4.91	-0.86	-0.43	-0.44	-0.44
M ₅ S ₂	-	59.12	19.62	4.62	-12.42	-26.23	-13.44	-40.56	157.6	-31.32	-40.38
M ₅ S ₃	-	44.86	14.13	2.97	-10.72	-20.78	-23.25	-36.52	139.9	-28.42	-29.03
M ₅ S ₄	-	60.98	8.02	4.40	-12.63	-22.65	-23.04	-43.87	184.3	-32.15	-30.18
M ₆ S ₁	-	-0.94	-0.48	0.00	-0.96	-2.42	4.46	-2.07	-2.12	-0.54	-1.09
M ₆ S ₂	-	43.23	18.00	7.60	0.55	-18.71	-31.87	-29.36	176.6	-32.27	-24.47
M ₆ S ₃	-	62.99	8.32	5.77	-4.61	-42.19	-30.47	-13.53	103.6	-32.50	-29.57
M ₆ S ₄	-	44.47	11.57	0.20	-4.10	-35.09	-35.99	-20.40	132.2	-36.82	-25.54

* Topdressing of urea was done

Table 19. Percentage change of soil NO₃ - N over previous day (1994)

Treat	Days after transplanting of rice seedlings										
	1	2	3	4	5	9	13	17	21 *	25	29
M ₁ S ₁	-	1.38	-2.10	-0.69	-0.74	-1.41	-1.43	-1.45	-2.96	-4.58	-3.20
M ₁ S ₂	-	31.33	19.61	-10.6	-18.13	-31.50	-28.65	-31.67	308.9	-32.83	-47.50
M ₁ S ₃	-	29.19	18.85	-14.1	-7.46	-32.99	-30.73	-37.45	289.6	-33.63	-47.15
M ₁ S ₄	-	43.68	18.27	-9.49	-18.59	-31.11	-35.49	-38.26	329.1	-32.79	-48.11
M ₂ S ₁	-	-1.08	-0.27	-1.65	-1.95	-4.27	-2.38	-4.87	-3.21	-4.96	-4.00
M ₂ S ₂	-	70.18	-2.61	-5.11	-7.09	-18.73	-38.06	-38.46	193.1	-17.23	-13.92
M ₂ S ₃	-	47.61	-5.59	-7.39	-12.17	-18.82	-18.79	-37.97	168.4	-21.67	-32.26
M ₂ S ₄	-	48.97	-5.69	-10.1	-20.15	-20.94	-7.62	-50.09	269.1	-21.29	-40.73
M ₃ S ₁	-	-0.29	-2.60	-3.31	-3.12	-7.07	-8.30	-2.26	-5.79	-1.64	-0.83
M ₃ S ₂	-	67.85	14.86	-1.04	-17.3	-21.19	-18.61	-46.53	156.9	-23.13	-16.20
M ₃ S ₃	-	51.47	19.95	-7.93	-14.49	-33.85	-20.38	-42.64	260.5	-18.44	-51.07
M ₃ S ₄	-	56.37	4.73	-13.6	-9.34	-23.99	-24.20	-46.24	284.9	-25.81	-34.78
M ₄ S ₁	-	-1.67	-1.27	-4.30	-4.03	-0.46	-3.30	-3.39	-7.04	-6.49	-4.05
M ₄ S ₂	-	48.02	10.06	-0.49	-10.68	-32.19	-35.71	-23.26	212.6	-18.73	-27.68
M ₄ S ₃	-	18.74	11.17	6.17	-21.35	-38.21	-26.99	-34.93	314.7	-37.46	-32.67
M ₄ S ₄	-	40.8	13.43	0.71	-14.07	-8.36	-27.71	-43.93	157.1	-24.98	-33.85
M ₅ S ₁	-	-2.63	-10.47	-5.66	-2.40	-1.64	-2.08	-0.85	-0.85	-1.30	-3.51
M ₅ S ₂	-	39.44	31.37	7.05	-8.94	-30.59	-22.60	-48.45	163.1	-15.09	-47.49
M ₅ S ₃	-	42.33	12.67	2.30	-7.54	-37.59	-14.06	-37.71	149.9	-21.79	-40.14
M ₅ S ₄	-	40.81	13.43	0.71	-14.07	-8.37	-27.71	-43.93	157.1	-24.98	-33.85
M ₆ S ₁	-	-2.46	-4.33	-4.15	-1.57	-2.40	-4.90	-14.22	-5.03	-1.59	-0.54
M ₆ S ₂	-	59.06	23.28	6.56	-2.24	-45.42	-26.39	-48.93	238.6	-36.81	-25.65
M ₆ S ₃	-	22.42	40.87	7.97	-16.20	-37.16	-19.16	-40.70	150.1	-38.12	-26.02
M ₆ S ₄	-	42.34	18.40	3.27	-10.53	-32.39	-25.59	-34.08	145.4	-39.70	-27.02

* Topdressing of urea was done

Table 20. Effect of different GLMs and N levels on the plant height at different growth stages (cm) - 1993

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	23.8	43.46	66.30	67.71
M ₂	27.56	54.60	82.26	83.30
M ₃	26.12	50.90	79.52	81.51
M ₄	24.81	46.01	73.45	74.74
M ₅	27.19	51.37	79.95	82.13
M ₆	25.69	47.65	78.38	80.38
SEd	0.26	0.52	0.64	0.71
CD(p=0.05)	0.58	1.15	1.42	1.57
Sub plot				
S ₁	20.00	40.83	71.36	73.11
S ₂	24.59	47.51	74.99	76.69
S ₃	28.21	51.91	78.68	80.41
S ₄	30.65	55.75	81.54	82.96
SEd	0.47	0.90	0.84	0.85
CD(p=0.05)	0.96	1.83	1.71	1.72
Interaction	Sig	Sig	Sig	Sig

M x S Interaction table

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
M ₁ S ₁	17.63	35.94	61.83	62.39
M ₁ S ₂	22.23	43.17	65.62	67.60
M ₁ S ₃	26.67	46.47	67.67	69.05
M ₁ S ₄	28.67	48.27	70.07	71.81
M ₂ S ₁	21.10	44.82	77.76	79.30
M ₂ S ₂	27.07	53.18	80.56	81.18
M ₂ S ₃	29.50	58.07	83.83	85.52
M ₂ S ₄	32.58	62.32	86.87	87.20
M ₃ S ₁	20.56	42.42	72.33	74.68
M ₃ S ₂	24.00	48.77	78.06	79.52
M ₃ S ₃	28.96	53.63	82.47	84.93
M ₃ S ₄	30.94	58.76	85.23	86.90
M ₄ S ₁	19.10	39.07	67.48	68.50
M ₄ S ₂	23.07	44.53	71.50	73.66
M ₄ S ₃	27.50	48.07	76.53	77.47
M ₄ S ₄	29.58	52.38	78.28	79.31
M ₅ S ₁	21.48	42.52	75.12	77.99
M ₅ S ₂	26.20	49.12	77.87	79.90
M ₅ S ₃	29.20	54.67	81.73	83.70
M ₅ S ₄	31.89	59.17	85.07	86.92
M ₆ S ₁	20.10	40.23	73.64	75.82
M ₆ S ₂	24.97	46.27	76.37	78.25
M ₆ S ₃	27.42	50.52	79.83	81.80
M ₆ S ₄	30.26	53.59	83.69	85.64
M SEd	0.26	0.52	0.64	0.71
CD	0.58	1.15	1.42	1.57
S SEd	0.47	0.90	0.84	0.85
CD	0.96	1.83	1.71	1.72
MxS SEd	0.70	1.35	1.38	1.46
CD	1.43	2.76	2.83	2.96
SxM SEd	0.76	1.38	1.44	1.58
CD	1.56	2.83	3.06	3.21

Significant at 5 per cent level

Table 21. Effect of different GLMs and N levels on the plant height at different growth stages - 1994

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	24.57	41.91	65.89	68.20
M ₂	27.90	55.77	81.89	83.80
M ₃	26.67	48.35	78.95	80.14
M ₄	25.95	43.63	69.05	71.51
M ₅	27.30	52.97	81.93	85.09
M ₆	26.56	46.18	71.78	75.30
SEd	0.31	0.48	0.70	0.72
CD(p=0.05)	0.69	1.06	1.55	1.59
Sub plot				
S ₁	21.23	40.97	69.89	73.56
S ₂	25.00	47.04	73.80	76.76
S ₃	27.80	50.61	76.75	79.03
S ₄	31.88	53.89	79.23	80.68
SEd	0.52	0.97	0.91	0.88
CD(p=0.05)	1.05	1.96	1.84	1.78
Interaction	Sig	Sig	Sig	Sig

M x S Interaction table

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
M ₁ S ₁	20.10	35.25	59.85	63.39
M ₁ S ₂	23.86	41.48	63.62	67.89
M ₁ S ₃	25.98	44.51	68.82	70.02
M ₁ S ₄	28.32	46.38	71.25	71.50
M ₂ S ₁	22.04	46.60	75.42	77.47
M ₂ S ₂	25.28	55.28	80.42	82.97
M ₂ S ₃	29.57	59.31	84.03	86.23
M ₂ S ₄	34.70	61.88	87.69	88.53
M ₃ S ₁	21.26	41.56	72.33	75.22
M ₃ S ₂	24.62	46.92	78.92	79.15
M ₃ S ₃	28.13	50.31	81.30	82.16
M ₃ S ₄	32.66	54.49	83.26	84.02
M ₄ S ₁	21.18	38.23	65.34	70.54
M ₄ S ₂	24.79	42.83	68.24	71.93
M ₄ S ₃	27.22	45.11	70.45	73.41
M ₄ S ₄	30.60	48.34	72.18	74.17
M ₅ S ₁	21.55	44.81	77.65	81.84
M ₅ S ₂	25.82	51.20	80.33	83.61
M ₅ S ₃	28.38	56.08	83.25	86.92
M ₅ S ₄	33.43	59.78	86.53	88.00
M ₆ S ₁	21.22	39.36	68.74	72.91
M ₆ S ₂	25.64	44.54	71.24	74.99
M ₆ S ₃	27.51	48.31	72.65	75.43
M ₆ S ₄	31.86	52.49	74.48	77.87
M SEd	0.31	0.48	0.70	0.72
CD	0.69	1.06	1.55	1.59
S SEd	0.52	0.97	0.91	0.88
CD	1.05	1.96	1.84	1.78
MxS SEd	0.69	1.22	1.43	1.51
CD	1.40	2.47	2.90	3.12
SxM SEd	0.74	1.29	1.50	1.55
CD	1.59	2.61	3.05	3.14

Significant at 5 per cent level

Interaction effect between green leaf manures and levels of N was significant at all the stages of observation. Application of GLMs along with 120 kg N ha⁻¹ produced taller rice plants. This was comparable with GLMs + 80 kg N ha⁻¹.

The same result was observed in 1994 also.

4.1.2.2. Leaf Area Index (LAI) (Tables 22 and 23)

In general with the advancement of crop growth, the LAI increased upto flowering stage and there after there was a decline towards harvest for all the treatments studied.

In both the Kharif seasons of rice crop, green leaf manuring showed a positive influence on LAI at all the growth stages of rice. The highest LAI was registered in *Sesbania aculeata* applied treatment, which was statistically at par with *Calotropis gigantea* and *Ipomoea reptans* applied treatments during AT stage. At PI and flowering stages *Sesbania aculeata* applied treatment was at par with *Calotropis gigantea*, *Ipomoea reptans* and *Leucaena leucocephala* applied treatments and was significantly superior to *Eichhornia crassipes* and control treatments. At harvesting stage all the green leaf manures significantly influenced LAI as compared to no green leaf manured plot. However, green leaf manured treatments were comparable.

Nitrogen levels had a marked influence on the LAI. Highest LAI was obtained for 120 kg N ha⁻¹ (S₄) which was comparable with 80 kg N ha⁻¹ (S₃).

The interaction effect was significant at PI and flowering stages. In both the stages application of GLMs along with 120 kg N ha⁻¹ produced increased LAI. However, this was comparable with green leaf manures + 80 kg N ha⁻¹.

Table 22. Effect of different GLMs and N levels on the leaf area index at different growth stages - 1993

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	1.97	3.70	4.87	3.52
M ₂	3.47	5.30	6.15	4.14
M ₃	3.04	4.79	5.70	4.39
M ₄	2.56	4.31	5.39	3.85
M ₅	3.09	4.79	5.99	4.28
M ₆	2.72	4.44	5.73	4.21
SEd	0.15	0.24	0.27	0.20
CD(p=0.05)	0.33	0.53	0.60	0.44
Sub plot				
S ₁	1.99	3.05	4.34	2.84
S ₂	2.62	4.46	5.31	3.91
S ₃	3.08	5.11	6.20	4.46
S ₄	3.54	5.59	6.70	5.05
SEd	0.31	0.39	0.37	0.34
CD(p=0.05)	0.63	0.79	0.75	0.69
Interaction	NS	Sig	Sig	NS

NS = Not significant.

M x S Interaction table at Panicle initiation stage

Treatment	N 0	N 40	N 80	N 120	Mean
Control	2.22	3.70	4.12	4.75	3.70
<i>Sesbania aculeata</i>	3.71	5.32	5.89	6.28	5.30
<i>Ipomoea reptans</i>	3.28	4.42	5.46	6.02	4.79
<i>Eichhornia crassipes</i>	2.85	4.30	4.83	5.24	4.31
<i>Calotropis gigantea</i>	3.30	4.48	5.42	5.96	4.79
<i>Leucaena leucocephala</i>	2.96	4.56	4.94	5.31	4.44
Mean	3.05	4.46	5.11	5.59	

	SEd	CD
M	0.24	0.53
S	0.39	0.79
MxS	0.55	1.12
SxM	0.71	1.44

M x S Interaction table at Flowering stage

Treatment	N 0	N 40	N 80	N 120	Mean
Control	3.56	4.64	5.29	5.97	4.87
<i>Sesbania aculeata</i>	4.82	5.56	6.91	7.31	6.15
<i>Ipomoea reptans</i>	4.47	4.71	6.52	7.11	5.70
<i>Eichhornia crassipes</i>	4.00	5.44	5.81	6.32	5.39
<i>Calotropis gigantea</i>	4.71	5.67	6.53	7.03	5.99
<i>Leucaena leucocephala</i>	4.46	5.82	6.16	6.47	5.73
Mean	4.34	5.31	6.20	6.70	

	SEd	CD
M	0.27	0.60
S	0.37	0.75
MxS	0.67	1.36
SxM	0.74	1.50

Table 23. Effect of different GLMs and N levels on the leaf area index at different growth stages - 1994

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	1.81	3.38	4.77	3.11
M ₂	3.59	5.07	6.30	4.53
M ₃	3.19	4.57	5.83	4.21
M ₄	2.56	4.12	5.55	4.11
M ₅	3.32	4.94	6.31	4.49
M ₆	2.83	4.38	5.92	4.19
SEd	0.29	0.31	0.30	0.41
CD(p=0.05)	0.65	0.69	0.67	0.91
Sub plot				
S ₁	2.08	3.00	4.32	2.78
S ₂	2.67	4.23	5.42	3.87
S ₃	3.20	4.91	6.47	4.62
S ₄	3.59	5.50	6.91	5.24
SEd	0.27	0.55	0.42	0.48
CD(p=0.05)	0.55	0.40	0.85	0.97
Interaction	NS	Sig	Sig	NS

NS = Not significant.

M x S Interaction table at Panicle initiation stage

Treatment	N 0	N 40	N 80	N 120	Mean
Control	2.11	3.23	3.85	4.33	3.38
<i>Sesbania aculeata</i>	3.56	5.14	5.56	6.01	5.07
<i>Ipomoea reptans</i>	3.12	4.24	5.14	5.78	4.57
<i>Eichhornia crassipes</i>	3.00	3.78	4.53	5.15	4.12
<i>Calotropis gigantea</i>	3.26	4.85	5.52	6.14	4.94
<i>Leucaena leucocephala</i>	2.97	4.16	4.83	5.57	4.38
Mean	3.00	4.23	4.91	5.50	

	SEd	CD
M	0.31	0.69
S	0.55	1.12
MxS	0.40	0.81
SxM	0.48	0.97

M x S Interaction table at Flowering stage

Treatment	N 0	N 40	N 80	N 120	Mean
Control	3.42	4.68	5.11	5.88	4.77
<i>Sesbania aculeata</i>	4.92	5.81	7.02	7.44	6.30
<i>Ipomoea reptans</i>	4.55	4.82	6.71	7.22	5.83
<i>Eichhornia crassipes</i>	3.89	5.55	6.21	6.56	5.55
<i>Calotropis gigantea</i>	4.89	5.79	7.11	7.45	6.31
<i>Leucaena leucocephala</i>	4.22	5.89	6.66	6.92	5.92
Mean	4.32	5.42	6.47	6.91	

	SEd	CD
M	0.30	0.67
S	0.42	0.85
MxS	0.44	0.89
SxM	0.51	1.04

4.1.2.3. Dry Matter Production (DMP)

The DMP of rice was recorded at AT, PI, flowering and harvesting stages and presented in Tables 24 and 25.

The DMP increased steadily with the progress of time and reached the maximum at harvest.

Application of GLMs significantly influenced the DMP at PI, flowering and harvesting stages. Incorporation of *Sesbania aculeata*, *Ipomoea reptans* and *Calotropis gigantea* were at par in increasing the DMP followed by *Leucaena leucocephala* and *Eichhornia crassipes*. Control did exhibit lower DMP

Application of N produced statistically measurable increase in DMP for all the crop growth stages over absolute control. DMP tended to increase progressively with increased N levels. The maximum DMP was recorded under 120 kg N ha⁻¹ (S₄).

The interaction effect between GLMs and N levels on DMP was significant at PI, flowering and harvesting stages. The highest dry matter was produced under GLMs + 120 kg N ha⁻¹ treatment. However, this was at par with GLMs + 80 kg N ha⁻¹.

The same trend was observed in the second year of experimentation also.

4.1.2. 3.1. Relative Dry Matter Efficiency (RDME)

The mean data on RDME of Kharif rice for the year 1993 and 1994 are presented in Fig 3.

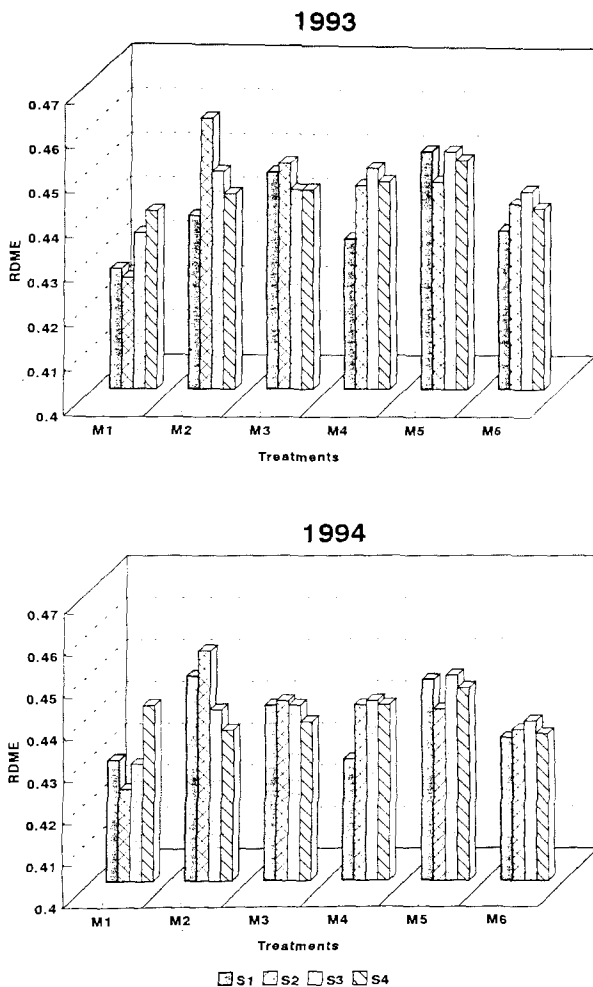


Fig.3. Relative Dry Matter Efficiency

Table 24. Effect of different GLMs and N levels on the dry matter production at different growth stages (kg ha⁻¹)- 1993

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	833.25	2973.00	5859.25	7804.75
M ₂	921.50	3906.25	7453.50	13302.75
M ₃	933.25	3840.75	7686.75	13184.50
M ₄	862.50	3249.75	6397.75	11047.75
M ₅	949.25	3799.50	7519.75	13095.25
M ₆	898.00	3397.50	6884.75	12169.00
SEd	37.21	135.82	188.35	212.44
CD(p=0.05)	82.90	302.61	419.64	473.32
Sub plot				
S ₁	459.20	1960.50	3788.17	8221.50
S ₂	930.83	3502.17	7166.00	11672.83
S ₃	1080.33	4122.67	8023.50	13353.67
S ₄	1128.17	4532.50	8890.17	13821.33
SEd	230.01	164.22	194.41	233.65
CD(p=0.05)	466.92	333.37	394.65	474.31
Interaction	NS	Sig	Sig	Sig

NS = Not significant.

M x S Interaction table

Treatment	Panicle Initiation	Flowering	Harvesting
M ₁ S ₁	1612	3084	5519
M ₁ S ₂	3179	6449	7447
M ₁ S ₃	3399	6772	8625
M ₁ S ₄	3702	7132	9628
M ₂ S ₁	2163	4102	9525
M ₂ S ₂	3798	7604	13110
M ₂ S ₃	4531	8576	15091
M ₂ S ₄	5133	9532	15485
M ₃ S ₁	2093	4109	8997
M ₃ S ₂	3724	7755	13097
M ₃ S ₃	4484	9247	15144
M ₃ S ₄	5062	9636	15500
M ₄ S ₁	1884	3584	7315
M ₄ S ₂	3214	6518	11025
M ₄ S ₃	3871	7076	12718
M ₄ S ₄	4070	8413	13133
M ₅ S ₁	2137	4077	9227
M ₅ S ₂	3768	7635	13264
M ₅ S ₃	4419	8802	14776
M ₅ S ₄	4874	9565	15114
M ₆ S ₁	1874	3773	8746
M ₆ S ₂	3330	7035	12094
M ₆ S ₃	4032	7668	13768
M ₆ S ₄	4354	9063	14068
M SED	135.82	188.35	212.44
CD	302.61	419.64	473.32
S SED	164.22	194.41	233.65
CD	333.37	394.65	474.31
MxS SED	187.46	212.57	240.56
CD	380.55	431.52	488.34
SxM SED	220.57	222.68	255.31
CD	447.76	452.04	518.28

Significant at 5 per cent level

Table 25. Effect of different GLMs and N levels on the dry matter production at different growth stages (kg ha⁻¹)- 1994

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	812.50	2917.25	5742.00	8111.25
M ₂	935.00	3752.00	7169.75	13590.50
M ₃	887.50	3700.50	7396.75	12915.50
M ₄	837.50	3226.50	6328.75	9860.25
M ₅	897.50	3659.25	7234.00	12785.50
M ₆	862.50	3301.75	6698.00	11388.25
SEd	23.93	124.65	158.00	191.02
CD(p=0.05)	53.32	277.72	353.49	425.59
Sub plot				
S ₁	448.33	1919.00	3714.17	8133.33
S ₂	900.00	3388.67	6928.67	11170.33
S ₃	1045.00	3999.17	7780.33	12681.33
S ₄	1098.33	4398.17	8626.33	13784.50
SEd	44.89	151.29	186.83	225.61
CD(p=0.05)	91.43	307.12	379.26	457.99
Interaction	NS	Sig	Sig	Sig

NS = Not significant.

M x S Interaction table

Treatment	Panicle Initiation	Flowering	Harvesting
M ₁ S ₁	1592	3027	6012
M ₁ S ₂	3100	6291	7561
M ₁ S ₃	3336	6632	8852
M ₁ S ₄	3641	7018	10020
M ₂ S ₁	2091	4020	10150
M ₂ S ₂	3630	7419	13466
M ₂ S ₃	4353	8882	14866
M ₂ S ₄	4935	9266	15880
M ₃ S ₁	2032	3972	9255
M ₃ S ₂	3569	7283	12485
M ₃ S ₃	4313	8258	14497
M ₃ S ₄	4888	9186	15425
M ₄ S ₁	1876	3569	6458
M ₄ S ₂	3174	6423	9562
M ₄ S ₃	3836	7010	11065
M ₄ S ₄	4020	8313	12356
M ₅ S ₁	2072	3940	8852
M ₅ S ₂	3615	7315	13065
M ₅ S ₃	4257	8474	14220
M ₅ S ₄	4693	9207	15005
M ₆ S ₁	1851	3757	8061
M ₆ S ₂	3244	6841	10883
M ₆ S ₃	3900	7426	12588
M ₆ S ₄	4212	8768	14021
M SEd	124.65	158.66	191.02
CD	277.72	353.49	425.59
S SEd	151.29	186.83	225.61
CD	307.12	379.26	457.99
MxS SEd	186.72	201.72	140.93
CD	379.04	409.49	286.09
SxM SEd	103.30	214.16	152.40
CD	209.70	434.74	309.37

Significant at 5 per cent level

In both the years, application of GLMs improved the RDME. Among the different green leaf manures tried, application of *Calotropis gigantea*, *Sesbania aculeata* and *Ipomoea reptans* stood equally good and this was followed by *Eichhornia crassipes* and *Leucaena leucocephala*. Control recorded the lowest RDME in both the years of experimentation

4.1.3. Yield Components (Table 26 and 27)

The yield components Viz., number of panicles m^{-2} , length of panicle, filled grain per cent and thousand grains weight were recorded and the results have been presented.

4.1.3.1. Number of panicles m^{-2}

Application of GLMs and N levels had influenced this parameter significantly. In 1993 Kharif, highest number of panicles were observed under *Calotropis gigantea* applied treatment and it was at par with *Sesbania aculeata* and *Ipomoea reptans* applied treatments. During 1994 Kharif, *Sesbania aculeata* treatment recorded maximum number of panicles which was at par with *Calotropis gigantea* and *Ipomoea reptans* applied treatments.

In both the years, highest N (120 kg N ha^{-1}) application markedly influenced the production of more panicles over no N application (S_1). The number of panicles per unit area was the highest (127.94 and 118.76 % in 1993 and 1994 respectively) at higher level of N application.

Interaction effect was also significant in both the years of study. Application of GLMs, irrespective of the green leaf manures studied, produced maximum number of panicles in conjunction with 120 kg N ha^{-1} as compared to other levels including lower

Table 26. Effect of different GLMs and N levels on yield attributes of Kharif rice -1993

Treatment	No. of panicles m ⁻²	Panicle length (cm)	Filled grain (%)	1000 grains weight (g)
Main plot				
M ₁	254.75	14.98	78.35	20.28
M ₂	350.00	17.90	83.03	20.28
M ₃	372.50	17.57	81.95	20.10
M ₄	294.25	16.03	80.55	19.83
M ₅	363.25	17.68	82.65	20.23
M ₆	315.75	16.81	81.05	19.95
SEd	10.16	0.50	0.59	0.34
CD(p=0.05)	22.64	1.11	1.32	NS
Sub plot				
S ₁	190.33	13.90	73.4	19.95
S ₂	296.00	15.82	80.97	20.18
S ₃	380.16	18.10	84.15	20.15
S ₄	433.83	19.49	86.53	20.15
SEd	12.56	0.78	1.04	0.62
CD(p=0.05)	25.50	1.58	2.11	NS
Interaction	Sig.	NS	NS	NS

NS = Not significant.

M x S Interaction table

Treatment	N 0	N 40	N 80	N 120	Mean
Control	144	234	292	349	254.75
<i>Sesbania aculeata</i>	201	322	410	467	350.00
<i>Ipomoea reptans</i>	239	357	421	473	372.50
<i>Eichhornia crassipes</i>	150	248	368	411	294.25
<i>Calotropis gigantea</i>	232	341	412	468	363.25
<i>Leucaena leucocephala</i>	176	274	378	435	315.75
Mean	190.33	296.00	380.16	433.83	

	SEd	CD
M	10.16	22.64
S	12.56	25.50
MxS	14.17	28.77
SxM	14.58	29.60

Table 27. Effect of different GLMs and N levels on yield attributes of Kharif rice -1994

Treatment	No. of panicles m ⁻²	Panicle length (cm)	Filled grain (%)	1000 grains weight (g)
Main plot				
M ₁	264.50	15.54	77.85	19.95
M ₂	365.5	20.38	84.50	20.23
M ₃	363.25	20.07	80.95	20.10
M ₄	308.00	16.76	75.80	20.10
M ₅	369.25	19.45	82.58	20.13
M ₆	335.75	17.76	79.10	20.05
SEd	12.85	0.48	0.46	0.41
CD(p=0.05)	28.56	1.07	1.02	NS
Sub plot				
S ₁	200.83	15.88	72.53	19.87
S ₂	307.50	17.70	76.55	20.20
S ₃	389.33	19.13	83.68	20.15
S ₄	439.33	20.59	87.75	20.15
SEd	16.32	0.81	0.85	0.77
CD(p=0.05)	33.13	1.64	1.73	NS
Interaction	Sig.	NS	NS	NS

NS = Not significant.

M x S Interaction table

Treatment	N 0	N 40	N 80	N 120	Mean
Control	152	240	311	355	264.50
<i>Sesbania aculeata</i>	222	341	421	478	365.50
<i>Ipomoea reptans</i>	245	332	411	465	363.25
<i>Eichhornia crassipes</i>	158	272	381	421	308.00
<i>Calotropis gigantea</i>	240	350	415	472	369.25
<i>Leucaena leucocephala</i>	188	310	397	448	335.75
Mean	200.83	307.50	389.33	439.83	

	SEd	CD
M	12.85	28.56
S	16.32	33.13
MxS	30.14	61.18
SxM	32.58	66.14

dose of N. Under all levels of N including absolute control, there was positive influence on number of panicles when *Ipomoea reptans* was incorporated and this was followed by *Calotropis gigantea*.

4.1.3.2. Panicle length

Green leaf manured treatments exerted significant influence on the length of panicle in both the years of study. Longer panicles were observed with *Sesbania aculeata* treatment and it was at par with the panicle length recorded under *Calotropis gigantea*, *Ipomoea reptans* and *Leucaena leucocephala* applied treatments. In respect of N levels studied, application of 120 kg N ha⁻¹ had increased panicle length and this was at par with 80 kg N ha⁻¹. The other doses of N recorded significantly shorter panicles.

The interaction effect between GLMs and levels of N was absent.

4.1.3.3. Percentage of filled grain

Filled grain percentage was significantly influenced by GLMs application and levels of N in the present study. The lowest filled grain percentage was with control treatment, where no green leaf manure was incorporated. Among the green leaf manures, *Sesbania aculeata* treatment recorded the maximum filled grain percentage in both the years. However, in 1993, the same treatment was at par with *Calotropis gigantea* and *Ipomoea reptans* applied treatments in registering higher filled grain percentage.

Levels of N application had positive influence on percentage of filled grain. The treatment S₄ recorded higher filled grain percentage and it was superior to S₃, S₂ and S₁ treatments.

In both the years the interaction effect between GLMs and N levels was not significant.

4.1.3.4. Thousand grains weight

Thousand grains weight was not affected by the green leaf manures as well as by different levels of N in both the years of study.

4.1.4. Yield of Rice

4.1.4.1. Grain Yield (Tables 28 and 29)

Grain yield of rice was significantly influenced by the application of green leaf manures as well as by the N levels. Among the green leaf manures, incorporation of *Sesbania aculeata* had increased rice grain yield in both the years of study. During 1993 Kharif, the *Sesbania aculeata* treatment was at par with *Calotropis gigantea* and *Ipomoea reptans* applied treatments, where as in 1994, *Sesbania aculeata* treatment was significantly superior and this was followed by *Calotropis gigantea* treatment (M_5) and the treatment M_5 was at par with M_3 (*Ipomoea reptans*). The grain yields recorded under *Leucaena leucocephala* and *Eichhornia crassipes* was higher than control, but, they stand next to *Sesbania aculeata*, *Calotropis gigantea* and *Ipomoea reptans* (Fig. 4).

Rice grain yield increased with increase in N application. Application of 120 kg N ha⁻¹ increased the grain yield to 70 and 71 per cent over absolute control during 1993 and 1994 Kharif respectively.

Interaction between sources and levels of N was significant in both the years. During 1994 Kharif, combined application of GLMs + 120 kg N ha⁻¹ registered maximum grain yield. Among the different green leaf manures, *Sesbania aculeata*, *Calotropis gigantea* and *Ipomoea reptans* with inorganic N (120 kg N ha⁻¹) proved

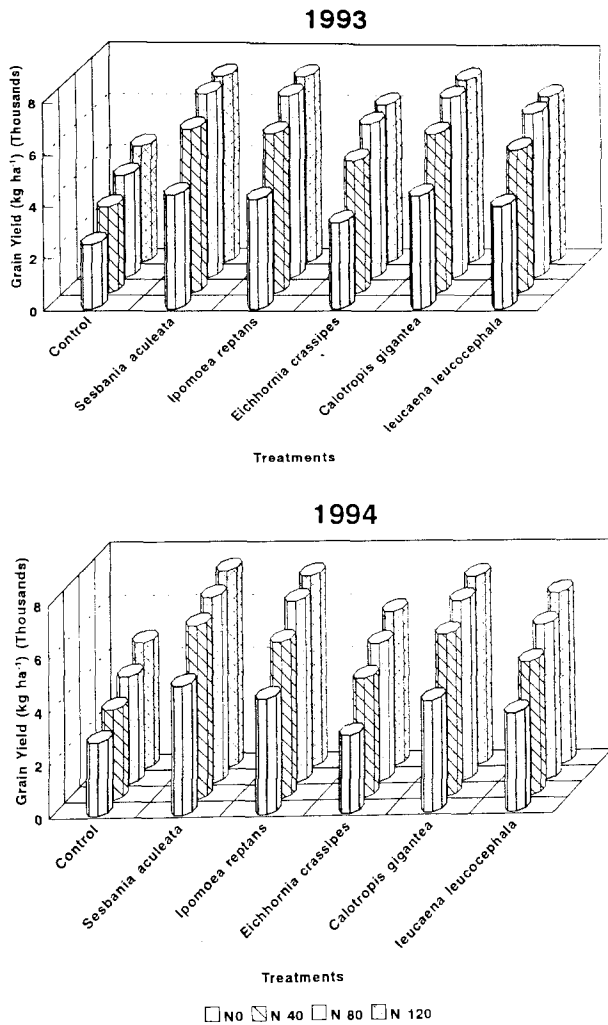


Fig.4. Effect of different GLMs and N levels on grain yield

Table 28. Effect of different GLMs and N levels on Grain yield of Kharif rice (kg ha⁻¹) - 1993

Treatment	N 0	N 40	N 80	N 120	Mean
Control	2476	3324	3950	4483	3558.3
<i>Sesbania aculeata</i>	4400	6350	7125	7225	6275.0
<i>Ipomoea reptans</i>	4250	6200	7075	7250	6193.8
<i>Eichhornia crassipes</i>	3338	5169	6013	6163	5170.8
<i>Calotropis gigantea</i>	4400	6225	7050	7175	6212.5
<i>Leucaena leucocephala</i>	4010	5610	6430	6510	5640.0
Mean	3812.3	5479.7	6273.8	6467.7	

SEd

CD

M

63.10

140.6

S

76.13

154.4

MxS

222.68

451.6

SxM

206.58

423.7

Table 29. Effect of different GLMs and N levels on Grain yield of Kharif rice (kg ha⁻¹) - 1994

Treatment	N 0	N 40	N 80	N 120	Mean
Control	2760	3413	4048	4740	3748.3
<i>Sesbania aculeata</i>	4880	6560	7020	7420	6470.0
<i>Ipomoea reptans</i>	4380	5920	6860	7220	6095.0
<i>Eichhornia crassipes</i>	2960	4520	5240	5840	4640.0
<i>Calotropis gigantea</i>	4240	6160	6840	7160	6100.0
<i>Leucaena leucocephala</i>	3740	5080	5900	6520	5310.0
Mean	3776.7	5258.2	5956.7	6433.3	

SEd

CD

M

56.48

125.84

S

73.70

149.47

MxS

180.53

366.12

SxM

217.30

441.12

to be a best- bet combinations than *Leucaena leucocephala* and *Eichhornia crassipes* with 120 kg N ha⁻¹. Different result was seen during 1993 Kharif, where in the rice grain yields were at par with GLMs applied either with 120 kg N ha⁻¹ or 80 kg N ha⁻¹. In the absence of any green leaf manure, higher level of N (120 kg N ha⁻¹) alone had produced non-statistical comparable rice grain yield at par with GLMs application alone.

4.1.4.2. Straw yield (Tables 30 and 31)

Straw yield was significantly influenced by the sources and levels of N. Among the main plot treatments, *Sesbania aculeata* incorporation registered the highest straw yield and it was at par with *Ipomoea reptans* and *Calotropis gigantea* treatments during 1993, while it was at par with *Ipomoea reptans* treatment during the Kharif season of 1994.

Nitrogen supply consistently increased the straw yield upto the highest level of N tried, though, the rate of increase was not commensurating with the increase in N levels.

The interaction effect between sources and levels of N was significant in both the years. In 1993, application of any one of the green leaf manures had increased the straw yield with 120 kg N ha⁻¹ and as well as with 80 kg N ha⁻¹ as compared to the other two levels tried in the present investigation, where as in the year 1994, during Kharif, GLMs application + 120 kg N ha⁻¹ registered significantly higher straw yield over other two levels of N and absolute control.

Table 30. Effect of different GLMs and N levels on straw yield of Kharif rice (kg ha⁻¹) - 1993

Treatment	N 0	N 40	N 80	N 120	Mean
Control	3015	4050	4615	5085	4191.3
<i>Sesbania aculeata</i>	4825	6675	7950	8225	6918.8
<i>Ipomoea reptans</i>	4725	6875	8050	8234	6971.0
<i>Eichhornia crassipes</i>	3938	5756	6675	6863	5808.0
<i>Calotropis gigantea</i>	4775	6975	7600	7850	6800.0
<i>Leucaena leucocephala</i>	4625	6400	7275	7475	6443.8
Mean	4317.2	6121.8	7027.5	7288.7	

SEd

CD

M	158.6	353.4
S	175.2	355.7
MxS	217.4	440.5
SxM	243.5	494.3

Table 31. Effect of different GLMs and N levels on straw yield of Kharif rice (kg ha⁻¹)- 1994

Treatment	N 0	N 40	N 80	N 120	Mean
Control	3239	4129	4769	5276	4353.3
<i>Sesbania aculeata</i>	5252	6896	7833	8447	7107.0
<i>Ipomoea reptans</i>	4869	6565	7617	8199	6812.5
<i>Eichhornia crassipes</i>	3490	5033	5817	6503	5210.8
<i>Calotropis gigantea</i>	4601	6902	7374	7833	6677.5
<i>Leucaena leucocephala</i>	4313	5795	6675	7486	6067.3
Mean	4294.0	5886.7	6680.8	7290.7	

SEd

CD

M	165.6	368.9
S	179.5	364.4
MxS	231.4	469.7
SxM	252.6	512.8

4.1.4.3. Harvest Index (HI)

The mean data on HI of Kharif rice for 1993 and 1994 are presented in Tables 32 and 33. The data on harvest index indicated that treatments receiving GLMs application recorded higher HI, when compared to control. In both the years, different levels of N did not alter the HI.

4.1.4.4. Productivity Score (PS) (Tables 34 and 35)

The Productivity Score was greatly influenced by the application of GLMs as well as by levels of N.

Among the GLMs, application of *Sesbania aculeata*, *Ipomoea reptans* and *Calotropis gigantea* was found better in increasing the productivity score. This was followed by *Leucaena leucocephala* and *Eichhornia crassipes*. Control registered the lowest PS.

Increasing levels of N, increased the PS. The response was found even upto 120 kg N ha⁻¹.

4.1.4.5. Relative Yield Index (RYI) (Tables 34 and 35)

RYI of Kharif rice in both the years followed the similar trend as that of rice grain yield. The results indicated that application of *Sesbania aculeata* recorded the highest RYI, followed by *Calotropis gigantea*, *Ipomoea reptans*, *Leucaena leucocephala* and *Eichhornia crassipes*.

Greater response for application of N was noticed with regard to RYI. Application of 120 kg N ha⁻¹ registered the maximum RYI.

Table 32. Effect of different GLMs and N levels on Harvest index of Kharif rice -1993

Treatment	N 0	N 40	N 80	N 120	Mean
Control	44.8	44.6	45.8	46.6	45.5
<i>Sesbania aculeata</i>	46.2	48.4	47.2	46.7	47.1
<i>Ipomoea reptans</i>	47.2	47.3	46.7	46.8	47.0
<i>Eichhornia crassipes</i>	45.6	46.9	47.3	46.9	46.7
<i>Calotropis gigantea</i>	47.7	46.9	47.7	47.5	47.5
<i>Leucaena leucocephala</i>	45.8	46.4	46.7	46.3	46.3
Mean	46.2	46.8	46.9	46.8	

Table 33. Effect of different GLMs and N levels on Harvest index of Kharif rice -1994

Treatment	N 0	N 40	N 80	N 120	Mean
Control	45.9	45.1	45.8	47.3	46.0
<i>Sesbania aculeata</i>	48.1	48.7	47.2	46.8	47.7
<i>Ipomoea reptans</i>	47.3	47.4	47.3	46.8	47.2
<i>Eichhornia crassipes</i>	45.9	47.3	47.3	47.3	46.9
<i>Calotropis gigantea</i>	47.9	47.3	48.1	47.7	47.8
<i>Leucaena leucocephala</i>	46.2	46.6	46.9	46.5	46.6
Mean	46.9	47.1	47.1	47.1	

Table 34. Productivity score - Kharif, 1993

Treatment	Economic yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Harvest index	Productivity score	Relative yield index
M ₁	3.56	7.80	45.5	56.86	79.1
M ₂	6.28	13.30	47.1	66.68	139.6
M ₃	6.19	13.18	47.0	66.37	137.6
M ₄	5.17	11.05	46.7	62.92	114.9
M ₅	6.21	13.10	47.5	66.81	138.0
M ₆	5.64	12.17	46.3	64.11	125.3
S ₁	3.81	8.22	46.2	58.23	84.7
S ₂	5.48	11.67	46.8	63.95	121.8
S ₃	6.27	13.35	46.9	66.52	139.3
S ₄	6.47	13.82	46.8	67.09	143.8

Table 35. Productivity score - Kharif, 1994

Treatment	Economic yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Harvest index	Productivity score	Relative yield index
M ₁	3.75	8.11	46.0	57.86	83.3
M ₂	6.47	13.59	47.7	67.76	143.8
M ₃	6.10	12.92	47.2	66.22	135.5
M ₄	4.64	9.86	46.9	61.40	103.1
M ₅	6.10	12.79	47.8	66.70	135.5
M ₆	5.31	11.39	46.6	63.30	118.0
S ₁	3.78	8.13	46.9	58.81	84.0
S ₂	5.26	11.17	47.1	63.53	116.9
S ₃	5.96	12.68	47.1	65.74	132.4
S ₄	6.43	13.78	47.1	67.31	142.9

4.1.5. Plant nutrients uptake

4.1.5.1. Nitrogen uptake (Tables 36 and 37)

Green leaf manure sources and levels of N had significant influence on N uptake at all the stages in both the years.

The N uptake increased with crop growth upto maturity (Fig. 5). The data on N uptake revealed that N accumulation was comparatively faster between AT and PI stages, while slower between PI and flowering stages and it increased considerably from flowering to harvesting stage.

During 1994, at AT stage, application of green leaf manures significantly influenced the N uptake over control. But in 1993, different green leaf manures did not show any measurable difference among themselves. In 1994, *Sesbania aculeata*, *Calotropis gigantea* and *Ipomoea reptans* were significantly superior as compared to *Leucaena leucocephala* and *Eichhornia crassipes* application in influencing the N uptake. In PI stage, all the green leaf manures showed a significant influence on N uptake over control. Highest N uptake was found in *Sesbania aculeata* followed by *Calotropis gigantea* which was at par with *Ipomoea reptans*. *Leucaena leucocephala* and *Eichhornia crassipes* applied treatments registered lesser N uptake as compared to the other green leaf manures in both the years. During flowering stage also, N uptake was the highest in *Sesbania aculeata* treatment. However, this was at par with *Calotropis gigantea*. *Ipomoea reptans* and *Leucaena leucocephala* treatments registered highest N uptake when compared to *Eichhornia crassipes* and control. During this stage *Eichhornia crassipes* failed to influence the N uptake. The same trend was noticed in 1994 also. At harvesting stage in both the years, all the green leaf manures applied treatments significantly influenced the N uptake of rice. *Sesbania aculeata* and *Calotropis gigantea* applied treatments registered significantly

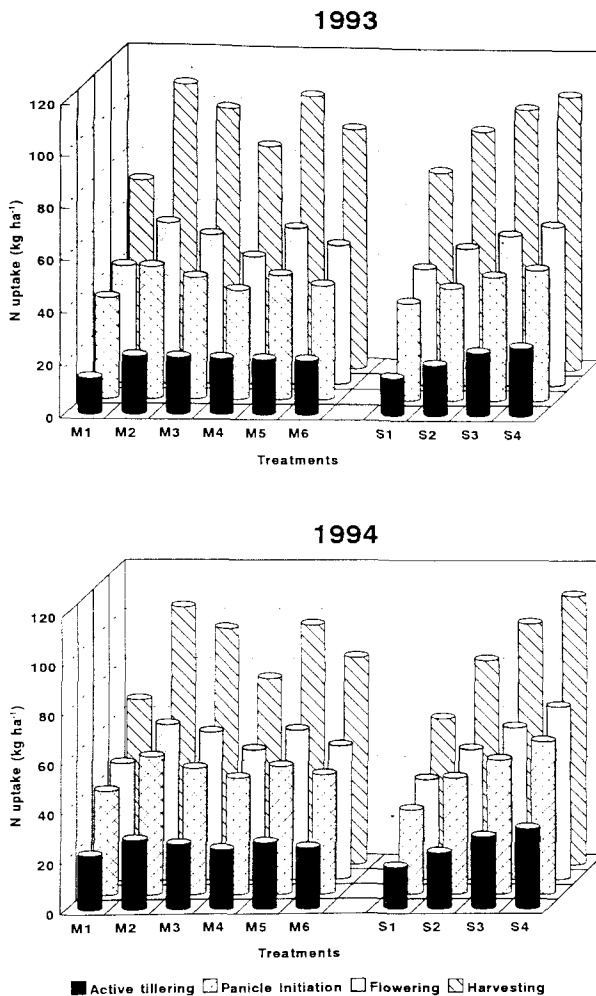


Fig.5. Effect of different GLMs and N levels on the N uptake at different growth stages

Table 36. Effect of different GLMs and N levels on the N uptake during Kharif season at different growth stages (kg ha⁻¹)- 1993

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	13.73	38.50	44.65	71.65
M ₂	22.15	50.35	61.33	108.88
M ₃	21.73	46.38	56.88	99.83
M ₄	21.40	41.70	48.65	85.33
M ₅	21.20	47.58	59.83	105.10
M ₆	20.90	43.73	53.38	92.38
SEd	0.59	1.01	1.97	2.86
CD(p=0.05)	1.31	2.26	4.39	6.37
Sub plot				
S ₁	14.37	37.40	44.80	76.13
S ₂	19.48	43.28	52.70	92.23
S ₃	24.33	47.70	57.65	100.93
S ₄	26.30	50.45	61.32	106.13
SEd	0.91	1.42	2.58	3.11
CD(p=0.05)	1.85	2.88	5.24	6.31
Interaction	Sig.	Sig.	Sig.	Sig.

M x S Interaction table

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
M ₁ S ₁	11.4	29.6	35.7	58.8
M ₁ S ₂	18.7	37.3	44.6	69.2
M ₁ S ₃	23.1	42.5	48.1	77.4
M ₁ S ₄	24.8	44.6	50.2	81.2
M ₂ S ₁	15.3	42.4	52.3	86.4
M ₂ S ₂	20.6	48.8	59.1	108.8
M ₂ S ₃	25.4	53.4	64.8	116.1
M ₂ S ₄	27.3	56.8	69.1	124.2
M ₃ S ₁	14.9	40.8	47.5	80.6
M ₃ S ₂	19.4	45.0	55.3	98.1
M ₃ S ₃	25.6	48.6	60.0	108.5
M ₃ S ₄	27.0	51.2	64.7	112.1
M ₄ S ₁	14.6	34.1	38.9	71.9
M ₄ S ₂	19.6	40.6	46.2	83.7
M ₄ S ₃	25.0	44.9	53.8	90.3
M ₄ S ₄	26.4	47.2	55.7	95.4
M ₅ S ₁	15.6	40.5	51.2	83.1
M ₅ S ₂	19.6	45.3	58.3	102.1
M ₅ S ₃	23.7	50.5	62.0	114.6
M ₅ S ₄	25.9	54.0	67.8	120.6
M ₆ S ₁	14.4	37.0	43.2	76.0
M ₆ S ₂	19.0	42.7	52.7	91.5
M ₆ S ₃	23.8	46.3	57.2	98.7
M ₆ S ₄	26.4	48.9	60.4	103.3
M SEd	0.59	1.01	1.97	2.86
CD	1.31	2.26	4.39	6.37
S SEd	0.91	1.42	2.58	3.11
CD	1.85	2.88	5.24	6.31
MxS SEd	0.97	1.48	2.61	3.86
CD	1.96	3.01	5.30	7.83
SxM SEd	1.00	1.64	2.73	4.05
CD	2.04	3.33	5.54	8.22

Significant at 5 per cent level

Table 37. Effect of different GLMs and N levels on the N uptake during Kharif season at different growth stages (kg ha^{-1})- 1994

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	21.78	42.08	47.38	67.13
M ₂	28.00	55.90	62.95	104.75
M ₃	26.25	51.15	59.83	95.98
M ₄	24.05	47.30	52.73	75.68
M ₅	26.88	51.98	60.68	97.43
M ₆	24.75	48.53	54.20	84.23
SEd	0.71	1.15	1.66	2.54
CD(p=0.05)	1.58	2.56	3.69	5.66
Sub plot				
S ₁	16.85	34.17	40.67	59.37
S ₂	22.67	47.25	52.78	83.08
S ₃	29.17	54.50	61.62	98.12
S ₄	32.45	62.03	70.10	109.55
SEd	1.14	1.62	1.85	2.86
CD(p=0.05)	2.31	3.29	3.76	5.81
Interaction	Sig.	Sig.	Sig.	Sig.

M x S Interaction table

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
M ₁ S ₁	13.1	32.8	35.6	48.4
M ₁ S ₂	20.8	38.6	43.4	68.2
M ₁ S ₃	25.3	45.6	52.3	72.4
M ₁ S ₄	27.9	51.3	58.2	79.5
M ₂ S ₁	18.8	37.2	45.2	68.3
M ₂ S ₂	24.4	53.4	62.1	96.5
M ₂ S ₃	32.5	61.2	68.9	123.5
M ₂ S ₄	36.3	71.8	75.6	130.7
M ₃ S ₁	17.5	34.4	43.6	62.1
M ₃ S ₂	22.6	49.4	56.9	88.3
M ₃ S ₃	30.7	56.9	64.7	111.1
M ₃ S ₄	34.2	63.9	74.1	122.4
M ₄ S ₁	16.4	33.6	37.6	53.6
M ₄ S ₂	21.9	43.8	46.8	73.7
M ₄ S ₃	27.4	52.3	58.9	79.6
M ₄ S ₄	30.5	59.5	67.6	95.8
M ₅ S ₁	18.5	33.9	43.2	65.4
M ₅ S ₂	24.8	51.8	59.0	91.4
M ₅ S ₃	30.5	58.1	65.7	109.4
M ₅ S ₄	33.7	64.1	74.8	123.5
M ₆ S ₁	16.8	33.1	38.8	58.4
M ₆ S ₂	21.5	46.5	48.5	80.4
M ₆ S ₃	28.6	52.9	59.2	92.7
M ₆ S ₄	32.1	61.6	70.3	105.4
M SEd	0.71	1.15	1.66	2.54
CD	1.58	2.56	3.69	5.66
S SEd	1.14	1.62	1.85	2.86
CD	2.31	3.29	3.76	5.81
MxS SEd	1.22	1.83	2.15	3.12
CD	2.48	3.71	4.36	6.33
SxM SEd	1.41	1.89	2.22	3.21
CD	2.86	3.84	4.51	6.52

Significant at 5 per cent level

increased N uptake when compared to other green leaf manures. N uptake under *Ipomoea reptans* incorporated treatment was also comparable with the *Calotropis gigantea* applied plot.

Nitrogen levels had positive influence on the uptake of N by rice at all stages. The highest dose (120 kg N ha⁻¹) registered the highest N uptake. However, it was at par with the N uptake under 80 kg N ha⁻¹ during the year 1993. The lowest N uptake was observed with control.

Interaction effect was significant in all the four stages of growth in both the years. At all N levels, green leaf manures addition increased N uptake over fertilizer N alone. Among different combinations of N levels and green leaf manures studied, combined application of *Sesbania aculeata* + 120 kg N ha⁻¹ registered the highest N uptake and was comparable with *Calotropis gigantea* at PI, flowering and harvesting stages in both the years, but higher than *Ipomoea reptans*, *Leucaena leucocephala* and *Eichhornia crassipes*.

4.1.5.2. Phosphorus uptake (Tables 338 and 39)

Green leaf manures and N levels had significant influence on P uptake at all stages in both the years.

Green leaf manuring promoted the uptake of P in rice. The maximum uptake was noticed in *Calotropis gigantea* applied plot upto flowering stage. However, it was comparable with *Ipomoea reptans*, *Sesbania aculeata* and *Leucaena leucocephala* in the above stages. At harvesting stage, the maximum uptake of P was recorded by *Ipomoea reptans* applied plot and was at par with *Sesbania aculeata*,

Table 38. Effect of different GLMs and N levels on the P uptake during Kharif season at different growth stages (kg ha⁻¹)- 1993

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	3.19	8.75	11.03	20.30
M ₂	3.57	10.00	12.90	27.77
M ₃	3.51	10.18	12.81	28.64
M ₄	3.34	9.24	12.09	22.97
M ₅	3.81	10.45	13.02	27.72
M ₆	3.55	9.64	12.33	25.86
SEd	0.15	0.39	0.51	1.25
CD(p=0.05)	0.33	0.87	1.14	2.79
Sub plot				
S ₁	2.74	6.85	10.11	21.46
S ₂	3.28	9.21	12.26	24.50
S ₃	3.73	10.86	12.95	26.99
S ₄	4.23	11.93	14.13	29.22
SEd	0.22	0.52	0.67	1.33
CD(p=0.05)	0.45	1.06	1.36	2.70
Interaction	NS	Sig.	Sig.	Sig.

NS = Not significant

M x S Interaction table

Treatment	Panicle Initiation	Flowering	Harvesting
M ₁ S ₁	6.35	8.75	16.87
M ₁ S ₂	9.59	11.37	19.72
M ₁ S ₃	9.00	11.89	21.38
M ₁ S ₄	10.07	12.11	23.21
M ₂ S ₁	7.20	10.93	22.94
M ₂ S ₂	9.23	12.74	27.46
M ₂ S ₃	11.33	13.30	29.55
M ₂ S ₄	12.25	14.64	31.13
M ₃ S ₁	6.90	10.18	24.77
M ₃ S ₂	9.42	12.98	28.00
M ₃ S ₃	11.41	13.15	29.49
M ₃ S ₄	13.00	14.92	32.30
M ₄ S ₁	6.38	9.52	18.71
M ₄ S ₂	8.68	12.06	21.26
M ₄ S ₃	10.52	12.74	24.32
M ₄ S ₄	11.36	14.05	27.59
M ₅ S ₁	7.44	11.12	23.73
M ₅ S ₂	9.58	12.85	26.13
M ₅ S ₃	11.84	13.33	29.80
M ₅ S ₄	12.93	14.79	31.22
M ₆ S ₁	6.84	10.17	21.73
M ₆ S ₂	8.73	11.58	24.42
M ₆ S ₃	11.05	13.30	27.42
M ₆ S ₄	11.95	14.28	29.88
M SEd	0.39	0.51	1.25
CD	0.87	1.14	2.79
S SEd	0.52	0.67	1.33
CD	1.06	1.36	2.70
MxS SEd	0.68	0.75	1.45
CD	1.38	1.52	2.94
SxM SEd	0.71	0.83	1.66
CD	1.44	1.69	3.37

Significant at 5 per cent level

Table 39. Effect of different GLMs and N levels on the P uptake during Kharif season at different growth stages (kg ha⁻¹)- 1994

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	3.26	8.49	11.02	22.69
M ₂	4.96	12.76	15.41	30.27
M ₃	4.67	11.41	14.06	29.40
M ₄	4.19	9.84	11.91	24.98
M ₅	4.71	12.96	14.03	30.73
M ₆	4.28	10.74	12.71	27.20
SEd	0.18	0.42	0.72	1.16
CD(p=0.05)	0.40	0.94	1.60	2.58
Sub plot				
S ₁	3.15	8.32	10.43	24.28
S ₂	4.27	10.29	12.68	26.66
S ₃	4.77	12.24	14.14	28.85
S ₄	5.18	13.29	15.51	30.39
SEd	0.31	0.55	0.85	1.24
CD(p=0.05)	0.69	1.23	1.89	2.76
Interaction	Sig.	Sig.	Sig.	Sig.

M x S Interaction table

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
M ₁ S ₁	2.64	6.32	8.73	20.83
M ₁ S ₂	3.19	8.50	11.35	22.34
M ₁ S ₃	3.31	9.02	11.84	23.34
M ₁ S ₄	3.88	10.11	12.14	24.24
M ₂ S ₁	3.76	9.20	12.90	26.90
M ₂ S ₂	4.82	12.26	14.78	29.48
M ₂ S ₃	5.42	14.35	16.33	31.59
M ₂ S ₄	5.85	15.22	17.64	33.11
M ₃ S ₁	3.20	8.86	10.21	25.81
M ₃ S ₂	4.58	10.44	13.95	28.98
M ₃ S ₃	5.13	12.38	15.13	30.52
M ₃ S ₄	5.77	13.97	16.96	32.29
M ₄ S ₁	2.92	7.40	8.55	21.69
M ₄ S ₂	4.37	8.55	11.42	24.23
M ₄ S ₃	4.56	11.22	13.39	26.36
M ₄ S ₄	4.89	12.19	14.26	27.64
M ₅ S ₁	3.34	9.48	11.66	26.71
M ₅ S ₂	4.54	12.24	12.94	29.18
M ₅ S ₃	5.33	14.79	14.63	32.82
M ₅ S ₄	5.64	15.33	16.88	34.21
M ₆ S ₁	3.03	8.63	10.52	23.76
M ₆ S ₂	4.16	9.74	11.62	25.74
M ₆ S ₃	4.89	11.68	13.54	28.44
M ₆ S ₄	5.02	12.92	15.16	30.86
M SEd	0.18	0.42	0.72	1.16
CD	0.40	0.94	1.60	2.58
S SEd	0.31	0.55	0.85	1.24
CD	0.69	1.23	1.89	2.76
MxS SEd	0.46	0.71	1.01	1.33
CD	1.02	1.58	2.25	2.96
SxM SEd	0.52	0.85	1.22	1.54
CD	1.16	1.89	2.72	3.43

Significant at 5 per cent level

Calotropis gigantea and *Leucaena leucocephala*. *Eichhornia crassipes* failed to influence the P uptake and was at par with control plot at PI, flowering and harvesting stages.

Phosphorus uptake increased with N levels and maximum P uptake was noticed under 120 kg N ha⁻¹ treatment at all the stages of observation. However, P uptake at 120 and 80 kg N ha⁻¹ did not differ significantly.

Interaction effect was significant at all the stages except AT stage. Increased P uptake was recorded with 120 kg N ha⁻¹ in the presence of green leaf manuring, while lesser P uptake was noticed under control (no GLMs and no N)

4.1.5.3. Potassium uptake (Tables 40 and 41)

Levels of N as well as green leaf manures had significant effect on K uptake of rice at all stages in both the years of study.

Potassium uptake was significantly influenced by green leaf manures application and the maximum K uptake was with *Sesbania aculeata*, but they didn't differ between them.

Potassium uptake increased with levels of N and highest K uptake was noticed at 120 kg N ha⁻¹, but this uptake was at par with the K uptake under 80 kg N ha⁻¹.

Interaction effect was significant. Increased K uptake was seen for combined application of 120 kg N ha⁻¹ + green leaf manures.

Table 40. Effect of different GLMs and N levels on the K uptake during Kharif season at different growth stages (kg ha⁻¹)- 1993

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	37.20	78.73	87.97	87.97
M ₂	42.55	85.59	96.30	122.42
M ₃	40.15	81.98	90.98	117.53
M ₄	39.19	77.66	87.32	112.62
M ₅	41.26	83.95	95.12	120.42
M ₆	40.43	80.34	90.29	116.49
SEd	1.21	2.12	3.35	6.85
CD(p=0.05)	2.70	4.72	7.46	15.26
Sub plot				
S ₁	35.27	74.51	84.73	104.73
S ₂	39.29	79.79	89.62	115.18
S ₃	42.07	84.18	93.82	121.62
S ₄	43.89	87.04	97.16	125.26
SEd	1.28	2.56	3.86	7.22
CD(p=0.05)	2.60	5.20	7.84	14.66
Interaction	Sig.	NS	Sig	Sig

NS = Not significant.

M x S Interaction table

Treatment	Active Tillering	Flowering	Harvesting
M ₁ S ₁	33.22	82.52	99.92
M ₁ S ₂	36.42	86.12	108.83
M ₁ S ₃	38.98	90.78	115.15
M ₁ S ₄	40.17	92.47	119.37
M ₂ S ₁	37.36	88.24	108.33
M ₂ S ₂	41.63	93.27	121.37
M ₂ S ₃	44.23	99.07	128.17
M ₂ S ₄	46.97	104.63	131.82
M ₃ S ₁	34.57	84.64	106.47
M ₃ S ₂	39.05	89.68	116.87
M ₃ S ₃	42.62	93.17	121.77
M ₃ S ₄	44.36	96.42	125.00
M ₄ S ₁	35.27	83.17	100.17
M ₄ S ₂	38.17	86.38	110.47
M ₄ S ₃	41.13	88.97	118.42
M ₄ S ₄	42.20	90.76	121.03
M ₅ S ₁	35.48	86.04	107.09
M ₅ S ₂	40.87	93.42	118.96
M ₅ S ₃	43.10	98.37	125.92
M ₅ S ₄	45.58	102.66	129.69
M ₆ S ₁	35.73	83.76	106.42
M ₆ S ₂	39.57	88.83	114.58
M ₆ S ₃	42.38	92.57	120.27
M ₆ S ₄	44.03	96.02	124.67
M SEd	1.21	3.35	6.85
CD	2.70	7.46	15.26
S SEd	1.28	3.86	7.22
CD	2.60	7.84	14.66
MxS SEd	1.33	4.01	7.31
CD	2.70	8.14	14.84
SxM SEd	1.48	4.16	7.45
CD	3.00	8.44	15.12

Significant at 5 per cent level

Table 41. Effect of different GLMs and N levels on the K uptake during Kharif season at different growth stages (kg ha⁻¹)- 1994

Treatment	Active Tillering	Panicle Initiation	Flowering	Harvesting
Main plot				
M ₁	46.03	84.77	90.92	112.43
M ₂	51.80	92.97	100.02	122.75
M ₃	50.18	91.38	97.48	120.94
M ₄	46.94	85.20	93.32	111.06
M ₅	52.27	91.37	98.21	122.07
M ₆	48.59	88.73	95.42	119.30
SEd	1.03	1.87	2.96	4.96
CD(p=0.05)	2.29	4.16	6.59	11.05
Sub plot				
S ₁	44.89	82.88	88.36	113.64
S ₂	48.78	87.56	94.35	117.68
S ₃	51.09	91.39	99.31	120.21
S ₄	52.44	94.52	101.57	120.83
SEd	1.22	1.93	3.20	5.40
CD(p=0.05)	2.48	3.92	6.50	10.96
Interaction	Sig.	Sig.	Sig.	NS

NS = Not significant

M x S Interaction table

Treatment	Active Tillering	Panicle Initiation	Flowering
M ₁ S ₁	42.62	76.34	85.22
M ₁ S ₂	45.42	84.98	90.44
M ₁ S ₃	47.24	87.43	93.17
M ₁ S ₄	48.84	90.34	94.86
M ₂ S ₁	47.27	85.57	92.44
M ₂ S ₂	51.39	91.46	98.24
M ₂ S ₃	53.42	95.81	103.80
M ₂ S ₄	55.12	99.02	150.60
M ₃ S ₁	45.25	88.23	88.84
M ₃ S ₂	49.20	87.91	93.52
M ₃ S ₃	52.54	92.48	102.95
M ₃ S ₄	53.73	96.91	104.61
M ₄ S ₁	43.49	79.75	86.33
M ₄ S ₂	46.68	83.53	92.24
M ₄ S ₃	48.08	87.04	96.43
M ₄ S ₄	49.50	90.47	98.28
M ₅ S ₁	46.41	84.89	90.66
M ₅ S ₂	51.72	89.62	96.83
M ₅ S ₃	54.53	94.38	101.25
M ₅ S ₄	56.40	96.57	104.10
M ₆ S ₁	44.32	82.12	86.67
M ₆ S ₂	48.27	87.83	94.80
M ₆ S ₃	50.72	91.20	98.27
M ₆ S ₄	51.04	93.78	101.95
M SEd	1.03	1.87	2.96
CD	2.29	4.16	6.59
S SEd	1.22	1.93	3.20
CD	2.48	3.92	6.50
MxS SEd	1.45	2.01	3.31
CD	2.94	4.08	6.72
SxM SEd	1.56	2.13	3.35
CD	3.17	4.32	6.80

Significant at 5 per cent level

4.1.6. Use efficiencies

Agronomic Efficiency(AE), Physiological Efficiency (PE), Apparent N Recovery (ANR) and N Harvest Index (NHI) were computed for harvest stage. These data were not analysed statistically.

4.1.6.1. Agronomic efficiency (Tables 42 and 43)

The AE was highly improved with the fertilizer N at 40 kg N ha⁻¹ in both the years. The next best was 80 kg N ha⁻¹ followed by 120 kg N ha⁻¹.

Agronomic efficiency with GLMs alone, in general, was lower than with fertilizer N. Irrespective of N levels, among the green leaf manures, highest AE was observed with *Sesbania aculeata*. This was followed by *Ipomoea reptans* and *Calotropis gigantea*, both recorded almost equal AE in both the years. The next best was *Leucaena leucocephala*. *Eichhornia crassipes* registered the lowest AE.

4.1.6.2. Physiological efficiency (Tables 44 and 45)

Physiological Efficiency (PE) was higher with lower doses of N. When the level of N was increased, the PE was decreased. The GLMs applied plots generally registered higher PE than their control. However, during 1994, the plot receiving *Sesbania aculeata* registered lower PE (46.35) as compared to control(50.55). Among the green leaf manures, PE was the highest with *Eichhornia crassipes* applied plot. Similar results were experienced in both the years of study.

**Table 42. Effect of different GLMs and N levels on Agronomic Efficiency
-1993 (Kharif)**

Treatment	N 40	N 80	N 120	Mean
Control	21.23	18.43	16.73	18.80
<i>Sesbania aculeata</i>	48.75	34.06	23.25	35.45
<i>Ipomoea reptans</i>	48.75	35.31	25.00	36.35
<i>Eichhornia crassipes</i>	45.78	33.44	23.54	34.25
<i>Calotropis gigantea</i>	45.63	33.13	23.13	33.96
<i>Leucaena leucocephala</i>	40.00	30.25	20.83	30.36
Mean	41.69	30.77	22.08	

**Table 43. Effect of different GLMs and N levels on Agronomic Efficiency
- 1994 (Kharif)**

Treatment	N 40	N 80	N 120	Mean
Control	16.33	16.50	16.50	16.44
<i>Sesbania aculeata</i>	42.00	26.75	21.17	29.97
<i>Ipomoea reptans</i>	38.50	31.00	23.67	31.06
<i>Eichhornia crassipes</i>	39.00	28.50	24.00	30.50
<i>Calotropis gigantea</i>	48.00	32.50	24.33	34.94
<i>Leucaena leucocephala</i>	33.50	27.00	23.17	27.89
Mean	36.22	27.04	22.14	

**Table 44. Effect of different GLMs and N levels on Physiological Efficiency
- 1993 (Kharif)**

Treatment	N 40	N 80	N 120	Mean
Control	81.54	77.99	89.59	83.04
<i>Sesbania aculeata</i>	87.05	91.75	74.74	84.51
<i>Ipomoea reptans</i>	111.43	101.25	95.24	102.64
<i>Eichhornia crassipes</i>	155.17	145.38	120.21	140.25
<i>Calotropis gigantea</i>	96.05	84.13	74.00	84.73
<i>Leucaena leucocephala</i>	103.23	106.61	91.58	100.47
Mean	105.75	101.19	90.23	

**Table 45. Effect of different GLMs and N levels on Physiological Efficiency
- 1994 (Kharif)**

Treatment	N 40	N 80	N 120	Mean
Control	32.98	55.00	63.67	50.55
<i>Sesbania aculeata</i>	59.57	38.77	40.71	46.35
<i>Ipomoea reptans</i>	58.78	50.61	47.10	52.16
<i>Eichhornia crassipes</i>	77.61	87.69	68.25	77.85
<i>Calotropis gigantea</i>	73.85	59.09	50.26	61.07
<i>Leucaena leucocephala</i>	60.91	62.97	59.15	61.01
Mean	60.62	59.02	54.86	

4.1.6.3. Apparent N recovery (Tables 46 and 47)

In both the years, the highest Apparent N Recovery (ANR) was seen where *Sesbania aculeata* was incorporated. This was followed by *Calotropis gigantea*, *Ipomoea reptans*, *Leucaena leucocephala* and *Eichhornia crassipes*. Lowest ANR was registered by green leaf manure control.

Among the levels of N, the highest ANR was recorded by 40 kg N ha⁻¹. This was followed by 80 kg N ha⁻¹ and 120 kg N ha⁻¹. Lower levels of N (40 kg N ha⁻¹) combined with GLMs registered the highest ANR. Higher level of N as fertilizer with out any GLMs registered the lowest ANR.

4.1.6.4. Nitrogen harvest index (Tables 48 and 49)

Nitrogen Harvest Index (NHI), was influenced by levels of N as well as by green leaf manures. All the green leaf manures registered highest NHI than their control. Among the green leaf manures, *Sesbania aculeata*, *Ipomoea reptans* and *Calotropis gigantea* registered nonstatistical comparable NHI. This was followed by *Leucaena leucocephala* and *Eichhornia crassipes*. Lowest NHI was observed with control.

Among the levels of N, 120 kg N ha⁻¹ recorded the maximum NHI value. It is interesting to note that, unlike other three N use efficiency parameters, in the case of NHI, the trend was reverse and the NHI values were higher with higher levels of N.

4.1.7. Post harvest soil available N after Kharif rice (Tables 50 and 51)

Green leaf manuring and levels of N altered the post harvest soil available N to a greater extent. Green leaf manuring left higher soil available N when compared to no green leaf manuring. Among the green leaf manures, *Ipomoea reptans*, *Leucaena*

**Table 46. Effect of different GLMs and N levels on Apparent N Recovery
- 1993 (Kharif)**

Treatment	N 40	N 80	N 120	Mean
Control	26.00	23.25	18.67	22.64
<i>Sesbania aculeata</i>	56.00	37.13	31.50	41.54
<i>Ipomoea reptans</i>	43.75	34.88	26.25	34.96
<i>Eichhornia crassipes</i>	29.50	23.00	19.58	24.03
<i>Calotropis gigantea</i>	47.50	39.38	31.25	39.38
<i>Leucaena leucocephala</i>	38.75	28.38	22.75	29.96
Mean	40.25	30.10	25.00	

**Table 47. Effect of different GLMs and N levels on Apparent N Recovery
- 1994 (Kharif)**

Treatment	N 40	N 80	N 120	Mean
Control	49.50	30.00	25.92	35.14
<i>Sesbania aculeata</i>	70.50	69.00	52.00	63.83
<i>Ipomoea reptans</i>	65.50	61.25	50.25	59.00
<i>Eichhornia crassipes</i>	50.25	32.50	35.17	39.31
<i>Calotropis gigantea</i>	65.00	55.00	48.42	56.14
<i>Leucaena leucocephala</i>	55.00	42.88	39.17	45.68
Mean	59.29	48.44	41.82	

**Table 48. Effect of different GLMs and N levels on N Harvest Index
- 1993 (Kharif)**

Treatment	N 0	N 40	N 80	N 120	Mean
Control	43.1	52.3	55.6	57.1	52.03
<i>Sesbania aculeata</i>	51.3	58.0	59.9	61.0	57.55
<i>Ipomoea reptans</i>	50.8	57.7	59.7	61.1	57.30
<i>Eichhornia crassipes</i>	46.4	54.8	57.4	59.0	54.40
<i>Calotropis gigantea</i>	51.1	57.9	60.0	60.7	57.43
<i>Leucaena leucocephala</i>	47.9	55.2	58.0	59.3	55.10
Mean	48.43	55.98	58.43	59.70	

**Table 49. Effect of different GLMs and N levels on N Harvest Index
- 1994 (Kharif)**

Treatment	N 0	N 40	N 80	N 120	Mean
Control	41.7	54.5	55.8	59.1	52.78
<i>Sesbania aculeata</i>	54.4	57.2	57.1	60.5	57.30
<i>Ipomoea reptans</i>	51.8	55.5	56.5	57.4	55.30
<i>Eichhornia crassipes</i>	44.0	50.4	54.2	56.7	51.33
<i>Calotropis gigantea</i>	53.4	56.3	57.3	60.3	56.83
<i>Leucaena leucocephala</i>	49.6	53.2	54.5	58.2	53.87
Mean	49.15	54.51	55.90	58.70	

Table 50. Effect of different GLMs and N levels on post harvest soil available N (kg ha^{-1}) - 1993 (Kharif)

Treatment	N 0	N 40	N 80	N 120	Mean
Control	236.2	251.4	263.6	269.5	255.2
<i>Sesbania aculeata</i>	238.3	257.7	270.5	283.3	262.5
<i>Ipomoea reptans</i>	260.4	276.8	281.2	292.8	277.8
<i>Eichhornia crassipes</i>	240.4	251.6	265.8	277.9	258.9
<i>Calotropis gigantea</i>	256.2	269.7	278.4	288.1	273.1
<i>Leucaena leucocephala</i>	259.1	273.3	280.4	291.4	276.1
Mean	248.4	263.4	273.3	283.8	

SEd

CD

M	2.62	5.84
S	3.04	6.17
MxS	3.87	7.86
SxM	4.12	8.36

Table 51. Effect of different GLMs and N levels on post harvest soil available N (kg ha^{-1}) - 1994 (Kharif)

Treatment	N 0	N 40	N 80	N 120	Mean
Control	223.5	233.9	244.1	252.0	238.4
<i>Sesbania aculeata</i>	230.9	243.5	249.7	266.0	247.5
<i>Ipomoea reptans</i>	253.2	266.9	274.1	285.8	270.0
<i>Eichhornia crassipes</i>	237.5	242.1	247.0	265.2	248.0
<i>Calotropis gigantea</i>	247.2	258.1	270.0	281.9	264.3
<i>Leucaena leucocephala</i>	248.7	266.1	272.9	278.8	266.6
Mean	240.2	251.8	259.6	271.6	

SEd

CD

M	2.71	6.04
S	2.92	5.93
MxS	3.16	6.41
SxM	3.27	6.64

leucocephala and *Calotropis gigantea* left significantly higher soil available N. The increase was 8.86, 8.19 and 7.01 during 1993 and 13.26, 11.83 and 10.86 percentage during 1994 respectively over control. This was followed by *Sesbania aculeata* (2.86 in 1993 and 3.82 % in 1994) and *Eichhornia crassipes* (1.5 and 4.03 %).

Levels of N showed a marked increase in post harvest soil available N status. Increasing N levels had increased post harvest soil available N. The increase was 6.04, 10.02 and 14.25 Per cent in 1993 and 4.83, 8.08 and 13.07 per cent in 1994 corresponding to 40, 80 and 120 kg N ha⁻¹ respectively over control.

The interaction effect was also found to be significant. The highest values were obtained in *Ipomoea reptans* + 120 kg N ha⁻¹ which was comparable with *Leucaena leucocephala* and *Calotropis gigantea* at same N level.

4.1.8. Soil available N balance after Kharif rice (Tables 52 and 53)

During the year 1993, before the start of Kharif rice, the initial soil N status was 270 kg N ha⁻¹. Green leaf manures were applied at equal N basis and the quantity of N supplied through GLMs was 45.03 kg N ha⁻¹. As per sub-plot treatments fertilizer N was added at the rate of 0, 40, 80 and 120 kg N ha⁻¹. The total quantity of N applied ranged between 0 and 165.03 kg ha⁻¹ for various treatments.

Uptake of N by Kharif rice was minimum in absolute control plot and maximum in *Sesbania aculeata* + 120 kg N ha⁻¹ and was comparable with *Calotropis gigantea* + 120 kg N ha⁻¹. The N balance of 1993 indicated that the treatment M₆S₄ (*Leucaena leucocephala* + 120 kg N ha⁻¹) had shown a positive computed balance of +61.73 kg against the actual balance of 291.4 kg, where net gain was +21.4 kg ha⁻¹. This was followed by M₇S₄ (*Calotropis gigantea* + 120 kg N ha⁻¹). On the other side, higher negative value (-58.8) was obtained for M₁S₁ (no GLM and no N).

Table 52. Available soil N balance - After Kharif, 1993

Treat.	Initial soil N status Kg ha ⁻¹	N applied as GLMs Kg ha ⁻¹	N applied as Urea Kg ha ⁻¹	Total quantity of N applied Kg ha ⁻¹	N uptake by the Kharif crop Kg ha ⁻¹	Computed Balance	Actual Balance	Net gain or loss
M ₁ S ₁	270	0	0	0	58.8	-58.8	236.2	-33.8
M ₁ S ₂	270	0	40	40	69.2	-29.2	251.4	-18.6
M ₁ S ₃	270	0	80	80	77.4	+2.6	263.6	-6.4
M ₁ S ₄	270	0	120	120	81.2	+38.8	269.5	-0.5
M ₂ S ₁	270	45.03	0	45.03	86.4	-41.37	238.3	-31.7
M ₂ S ₂	270	45.03	40	85.03	108.8	-23.77	257.7	-12.3
M ₂ S ₃	270	45.03	80	125.03	116.1	+8.93	270.5	+0.5
M ₂ S ₄	270	45.03	120	165.03	124.2	+40.83	283.3	+13.3
M ₃ S ₁	270	45.03	0	45.03	80.6	-35.57	260.4	-9.6
M ₃ S ₂	270	45.03	40	85.03	98.1	-13.07	276.8	+6.8
M ₃ S ₃	270	45.03	80	125.03	108.5	+16.53	281.2	+11.2
M ₃ S ₄	270	45.03	120	165.03	112.1	+52.93	292.8	+22.8
M ₄ S ₁	270	45.03	0	45.03	71.9	-26.87	240.4	-29.6
M ₄ S ₂	270	45.03	40	85.03	83.7	+1.33	251.6	-18.4
M ₄ S ₃	270	45.03	80	125.03	90.3	+34.73	265.8	-4.2
M ₄ S ₄	270	45.03	120	165.03	95.4	+69.63	277.9	+7.9
M ₅ S ₁	270	45.03	0	45.03	83.1	-38.07	256.2	-13.8
M ₅ S ₂	270	45.03	40	85.03	102.1	-17.03	269.7	-0.3
M ₅ S ₃	270	45.03	80	125.03	114.6	+10.43	278.4	+8.4
M ₅ S ₄	270	45.03	120	165.03	120.6	+44.43	288.1	+18.1
M ₆ S ₁	270	45.03	0	45.03	76.0	-30.97	259.1	-10.9
M ₆ S ₂	270	45.03	40	85.03	91.5	-6.47	273.3	+3.3
M ₆ S ₃	270	45.03	80	125.03	98.7	+26.33	280.4	+10.4
M ₆ S ₄	270	45.03	120	165.03	103.3	+61.73	291.4	+21.4

Table 53. Available soil N balance - After Kharif, 1994

Treat	Initial soil N status Kg ha ⁻¹	N applied as GLMs Kg ha ⁻¹	N applied as Urea Kg ha ⁻¹	Total quantity of N applied Kg ha ⁻¹	N uptake by the Kharif crop Kg ha ⁻¹	Computed Balance	Actual Balance	Net gain or loss
M ₁ S ₁	254.3	0	0	0	48.4	-48.4	223.5	-30.8
M ₁ S ₂	254.3	0	40	40	68.2	-28.2	233.9	-20.4
M ₁ S ₃	254.3	0	80	80	72.4	+7.6	244.1	-10.2
M ₁ S ₄	254.3	0	120	120	79.5	+40.5	252.0	-2.3
M ₂ S ₁	254.3	54.57	0	54.57	68.3	-13.73	230.9	-23.4
M ₂ S ₂	254.3	54.57	40	94.57	96.5	-19.3	243.5	-10.8
M ₂ S ₃	254.3	54.57	80	134.57	123.5	+11.07	249.7	-4.6
M ₂ S ₄	254.3	54.57	120	174.57	130.7	+52.17	266.0	+11.7
M ₃ S ₁	254.3	54.57	0	54.57	62.1	-7.53	253.2	-1.1
M ₃ S ₂	254.3	54.57	40	94.57	88.3	+6.27	266.9	+12.6
M ₃ S ₃	254.3	54.57	80	134.57	111.1	+23.47	274.1	+19.8
M ₃ S ₄	254.3	54.57	120	174.57	122.4	+52.17	285.8	+31.5
M ₄ S ₁	254.3	54.57	0	54.57	53.6	+0.97	237.5	-16.8
M ₄ S ₂	254.3	54.57	40	94.57	73.7	+20.87	242.1	-12.2
M ₄ S ₃	254.3	54.57	80	134.57	79.6	+54.97	247.0	-7.3
M ₄ S ₄	254.3	54.57	120	174.57	95.8	+78.77	265.2	+10.9
M ₅ S ₁	254.3	54.57	0	54.57	65.4	-10.83	247.2	-7.1
M ₅ S ₂	254.3	54.57	40	94.57	91.4	+3.17	258.1	+3.8
M ₅ S ₃	254.3	54.57	80	134.57	109.4	+25.17	270.0	+15.7
M ₅ S ₄	254.3	54.57	120	174.57	123.5	+51.07	281.9	+27.6
M ₆ S ₁	254.3	54.57	0	54.57	58.4	-3.83	248.7	-5.6
M ₆ S ₂	254.3	54.57	40	94.57	80.4	+14.17	266.1	+11.8
M ₆ S ₃	254.3	54.57	80	134.57	92.7	+41.87	272.9	+18.6
M ₆ S ₄	254.3	54.57	120	174.57	105.4	+69.17	278.8	+24.5

During 1994, the initial soil N status was 254.3 kg ha⁻¹ and the N supplied through GLMs was 54.57 kg ha⁻¹. The total quantity of N applied ranged between 0 and 174.57 kg ha⁻¹. Similar to 1993, N uptake was maximum in *Sesbania aculeata* + 120 kg N ha⁻¹.

Computed N balance was positive when GLMs + inorganic N fertilizer were applied. Maximum net gain was observed in *Ipomoea reptans* + 120 kg N ha⁻¹, followed by *Calotropis gigantea*, *Leucaena leucocephala*, *Eichhornia crassipes* and *Sesbania aculeata*.

In general, soil available N showed a net loss even in higher level of N (120 kg N ha⁻¹), if green leaf manure was not combined. Similarly, GLMs alone also resulted in negative N balance. GLMs + fertilizer N improved the soil N status.

Experiment II.

This experiment was conducted during Rabi 1993 and 1994 after the harvest of Experiment I, to study the residual effect of applied green leaf manures and fertilizer N.

4.2. Residual effect of green leaf manures and fertilizer N on Rabi season rice

4.2.1. Growth attributes of Rabi rice at flowering (Table 54)

4.2.1.1. Plant height

The carry over effect of Kharif season green leaf manures was seen on the plant height of rice sown during Rabi, 1993. Residual effect on plant height was higher in plots applied with *Leucaena leucocephala*, *Calotropis gigantea* and *Ipomoea reptans*. This was followed by *Sesbania aculeata* and *Eichhornia crassipes*.

Table 54. Growth attributes of rice at flowering - Rabi

Treatment	1993 -'94		1994 -'95	
	Plant height (cm)	LAI	Plant height (cm)	LAI
Main plot				
M ₁	60.5	5.21	63.2	5.33
M ₂	78.3	6.13	75.6	6.22
M ₃	79.2	6.41	77.1	6.31
M ₄	70.5	5.72	70.1	5.79
M ₅	80.6	6.38	78.5	6.42
M ₆	81.2	6.45	79.0	6.40
SEd	0.75	0.27	1.15	0.22
CD (P=.05)	1.68	0.61	2.56	0.49
Sub plot				
S ₁	75.6	5.98	75.1	5.95
S ₂	74.1	5.99	74.0	5.99
S ₃	75.3	6.02	73.4	6.14
S ₄	76.3	6.21	73.2	6.24
SEd	1.28	0.19	1.03	0.20
CD (P=.05)	NS	NS	NS	NS
Sub-Sub plot				
F ₀	59.0	5.07	57.5	5.21
F ₁	92.2	7.03	90.4	6.95
SEd	5.45	0.23	4.06	0.48
CD (P=.05)	10.9	0.45	8.12	0.96
Interaction	NS	NS	NS	NS

NS = Not significant

Residual effect of applied fertilizer, at all N levels were not significant. The result from sub-sub plot revealed that application of recommended level of N (100 kg N ha⁻¹) to the Rabi rice increased the plant height to a considerable extent as compared to no N application (F₀).

Interaction effect was not significant. Similar results were observed in Rabi, 1994 also.

4.2.1.2. Leaf Area Index (Table 54)

Leaf area index at flowering was influenced significantly by all the green leaf manures applied during Kharif season except *Eichhornia crassipes* during 1993 and *Eichhornia crassipes* and *Sesbania aculeata* during 1994 which were at par with control. Levels of fertilizer N applied to Kharif crop did not influence the LAI of Rabi rice crop. Recommended level of N applied to Rabi crop had influenced the LAI and was significantly superior over no fertilizer applied treatment (F₀).

Interaction effect was absent in both the years.

4.2.1.3. Dry matter production (Tables 55 and 56)

Green leaf manuring done to Kharif rice crop had exerted a significant influence on DMP at all the four growth stages of Rabi rice. Residual effect of *Ipomoea reptans*, *Leucaena leucocephala*, *Calotropis gigantea* and *Sesbania aculeata* was observed throughout the growth periods and the effect of these green leaf manures on DMP was comparable. Even though *Eichhornia crassipes* produced significantly higher DMP than control, its effect was significantly lower than other green leaf manures studied.

Levels of N had non significant influence on Rabi rice DMP.

Fertilizer application to Rabi crop appreciably increased the DMP.

**Table 55. Dry matter production at different growth stages of rice
(kg ha⁻¹)-Rabi (1993 - '94)**

Treatment	Active tillering	Panicle initiation	Flowering	Harvesting
Main plot				
M ₁	943.5	2598.3	3589.3	5833.9
M ₂	1042.1	3366.4	5281.4	9345.5
M ₃	1138.3	3473.8	5435.3	9502.0
M ₄	910.8	2938.9	3790.9	6666.3
M ₅	1034.0	3592.1	5374.8	9526.3
M ₆	1002.1	3429.9	5428.8	9881.1
SEd	64.95	148.43	188.82	217.6
CD (P=.05)	144.7	330.7	420.7	484.8
Sub plot				
S ₁	964.6	3197.9	4810.1	8442.9
S ₂	1018.1	3235.9	4784.0	8421.9
S ₃	1020.9	3233.2	4759.0	8503.3
S ₄	1043.7	3269.2	4913.8	8560.3
SEd	41.8	54.2	96.3	112.5
CD (P=.05)	NS	NS	NS	NS
Sub-Sub plot				
F ₀	802.4	1416.4	2729.0	4930.6
F ₁	1221.5	5051.7	6904.4	1260.6
SEd	82.2	186.9	225.6	344.0
CD (P=.05)	164.2	373.8	451.2	688.0
Interaction	NS	NS	Sig	Sig

NS = Not significant

Table 56. Dry matter production at different growth stages of rice (kg ha⁻¹) -Rabi (1994 - '95)

Treatment	Active tillering	Panicle initiation	Flowering	Harvesting
Main plot				
M ₁	908.13	2263.9	3212.5	5585.4
M ₂	1164.5	4120.5	5361.6	9387.0
M ₃	1192.6	4221.8	5523.1	9589.4
M ₄	991.0	2959.5	5462.7	6746.3
M ₅	1149.0	4136.4	5565.0	9431.3
M ₆	1132.5	4162.3	5401.4	9489.6
SEd	49.64	71.72	196.68	229.98
CD (P=.05)	110.6	159.8	438.2	512.4
Sub plot				
S ₁	1067.5	3496.7	4799.0	8255.4
S ₂	1088.4	3703.8	4881.0	8403.1
S ₃	1095.8	3695.5	4895.7	8424.5
S ₄	1106.8	3691.2	4864.0	8394.7
SEd	39.9	64.8	97.5	129.3
CD (P=.05)	NS	NS	NS	NS
Sub-Sub plot				
F ₀	1015.2	2630.6	3450.0	5976.5
F ₁	1164.0	4662.9	6270.1	10762.4
SEd	70.1	101.1	148.4	311.6
CD (P=.05)	140.2	202.3	296.8	623.2
Interaction	NS	NS	Sig	Sig

NS = Not significant

Interaction effect between main plot and sub-sub plot was significant at flowering and harvesting stages. Application of all the green leaf manures except *Eichhornia crassipes* to Kharif crop, followed by recommended level of N application to Rabi crop significantly increased the DMP.

The same results were recorded for 1993 and 1994 Rabi rice crops.

4.2.2. Yield attributes (Tables 57 and 58)

4.2.2.1. Productive tillers

Residual effect of GLMs on number of productive tillers per m² was more pronounced in Rabi crop. Application of *Sesbania aculeata* to Kharif rice produced maximum number of tillers per m² followed by *Leucaena leucocephala* which was at par with *Calotropis gigantea* and *Ipomoea reptans* in the year 1993. During 1994, *Calotropis gigantea* and *Ipomoea reptans* produced maximum number of productive tillers. This was followed by *Sesbania aculeata* and *Leucaena leucocephala*. Green leaf manure control recorded the least number of productive tillers in both the years of study.

Levels of N applied to Kharif crop significantly influenced the number of productive tillers in Rabi rice crop during 1994. Higher level of N (120 kg N ha⁻¹) produced maximum number of productive tillers when compared to other levels. In 1993, the levels of N applied to Kharif rice had no significant influence on the productive tillers of the succeeding Rabi rice crop. The results from sub-sub plot revealed that application of recommended dose of N to Rabi crop produced maximum number of tillers in both the years.

The interaction effect was absent.

4.2.2.2. Panicle length (Tables 57 and 58)

Panicle length was highly influenced by the green leaf manures. Application of *Leucaena leucocephala*, *Ipomoea reptans*, *Calotropis gigantea* and *Sesbania aculeata* to Kharif rice produced longer panicles when compared to *Eichhornia crassipes*. In both the years, control plot recorded shorter panicles.

Levels of N had influenced the panicle length. Higher levels of N produced longer panicles. Application of recommended level of N to Rabi crop significantly increased the panicle length when compared to no N.

Interaction effect was not significant in both the years.

4.2.2.3. Filled grain percentage (Tables 57 and 58)

Maximum filled grain percentage was recorded in *Ipomoea reptans* applied plot and was comparable with *Leucaena leucocephala*, *Calotropis gigantea* and *Sesbania aculeata*.

Among the levels of N applied to Kharif rice, 120 kg N ha⁻¹ registered significantly higher filled grain percentage as compared to other doses. Application of recommended dose of N to Rabi crop recorded 18.62 per cent increased filled grain percentage over control plot.

Interaction effect was not significant in both the years of experimentation.

Table 57. Yield attributes of rice - Rabi (1993 - '94)

Treatment	Productive tillers (m ⁻²)	Panicle length (cm)	Filled grain (%)	1000 grains weight (g)
Main plot				
M ₁	253	11.81	67.41	18.56
M ₂	327	13.30	72.10	18.88
M ₃	305	14.16	73.49	18.78
M ₄	285	12.26	70.30	18.77
M ₅	306	13.85	72.12	18.96
M ₆	315	14.01	73.41	19.00
SEd	4.54	0.45	0.74	0.24
CD (P=.05)	10.12	1.012	1.65	NS
Sub plot				
S ₁	294	9.95	61.17	18.44
S ₂	295	12.22	68.43	18.62
S ₃	293	14.74	72.24	18.73
S ₄	291	16.33	75.43	19.02
SEd	2.12	1.74	1.95	0.55
CD (P=.05)	NS	3.53	3.96	NS
Sub-Sub plot				
F ₀	245	9.92	58.33	18.13
F ₁	341	17.11	78.14	19.11
SEd	10.2	4.21	3.78	0.49
CD (P=.05)	20.4	8.41	7.56	0.97
Interaction	NS	NS	NS	NS

NS = Not significant

Table 58. Yield attributes of rice - Rabi (1994 - '95)

Treatment	Productive tillers (m ⁻²)	Panicle length (cm)	Filled grain (%)	1000 grains weight (g)
Main plot				
M ₁	247	10.79	70.22	18.45
M ₂	313	12.51	74.51	18.52
M ₃	320	13.33	75.62	18.58
M ₄	276	11.56	71.33	18.50
M ₅	325	12.64	74.18	18.71
M ₆	307	13.81	73.22	18.85
SEd	3.82	0.68	0.45	1.01
CD (P=.05)	8.5	1.51	1.01	NS
Sub plot				
S ₁	231	9.44	66.12	18.33
S ₂	252	11.56	70.43	18.46
S ₃	285	13.47	73.77	18.40
S ₄	333	14.82	77.56	18.52
SEd	5.57	0.93	0.96	0.94
CD (P=.05)	11.3	1.88	1.95	NS
Sub-Sub plot				
F ₀	211	8.14	63.17	18.22
F ₁	352	16.21	81.79	19.14
SEd	8.10	1.63	2.07	0.72
CD (P=.05)	16.2	3.26	4.14	1.43
Interaction	NS	NS	NS	NS

NS = Not significant

4.2.2.4. Thousand grains weight (Tables 57 and 58)

Thousand grains weight was unaltered due to green leaf manures as well as by the levels of N supplied to Kharif rice. However, application of recommended level of N to Rabi crop significantly increased thousand grains weight (19.61g) over no N treatment (17.63 g).

In both the years of experimentation, the interaction effect was not significant.

4.2.3. Nutrient uptake of Rabi crop at harvest (Table 59)

The carry over effect of different green leaf manures and levels of N applied to the previous rice crop altered the uptakes of N, P and K of Rabi rice crop. The variations due to the residual effect were large enough to measure statistically.

4.2.3.1. Nitrogen uptake (Table 59)

Application of green leaf manures to Kharif crop significantly increased the N uptake of Rabi crop. The highest uptake of N was recorded in *Ipomoea reptans* applied plot and this was comparable with *Leucaena leucocephala*, *Calotropis gigantea* and *Sesbania aculeata*. *Eichhornia crassipes* was next to the above. Control recorded the lowest N uptake.

Among the levels of N, the highest dose (120 kg N ha⁻¹) recorded the maximum uptake of N and was comparable with 80 kg N ha⁻¹ during 1993 and 80 as well as 40 kg N ha⁻¹ in 1994.

In both the years, application of recommended level of N to Rabi crop recorded significantly higher N uptake as compared to no N.

Table 59. Nutrient uptake of rice at harvest (kg ha⁻¹) - Rabi crop

Treatment	Nitrogen		Phosphorus		Pottasium	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994 -95
Main plot						
M ₁	71.5	68.3	10.32	11.03	104.0	103.3
M ₂	86.0	82.6	17.51	17.66	119.8	116.6
M ₃	91.3	90.0	18.32	17.75	125.4	121.3
M ₄	75.8	78.3	14.18	14.44	113.1	108.3
M ₅	88.9	87.9	18.55	17.57	128.6	121.6
M ₆	90.7	87.8	19.53	17.98	124.1	120.5
SEd	2.60	3.42	0.68	0.91	3.37	2.75
CD (p=.05)	5.79	7.62	1.51	2.02	7.50	6.13
sub plot						
S ₁	78.9	78.5	14.89	14.72	117.30	112.0
S ₂	83.1	82.3	15.45	15.34	118.8	114.3
S ₃	85.9	83.8	16.38	16.47	120.2	114.5
S ₄	88.3	85.4	19.22	18.73	121.1	118.3
SEd	1.89	1.63	1.25	1.40	1.72	2.56
CD (p=.05)	3.83	3.31	2.53	2.85	3.50	5.20
Sub-sub plot						
F ₀	54.9	58.6	10.46	12.61	97.63	104.8
F ₁	113.2	110.8	22.51	20.02	141.04	125.8
SEd	6.95	8.4	4.11	3.93	6.27	7.35
CD (p=.05)	13.9	16.9	8.21	7.58	12.54	14.7
Interaction	Sig	Sig.	Sig.	Sig.	NS	NS

NS = Not significant

Nitrogen uptake

M x F Interaction table

1993 - '94			
Treat	F ₀	F ₁	Mean
M ₁	51.0	92.1	71.6
M ₂	54.7	117.4	86.1
M ₃	57.2	125.6	91.4
M ₄	51.9	99.7	75.8
M ₅	57.4	120.5	88.9
M ₆	57.4	124.0	90.7
Mean	54.9	113.2	

1994 - '95			
Treat	F ₀	F ₁	Mean
M ₁	51.9	84.8	68.4
M ₂	58.1	107.1	82.6
M ₃	62.8	117.1	89.9
M ₄	55.8	100.8	78.3
M ₅	60.9	115.0	87.9
M ₆	62.3	113.3	87.8
Mean	58.6	110.8	

SEd 2.65
 CD (p = 0.05) 5.33

3.40
 6.85

Phosphorus uptake

M x F Interaction table

1993 - '94			
Treat	F ₀	F ₁	Mean
M ₁	6.42	14.22	10.32
M ₂	11.52	23.50	17.51
M ₃	11.86	24.79	18.33
M ₄	8.26	20.11	14.19
M ₅	14.23	22.86	18.55
M ₆	14.48	24.58	19.53
Mean	11.13	21.68	

1994 - '95			
Treat	F ₀	F ₁	Mean
M ₁	7.77	14.29	11.03
M ₂	14.78	20.61	17.70
M ₃	14.01	21.49	17.75
M ₄	9.74	19.05	14.40
M ₅	14.77	20.38	17.58
M ₆	14.65	21.31	17.98
Mean			

SEd 2.90
 CD (p = 0.05) 5.85

2.29
 4.62

**N uptake of rice at harvest (kg ha⁻¹) -
M x S x F interaction table -
Rabi,1993.**

Treat	S ₁		S ₂		S ₃		S ₄		Mean
Main plot	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	
M ₁	45.6	90.4	50.2	91.6	53.4	92.3	54.8	94.0	71.5
M ₂	50.2	110.6	52.4	116.3	56.6	120.2	59.4	122.4	86.0
M ₃	53.8	118.4	56.2	124.4	58.3	128.3	60.5	131.2	91.3
M ₄	46.6	96.3	50.8	99.7	54.2	100.2	55.9	102.4	75.8
M ₅	54.0	111.7	56.6	119.3	58.0	123.9	60.8	127.1	88.9
M ₆	54.2	115.8	56.4	122.8	58.2	126.6	60.7	130.9	90.7
Mean	50.7	107.2	53.8	112.4	56.5	115.3	58.7	118.0	
S mean	78.97		83.06		85.88		88.34		

F₀ = 54.91

F₁ = 113.21

SEd

CD

M x S x F

4.18

8.46

**N uptake of rice at harvest (kg ha⁻¹) -
M x S x F interaction table -
Rabi,1994.**

Treat	S ₁		S ₂		S ₃		S ₄		mean
Main plot	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	
M ₁	48.3	82.4	51.6	84.2	52.5	85.8	55.0	86.7	68.3
M ₂	54.1	103.4	58.7	106.6	59.2	108.3	60.4	109.9	82.6
M ₃	58.2	112.8	62.7	117.4	64.8	118.2	65.6	120.0	90.0
M ₄	51.9	98.1	55.4	100.1	57.5	101.3	58.4	103.8	78.3
M ₅	56.3	110.5	60.0	114.9	62.6	116.4	64.5	118.2	87.9
M ₆	57.7	108.4	62.1	113.2	63.9	114.8	65.3	116.6	87.8
Mean	54.4	102.6	68.4	106.1	60.1	107.5	61.5	109.2	
S mean	78.5		82.3		83.8		85.4		

F₀ = 58.61

F₁ = 110.84

SEd

CD

M x S x F

5.05

10.22

Interaction effect between main plot and sub-sub plot as well as between main plot and sub plot and sub-sub plot were significant in both the years. When main plot and sub-sub plot interaction was analysed, the combination of application of *Ipomoea reptans* or *Leucaena leucocephala* or *Calotropis gigantea* to Kharif rice crop along with the recommended dose of N to Rabi crop recorded maximum N uptake.

4.2.3.2. Phosphorus uptake (Table 59)

Different green leaf manures applied to Kharif rice crop significantly influenced the P uptake in both the years. The highest P uptake of 19.53 kg ha⁻¹ was observed in *Leucaena leucocephala* applied plot which was at par with *Calotropis gigantea* and *Ipomoea reptans* applied plots. This was followed by *Sesbania aculeata* and *Eichhornia crassipes* in 1993. During 1994, all the green leaf manures except *Eichhornia crassipes* were comparable in increasing the P uptake.

The levels of N also had significant influence on P uptake of subsequent rice crop. Application of 120 kg N ha⁻¹ had increased P uptake. However, this was comparable with 80 kg N ha⁻¹. The sub-sub plot results revealed that application of recommended level of N to the Rabi rice crop had improved P uptake considerably.

The interaction effect between main plot and sub-sub plot was significant in both the years. It is interesting to note that P uptake in *Sesbania aculeata* and *Calotropis gigantea* applied plots was higher when recommended level of N was given to Rabi rice crop during 1993. In 1994 M₁F₁ (no GLM to Kharif crop + recommended level of N to Rabi crop) recorded higher P uptake and it was comparable with GLMs application alone except *Eichhornia crassipes*.

4.2.3.3. Potassium uptake (Table 59)

Higher K uptake was observed for application of green leaf manures to the Kharif crop. Among the green leaf manures *Calotropis gigantea*, *Ipomoea reptans* and *Leucaena leucocephala* applied plots recorded significantly higher K uptake values. This was followed by *Sesbania aculeata* and *Eichhornia crassipes*.

The levels of N also influenced K uptake. Higher level of N increased the uptake of K, but only to a little extent. Application of recommended level of N to Rabi crop significantly increased the K uptake.

Interaction effect was not significant in both the years of experimentation.

4.2.4. Yield of Rabi rice

4.2.4.1. Grain yield (Table 60)

The effect of different green leaf manures applied to the Kharif crop had significant influence on the grain yield of Rabi rice. Application of GLMs to Kharif rice had increased the Rabi rice grain yield to the tune of 312.5 to 1862.6 kg ha⁻¹ (12.9 to 77.8 %) over control. Among the green leaf manures, *Leucaena leucocephala* applied plot recorded the maximum grain yield. However, it was comparable with yield obtained under *Ipomoea reptans*, *Calotropis gigantea* and *Sesbania aculeata* applied plots in both the years. *Eichhornia crassipes* produced significantly higher grain yield than control. But, it was not comparable with the above green leaf manures studied (Fig. 6).

Levels of N applied to Kharif crop had influenced grain yield during 1993. The highest grain yield was recorded at 120 kg N ha⁻¹. This was statistically at par with 80

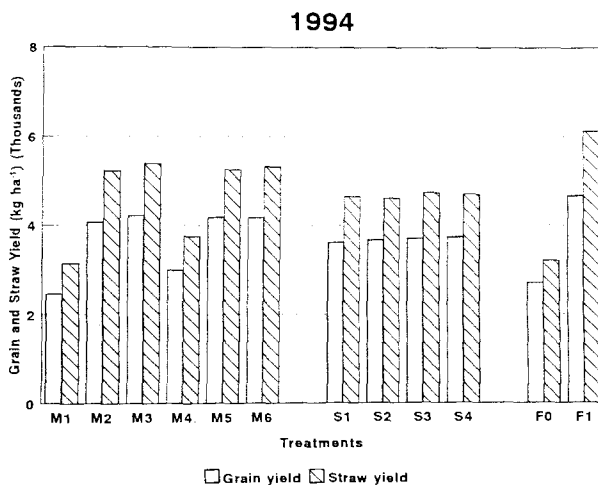
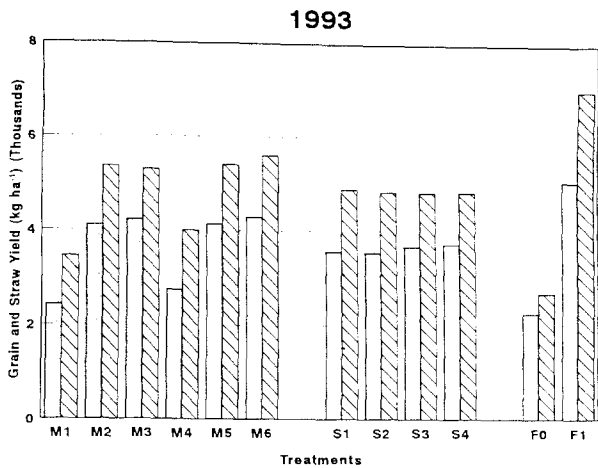


Fig.6. Effect of different GLMs and N levels on grain and straw yield of Rabi season rice

Grain yield of rice (kg ha⁻¹)
M x S x F interaction table -
Rabi,1993.

Treat	S ₁		S ₂		S ₃		S ₄		Mean
Main plot	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	
M ₁	1084	3658	1163	3670	1210	3683	1224	3700	2424
M ₂	2528	5469	2539	5646	2569	5725	2597	5759	4104
M ₃	2612	5648	2668	5731	2671	5847	2680	5868	4215.6
M ₄	1567	3706	1674	3866	1694	3811	1728	3846	2736.5
M ₅	2684	5400	2688	5461	2747	5497	2761	5814	4131.5
M ₆	2716	5636	2740	5858	2743	5900	2758	5942	4286.6
Mean	2198.	4919.5	2245.3	5038.7	2272.3	5077.2	2291.3	5155	
S mean	3558.8		3642		3674.8		3723.1		

F₀ = 58.61

F₁ = 110.84

	SEd	CD
M x S x F	228.7	562.0

Grain yield of rice (kg ha⁻¹)
M x S x F interaction table -
Rabi,1994.

Treat	S ₁		S ₂		S ₃		S ₄		Mean
Main plot	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	
M ₁	1241	3587	1286	3615	1309	3632	1330	3668	2458.5
M ₂	2987	4862	3108	5022	3136	5086	3173	5146	4065.0
M ₃	3222	5077	3260	2127	3270	5178	3283	5264	4210.1
M ₄	2086	3840	2092	3859	2115	3895	2147	3910	2993.0
M ₅	3179	5067	3208	5107	3219	5190	3223	5211	4175.5
M ₆	3200	5044	3248	5085	3265	5123	3281	5136	4172.8
Mean	2652.	4579.5	2700.3	4635.8	2719	4684	2739.5	4723	
S mean	3616		3668.1		3701.5		3731		

	SEd	CD
M x S x F	312.8	631.8

and 40 kg N ha⁻¹. Absolute control (S₀), produced the lowest grain yield. During 1994, the grain yield was unaltered due to levels of N applied to Kharif crop.

Application of recommended level of N to Rabi crop significantly influenced the grain yield and produced 124 and 72 per cent increased grain yield during 1993 and 1994 respectively over no fertilizer application (F₀).

Interaction effect between main plot and sub-sub plot as well as between main plot and sub plot and sub-sub plot were significant in both the years. The results indicated that application of green leaf manures with the recommended dose of N to Rabi crop produced significantly higher yields when compared to control. During 1994, the plots received *Ipomoea reptans*, *Calotropis gigantea* and *Leucaena leucocephala* during Kharif season registered higher grain yield under F₀ treatment of Rabi rice and this was at par with M₁F₁ (No GLM to Kharif rice + recommended dose of N to Rabi crop).

4.2.4.2. Straw yield (Table 60)

Straw yield of Rabi crop was influenced by the GLMs applied to Kharif crop as well as by the fertilizer N applied to Rabi crop. Application of green leaf manures influenced the straw yield. Rabi rice grown from *Leucaena leucocephala*, *Calotropis gigantea*, *Sesbania aculeata* and *Ipomoea reptans* applied treatments of Kharif season produced comparable straw yield and were significantly higher than *Eichhornia crassipes* in both the years of study.

The levels of N applied to Kharif crop did not show any effect on succeeding Rabi rice crop straw yield. Application of recommended level of N to Rabi crop significantly influenced the straw yield positively.

In both the years the interaction effect was not significant.

4.2.5. Use efficiencies

Agronomic Efficiency, Physiological Efficiency and Apparent N Recovery were worked out and presented. The data were not analysed statistically.

4.2.5.1. Agronomic Efficiency (Tables 61 and 62)

Carry over effect of green leaf manures applied to Kharif rice crop was exhibited in Rabi season also. AE was increased by the application of all the green leaf manures except *Eichhornia crassipes* during 1993, where as in 1994, the trend was completely reversed. The green leaf manured plots registered lower AE when compared to control. Levels of N had a very slight positive influence on AE.

4.2.5.2. Physiological Efficiency (Tables 63 and 64)

Improvement in PE of Rabi rice was seen for control plot as compared to green leaf manured plots of Kharif season of both the years of study.

Levels of N had positive influence on PE and higher levels of N showed a maximum PE in both the years.

4.2.5.3. Apparent N Recovery (Tables 65 and 66)

Green leaf manured plots invariably improved the ANR. Application of *Ipomoea reptans* recorded the maximum ANR in both the years. This was followed by *Leucaena leucocephala*, *Calotropis gigantea*, *Sesbania aculeata* and *Eichhornia crassipes*. In 1993, levels of N had positive influence on ANR. The ANR values were increased with increasing N levels. However, in 1994, the effect was not significant.

Table 61. Agronomic Efficiency - Rabi,1993.

Treatment	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	25.74	25.07	24.73	24.76	25.08
M ₂	29.41	31.07	31.56	31.62	30.92
M ₃	31.21	30.63	31.76	31.88	31.37
M ₄	21.39	21.92	21.17	21.18	21.42
M ₅	27.16	27.93	27.50	30.53	28.23
M ₆	29.20	31.18	31.57	31.84	30.95
Mean	27.35	27.93	28.05	28.64	

Table 62. Agronomic Efficiency - Rabi,1994.

Treatment	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	23.46	23.29	23.23	23.38	23.34
M ₂	18.75	19.14	19.50	19.73	19.28
M ₃	18.55	18.67	19.08	19.81	19.03
M ₄	17.54	17.67	17.80	17.63	17.66
M ₅	18.88	18.99	19.71	19.88	19.37
M ₆	18.44	18.37	18.58	18.55	18.49
Mean	19.27	19.36	19.65	19.83	

Table 63. Physiological Efficiency - Rabi,1993.

Treatment	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	57.45	60.55	63.57	63.16	61.18
M ₂	48.69	48.62	49.62	50.19	49.28
M ₃	48.31	44.91	45.37	45.09	45.92
M ₄	43.04	44.83	46.02	45.55	44.86
M ₅	47.07	44.23	41.73	46.05	44.77
M ₆	47.40	46.96	46.15	45.36	46.47
Mean	48.66	48.35	48.74	49.23	

Table 64. Physiological Efficiency - Rabi,1994.

Treatment	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	68.79	71.44	69.76	73.75	70.44
M ₂	38.03	39.96	39.71	39.86	39.39
M ₃	33.97	34.13	35.73	36.42	35.06
M ₄	37.75	39.53	40.64	38.83	39.19
M ₅	34.83	34.59	36.64	37.02	35.77
M ₆	36.37	35.95	36.50	36.16	26.25
Mean	41.62	42.60	43.16	43.67	

Table 65. Apparent N Recovery - Rabi,1993.

Treatment	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	44.8	41.4	38.9	39.2	41.08
M ₂	60.4	63.9	63.6	63.0	62.73
M ₃	64.6	68.2	70.0	70.7	68.38
M ₄	49.7	48.9	46.0	46.5	47.78
M ₅	57.7	62.7	65.9	66.3	63.15
M ₆	61.6	66.4	68.4	70.2	66.65
Mean	56.47	58.58	58.65	59.32	

Table 66. Apparent N Recovery - Rabi,1994.

Treatment	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	34.1	32.6	33.3	31.7	32.93
M ₂	49.3	47.9	49.1	49.5	48.95
M ₃	54.6	54.7	53.4	54.4	54.28
M ₄	46.2	44.7	43.8	45.4	45.03
M ₅	54.2	54.9	53.8	53.7	54.15
M ₆	50.7	51.1	50.9	51.3	51.00
Mean	48.18	47.65	47.38	47.67	

4.2.6. Post harvest soil available nutrients after rice- rice cropping system

4.2.6.1. Soil available N (Tables 67)

Soil available N status was significantly influenced by the different green leaf manures and the levels of N application done to Kharif rice. Among the different green leaf manures, application of *Calotropis gigantea* and *Leucaena leucocephala* significantly showed higher level of post harvest soil available N. This was followed by *Ipomoea reptans* and *Sesbania aculeata*. *Eichhornia crassipes* recorded comparatively lower soil available N than other green leaf manures. Control registered the lowest soil available N.

Among the different levels of N studied to Kharif rice, application of highest dose (120 kg N ha⁻¹) registered maximum soil available N. However, it was comparable with 80 kg N ha⁻¹. No N applied plot registered the lowest soil available N.

In sub- sub plot, application of recommended level of fertilizer N to Rabi crop shown statistically higher soil available N as compared to no fertilizer N application.

Interaction effect between main plot and sub- sub plot was significant in both the years. Application of GLMs to Kharif crop along with recommended level of fertiliser N to Rabi crop registered higher soil available N. The above result was observed in both the years of study.

4.2.6.2. Soil available Phosphorus (Table 67)

Application of GLMs to Kharif rice improved soil available P in both the years. Maximum soil available P was recorded in *Calotropis gigantea* applied plot and it was at par with *Sesbania aculeata*, *Leucaena leucocephala* and *Ipomoea reptans*.

Higher N application tended to decrease the soil available P. In sub- sub plot F₀ (no fertilizer N) recorded significantly higher soil available P than recommended dose of N applied plot.

4.2.6.3. Soil available Potassium (Table 67)

Higher soil available K was observed in GLMs applied plots of Kharif season. Highest value was recorded for *Sesbania aculeata* applied plot. However, it was at par with *Ipomoea reptans*, *Calotropis gigantea* and *Leucaena leucocephala*. Similar to soil available P, higher N application to Kharif crop and application of N to Rabi crop tended to decrease soil available K.

Interaction effect was not significant in both the years.

4.2.6.4. Organic carbon (Table 67)

Organic carbon content in the soil was significantly influenced by the application of green leaf manures in both the years. During 1993, incorporation of *Leucaena leucocephala* to Kharif rice recorded the maximum organic carbon content in the post harvest soil samples of Rabi rice and it was comparable with *Calotropis gigantea*, *Sesbania aculeata* and *Ipomoea reptans*. In 1994, highest organic carbon was seen for *Sesbania aculeata* applied plot and was comparable with *Calotropis gigantea*, *Ipomoea reptans* and *Leucaena leucocephala*. Application of *Eichhornia crassipes* did not have any effect on soil organic carbon during both the years.

Levels of N studied to Kharif rice did not show any appreciable difference in soil organic carbon of Rabi rice soil. Application of fertilizer to Rabi crop also had no influence on soil organic carbon.

Interaction effect was not significant in both the years.

Table 67. Post harvest available nutrient after rice - rice cropping system

Treatment	Organic carbon		Nitrogen		Phosphorus		Pottasium	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
Main plot								
M ₁	0.608	0.613	231.1	221.7	13.2	13.6	482.3	479.6
M ₂	0.629	0.649	251.7	247.9	20.5	23.4	582.9	553.8
M ₃	0.625	0.644	252.4	247.0	19.2	21.2	572.0	527.8
M ₄	0.603	0.615	238.7	239.5	18.6	18.2	498.8	497.8
M ₅	0.629	0.646	262.2	250.8	21.6	23.5	572.8	530.5
M ₆	0.640	0.643	262.9	251.7	20.5	22.3	567.9	541.0
SEd	0.007	0.003	4.05	1.43	1.26	1.17	7.36	6.28
CD (p=.05)	0.016	0.007	8.22	3.18	2.81	2.61	16.4	15.2
sub plot								
S ₁	0.619	0.634	242.9	232.2	19.8	20.9	559.1	520.5
S ₂	0.623	0.636	249.5	240.2	19.1	20.5	548.7	518.0
S ₃	0.623	0.639	251.9	243.8	18.7	20.2	541.1	522.4
S ₄	0.622	0.629	258.2	249.5	18.3	19.9	535.5	526.1
SEd	0.008	0.006	3.16	3.39	1.01	0.86	10.1	7.19
CD (p=.05)	NS	NS	6.41	6.88	NS	NS	20.5	NS
Sub-sub plot								
F ₀	0.631	0.625	236.5	226.2	20.25	21.3	553.2	528.3
F ₁	0.613	0.644	264.8	257.0	17.59	19.5	539.0	515.2
SEd	0.09	0.07	5.07	7.26	0.98	0.75	8.46	7.4
CD (p=.05)	NS	NS	10.2	14.6	1.96	1.50	NS	NS
Interaction	NS	NS	Sig	Sig	NS	NS	NS	NS

Sig : Significant at five per cent level

NS : Not significant

4.2.7. Available N balance after rice - rice cropping system (Tables 68 and 69)

During 1993 - '94, N applied to Kharif crop ranged between 0 and 165.3 kg ha⁻¹ and in 1994, it was upto 170.5 kg ha⁻¹. For Rabi crop, complete control and 100 kg N ha⁻¹ treatments were imposed. Total N uptake from the cropping system ranged between 104.4 kg ha⁻¹ (absolute control) to 243.3 kg ha⁻¹ (*Calotropis gigantea* + 120 kg N ha⁻¹ in Kharif and 100 kg N ha⁻¹ in Rabi season). In 1994, it was 48.3 and 241.7 kg ha⁻¹. The trend in the computed N balance based on the total additions and removals was the same as that observed during Kharif season except that a positive balance was noticed in F₁, where 100 kg N ha⁻¹ was applied to Rabi crop.

The actual balance showed a depletion of soil available N with out fertilizer addition to the rice, even if the green leaf manures were applied, compared to the available N status at the beginning of the cropping cycle. The change in soil available N ranged from -68.2 to +15.2 kg N ha⁻¹ in 1993 and -60.4 to +21.6 in 1994.

After examining the N balance at both years of experimentation, it was observed that application of GLMs along with 80 to 120 kg N ha⁻¹ during Kharif season + application of 100 kg N ha⁻¹ to Rabi season improved the soil available N status compared to pre-experimental level. No application of fertilizer to Kharif and Rabi rice resulted in a sharp decrease.

4.3. Correlation and Regression study

The variables studied were soil NH₄⁺-N and NO₃⁻-N at different days after transplanting of rice Viz., first day (x₁), second day(x₂), third day(x₃), fourth day(x₄), fifth day(x₅), ninth day(x₆), thirteenth day(x₇), seventeenth day(x₈), twenty first day(x₉), twenty fifth day(x₁₀) and twenty ninth day(x₁₁) and these were correlated with

Table 68. Available soil N balance after rice - rice cropping system 1993 - '94.

Treatments	Initial soil N status Kg ha ⁻¹	N applied to Kharif crop Kg ha ⁻¹	N applied to Rabi crop Kg ha ⁻¹	Total quantity of N applied	N uptake by the Kharif crop	N uptake by the Rabi crop	Total N uptake	Computed Balance	Actual Balance	Net gain or loss
M1 S1 F0	270.0	0	0	58.8	45.6	104.4	-104.4	201.8	-68.2	
M1 S1 F1	270.0	0	100	100	58.8	149.2	-49.2	249.8	-20.2	
M1 S2 F0	270.0	40	0	40	69.2	50.2	119.4	-79.4	204.8	-65.2
M1 S2 F1	270.0	40	100	140	69.2	91.6	160.8	-20.8	250.4	-19.6
M1 S3 F0	270.0	80	0	80	77.4	53.4	130.8	-50.8	210.2	-59.8
M1 S3 F1	270.0	80	100	180	77.4	92.3	169.7	+10.3	258.0	-12.0
M1 S4 F0	270.0	120	0	120	81.2	54.8	136.0	-16.0	213.8	-56.2
M1 S4 F1	270.0	120	100	220	81.2	94.0	175.2	+44.8	260.7	-9.3
M2 S1 F0	270.0	45.03	0	45.03	86.4	50.2	136.6	-91.57	229.8	-40.2
M2 S1 F1	270.0	45.03	100	145.03	86.4	110.6	196.4	-51.37	258.4	-11.6
M2 S2 F0	270.0	85.03	0	85.03	108.8	52.4	161.2	-76.17	233.2	-36.8
M2 S2 F1	270.0	85.03	100	185.03	108.8	116.3	225.1	-40.07	262.7	-7.3
M2 S3 F0	270.0	125.03	0	125.03	116.1	56.6	172.7	-47.67	247.4	-28.6
M2 S3 F1	270.0	125.03	100	225.03	116.1	120.2	236.3	-11.27	267.4	-2.6
M2 S4 F0	270.0	165.03	0	165.03	124.2	59.4	183.6	-18.57	246.6	-23.4
M2 S4 F1	270.0	165.03	100	265.03	124.2	122.4	246.6	+18.43	274.2	+4.2
M3 S1 F0	270.0	45.03	0	45.03	80.6	53.8	134.4	-89.37	230.3	-39.7
M3 S1 F1	270.0	45.03	100	145.03	80.6	118.4	199.0	-53.97	259.6	-10.4
M3 S2 F0	270.0	85.03	0	85.03	98.1	56.2	154.3	-69.27	237.4	-32.6
M3 S2 F1	270.0	85.03	100	185.03	98.1	124.4	222.5	-37.47	260.7	-9.3
M3 S3 F0	270.0	125.03	0	125.03	108.5	58.3	166.8	-41.77	240.9	-29.1
M3 S3 F1	270.0	125.03	100	225.03	108.5	128.3	236.8	-11.77	265.8	-4.2
M3 S4 F0	270.0	165.03	0	165.03	112.1	60.5	172.6	-7.57	248.3	-21.7
M3 S4 F1	270.0	165.03	100	265.03	112.1	131.2	243.3	+21.73	276.2	+6.2
M4 S1 F0	270.0	45.03	0	45.03	71.9	46.6	118.5	-73.47	218.2	-51.8
M4 S1 F1	270.0	45.03	100	145.03	71.9	96.3	168.2	-23.17	245.4	-24.6
M4 S2 F0	270.0	85.03	0	85.03	83.7	50.8	134.5	-49.47	222.7	-47.3
M4 S2 F1	270.0	85.03	100	185.03	83.7	99.7	183.4	+1.63	248.2	-21.8
M4 S3 F0	270.0	125.03	0	125.03	90.3	54.2	144.5	-19.47	229.6	-40.4
M4 S3 F1	270.0	125.03	100	225.03	90.3	100.2	190.5	+34.53	252.8	-17.2
M4 S4 F0	270.0	165.03	0	165.03	95.4	55.9	151.3	+13.93	232.2	-37.8
M4 S4 F1	270.0	165.03	100	265.03	95.4	120.4	197.8	+67.23	260.4	-9.6
M5 S1 F0	270.0	45.03	0	45.03	83.1	54.0	137.1	-92.07	241.3	-28.7
M5 S1 F1	270.0	45.03	100	145.03	83.1	111.7	194.8	-49.77	270.3	+0.3
M5 S2 F0	270.0	85.03	0	85.03	102.1	56.6	158.7	-73.67	246.5	-23.5
M5 S2 F1	270.0	85.03	100	185.03	102.1	119.3	221.4	-36.37	273.1	+3.1
M5 S3 F0	270.0	125.03	0	125.03	114.6	58.0	172.6	-47.57	250.3	-19.7
M5 S3 F1	270.0	125.03	100	225.03	114.6	123.9	238.5	-13.47	274.5	+4.5
M5 S4 F0	270.0	165.03	0	165.03	120.6	60.8	181.4	-16.37	259.1	-10.9
M5 S4 F1	270.0	165.03	100	265.03	120.6	127.1	247.7	+17.33	282.6	+12.6
M6 S1 F0	270.0	45.03	0	45.03	76.0	54.2	130.2	-85.17	243.6	-26.4
M6 S1 F1	270.0	45.03	100	145.03	76.0	115.8	191.8	-46.77	266.5	-3.5
M6 S2 F0	270.0	85.03	0	85.03	91.5	56.4	147.9	-62.87	245.6	-24.4
M6 S2 F1	270.0	85.03	100	185.03	91.5	122.8	214.3	-29.27	272.0	+2.0
M6 S3 F0	270.0	125.03	0	125.03	98.7	58.2	156.9	-31.87	252.4	-17.6
M6 S3 F1	270.0	125.03	100	225.03	98.7	126.6	225.3	-0.27	279.8	+9.8
M6 S4 F0	270.0	165.03	0	165.03	103.3	60.7	164.0	+1.03	258.5	-11.5
M6 S4 F1	270.0	165.03	100	265.03	103.3	130.9	234.2	+30.83	285.2	+15.2

Table 69. Available soil N balance after rice - rice cropping system 1994 - '95.

Treatments	Initial soil N status Kg ha ⁻¹	N applied to Kharif crop Kg ha ⁻¹	N applied to Rabi crop Kg ha ⁻¹	Total quantity of N applied	N uptake by the Kharif crop	N uptake by the Rabi crop	Total N uptake	Computed Balance	Actual Balance	Net gain or loss
M1 S1 F0	254.3	0	0	0	48.4	48.3	96.7	-96.7	193.9	-60.4
M1 S1 F1	254.3	0	100	100	48.4	82.4	130.8	-30.8	231.9	-22.4
M1 S2 F0	254.3	40	0	40	68.2	51.6	119.8	-79.8	196.1	-58.2
M1 S2 F1	254.3	40	100	140	68.2	84.2	152.4	-12.4	240.7	-13.6
M1 S3 F0	254.3	80	0	80	72.4	52.5	124.9	-44.9	205.7	-48.6
M1 S3 F1	254.3	80	100	180	72.4	85.8	158.2	+21.8	243.0	-11.3
M1 S4 F0	254.3	120	0	120	79.5	55.0	134.5	-14.5	225.6	-28.7
M1 S4 F1	254.3	120	100	220	79.5	86.7	166.2	+53.8	236.9	-17.4
M2 S1 F0	254.3	54.57	0	54.57	68.3	54.1	142.4	-87.83	222.7	-31.6
M2 S1 F1	254.3	54.57	100	154.57	68.3	103.4	171.7	-17.13	252.1	-2.2
M2 S2 F0	254.3	94.57	0	94.57	96.5	58.7	155.2	-60.63	231.7	-22.6
M2 S2 F1	254.3	94.57	100	194.57	96.5	106.6	203.1	-8.53	260.5	+6.2
M2 S3 F0	254.3	134.57	0	134.57	123.5	59.2	182.5	-47.93	234.9	-19.4
M2 S3 F1	254.3	134.57	100	234.57	123.5	108.3	231.8	+2.77	266.6	+12.3
M2 S4 F0	254.3	174.57	0	174.57	130.7	60.4	191.1	-16.53	243.8	-10.5
M2 S4 F1	254.3	174.57	100	274.57	130.7	109.9	240.6	+33.97	270.5	+16.2
M3 S1 F0	254.3	54.57	0	54.57	62.1	58.2	120.3	-65.73	223.8	-30.5
M3 S1 F1	254.3	54.57	100	154.57	62.1	112.8	174.9	-20.33	245.1	-9.2
M3 S2 F0	254.3	94.57	0	94.57	88.3	62.7	151.0	-56.43	227.9	-26.4
M3 S2 F1	254.3	94.57	100	194.57	88.3	117.4	205.7	-11.13	256.9	+2.6
M3 S3 F0	254.3	134.57	0	134.57	111.1	64.8	175.9	-41.33	232.7	-21.6
M3 S3 F1	254.3	134.57	100	234.57	111.1	118.2	229.3	+5.27	268.0	+13.7
M3 S4 F0	254.3	174.57	0	174.57	122.4	65.6	188.0	-13.43	245.8	-8.5
M3 S4 F1	254.3	174.57	100	274.57	122.4	120.0	242.4	+32.17	275.9	+21.6
M4 S1 F0	254.3	54.57	0	54.57	53.6	51.9	105.5	-50.93	209.7	-44.6
M4 S1 F1	254.3	54.57	100	154.57	53.6	98.1	151.7	+2.87	251.1	-3.2
M4 S2 F0	254.3	94.57	0	94.57	73.7	55.4	129.1	-34.53	217.5	-36.8
M4 S2 F1	254.3	94.57	100	194.57	73.7	100.1	173.8	+20.77	258.5	+4.2
M4 S3 F0	254.3	134.57	0	134.57	79.6	57.5	137.1	-2.53	220.0	-34.3
M4 S3 F1	254.3	134.57	100	234.57	79.6	101.3	180.9	+53.67	263.1	+8.8
M4 S4 F0	254.3	174.57	0	174.57	95.8	58.4	154.2	+20.37	230.8	-23.5
M4 S4 F1	254.3	174.57	100	274.57	95.8	103.8	199.6	+74.97	264.9	+10.6
M5 S1 F0	254.3	54.57	0	54.57	65.4	56.3	121.7	-67.13	235.7	-18.6
M5 S1 F1	254.3	54.57	100	154.57	65.4	110.5	175.9	-21.33	244.7	-9.6
M5 S2 F0	254.3	94.57	0	94.57	91.4	60.0	151.4	-56.83	239.0	-15.3
M5 S2 F1	254.3	94.57	100	194.57	91.4	114.9	206.3	-11.73	255.7	+1.4
M5 S3 F0	254.3	134.57	0	134.57	109.4	62.6	172.0	-37.43	243.0	-11.3
M5 S3 F1	254.3	134.57	100	234.57	109.4	116.4	225.8	+8.77	265.2	+10.9
M5 S4 F0	254.3	174.57	0	174.57	123.5	64.5	188.0	-13.43	248.9	-5.4
M5 S4 F1	254.3	174.57	100	274.57	123.5	118.2	241.7	+32.87	274.1	+19.8
M6 S1 F0	254.3	54.57	0	54.57	58.4	57.7	116.1	-61.53	238.0	-16.3
M6 S1 F1	254.3	54.57	100	154.57	58.4	108.4	166.8	-12.23	247.9	-6.4
M6 S2 F0	254.3	94.57	0	94.57	80.4	62.1	142.5	-47.93	241.9	-12.4
M6 S2 F1	254.3	94.57	100	194.57	80.4	113.2	193.6	+0.97	255.5	+1.2
M6 S3 F0	254.3	134.57	0	134.57	92.7	63.9	156.6	-22.03	243.7	-10.6
M6 S3 F1	254.3	134.57	100	234.57	92.7	114.8	207.5	+27.07	269.9	+15.6
M6 S4 F0	254.3	174.57	0	174.57	105.4	65.3	170.7	+3.87	246.4	-7.9
M6 S4 F1	254.3	174.57	100	274.57	105.4	116.6	222.0	+52.57	270.5	+16.2

dependent variable, rice grain yield. Regression was also worked out for both 1993 and 1994 and are furnished in Tables 70 through 73.

4.3.1. NH_4^+ -N content Vs Yield

It is observed that significant positive correlation existed between yield and all the variables (x) studied.

In respect of correlation between different x variables studied, except between x_1 (first day) and x_{10} (twenty fifth day) and also between x_1 (first day) and x_{11} (twenty ninth day), all the variables were highly correlated with each other positively during 1993 (Table 70). In 1994, all the x variables were highly correlated with each other positively (Table 71).

Linear regression was done and final equations are as follows :

Linear regression equations for NH_4^+ -N at different days Vs Yield for 1993 Kharif.

$$\begin{aligned}
 \hat{Y} &= 3449.80 + 67 x_1 \\
 \hat{Y} &= 2958.09 + 71 x_2 \\
 \hat{Y} &= 2818.48 + 62 x_3 \\
 \hat{Y} &= 2087.15 + 77 x_4 \\
 \hat{Y} &= 2757.69 + 57 x_5 \\
 \hat{Y} &= 2881.82 + 52 x_6 \\
 \hat{Y} &= 3178.36 + 46 x_7 \\
 \hat{Y} &= 3265.43 + 46 x_8 \\
 \hat{Y} &= 620.70 + 75 x_9 \\
 \hat{Y} &= 3025.03 + 76 x_{10} \\
 \hat{Y} &= 3051.77 + 49 x_{11}
 \end{aligned}$$

Linear regression equations for $\text{NH}_4^+\text{-N}$ at different days Vs Yield for 1994 Kharif

$$\begin{aligned} \hat{Y} &= 2551.95 + 86 X_1 \\ \hat{Y} &= 2210.69 + 86 X_2 \\ \hat{Y} &= 2184.10 + 81 X_3 \\ \hat{Y} &= 2470.95 + 56 X_4 \\ \hat{Y} &= 2454.24 + 53 X_5 \\ \hat{Y} &= 2674.07 + 48 X_6 \\ \hat{Y} &= 3083.52 + 41 X_7 \\ \hat{Y} &= 3277.26 + 38 X_8 \\ \hat{Y} &= 2982.00 + 37 X_9 \\ \hat{Y} &= 3097.15 + 40 X_{10} \\ \hat{Y} &= 3097.67 + 47 X_{11} \end{aligned}$$

4.3.2. $\text{NO}_3^-\text{-N}$ content Vs Yield

Significant positive correlation existed between yield and X_1, X_2, X_3, X_7 and X_{11} , where as no correlation existed for X_4, X_5, X_6, X_8, X_9 and X_{10} variables with the yield during the year 1993 (Table 72). In 1994, all the variables had significant positive correlation except X_3, X_9 and X_{10} with the rice grain yield (Table 73).

Simple linear regression was done and the final equations are as follows:

Linear regression equations for $\text{NO}_3^-\text{-N}$ at different days Vs Yield for 1993 Kharif.

$$\begin{aligned} \hat{Y} &= -2408.24 + 731 X_1 \\ \hat{Y} &= -58.95 + 363 X_2 \\ \hat{Y} &= -1899.68 + 443 X_3 \\ \hat{Y} &= 599.59 + 304 X_4 \\ \hat{Y} &= 1390.37 + 286 X_5 \\ \hat{Y} &= 1964.46 + 347 X_6 \\ \hat{Y} &= 2460.74 + 391 X_7 \\ \hat{Y} &= 2229.83 + 654 X_8 \\ \hat{Y} &= 638.64 + 340 X_9 \\ \hat{Y} &= 1394.29 + 394 X_{10} \\ \hat{Y} &= 1197.28 + 610 X_{11} \end{aligned}$$

Linear regression equations for NO₃⁻-N at different days Vs Yield for 1994 Kharif.

$$\begin{aligned}
 \hat{Y} &= -1819.98 + 582 x_1 \\
 \hat{Y} &= 281.99 + 296 x_2 \\
 \hat{Y} &= 2943.30 + 116 x_3 \\
 \hat{Y} &= -488.59 + 311 x_4 \\
 \hat{Y} &= 366.94 + 304 x_5 \\
 \hat{Y} &= 825.17 + 384 x_6 \\
 \hat{Y} &= 1510.68 + 425 x_7 \\
 \hat{Y} &= 472.36 + 873 x_8 \\
 \hat{Y} &= -575.07 + 362 x_9 \\
 \hat{Y} &= 1726.89 + 303 x_{10} \\
 \hat{Y} &= 1280.70 + 523 x_{11}
 \end{aligned}$$

4.4 Economics

4.4.1. Net return of the cropping system (Tables 74 and 75)

Net return of the cropping system was greatly influenced by the application of GLMs and levels of N. All the GLMs applied plots registered higher net return compared to no GLMs application. In the year 1993 - '94, highest net return was observed for *Ipomoea reptans* applied plot followed by *Calotropis gigantea*, *Sesbania aculeata*, *Leuciana leucocephala* and *Eichhornia crassipes*. During 1994 - '95, highest net return was observed for *Sesbania aculeata* applied plot followed by *Ipomoea reptans*, *Calotropis gigantea*, *Leuciana leucocephala* and *Eichhornia crassipes*.

Increased levels of N positively influenced the net return. Among the different levels of N tried, application of 120 kg N ha⁻¹ recorded the maximum net return. Similarly application of recommended dose of N to Rabi crop also increased the net return of the cropping system as a whole.

Table 70 . Correlation between $\text{NH}_4^+\text{-N}$ at different days and yield - 1993

Days	$\text{NH}_4^+\text{-N}$ content at different days after transplanting										Yield	
	1	2	3	4	5	9	13	17	21	25		29
1	1	.985**	.990**	.924**	.991**	.962**	.922**	854*	834*	770NS	799NS	863*
2		1.0	.991**	.961**	.992**	.984**	.954**	910*	915*	844*	869*	920**
3			1.0	.964**	1.0**	.989**	.965**	913*	877*	840*	869*	920**
4				1.0	.964**	.991**	.996**	.987**	.946**	.952**	.968**	.990**
5					1.0	.989**	.964**	.912*	880*	841*	868*	.919**
9						1.0	.992**	.962**	.924**	.909*	.930**	.966**
13							1.0	.986**	.930**	.948**	.965**	.987**
17								1.0	.952**	.987**	.995**	.999**
21									1.0	.944**	.950**	.960**
25										1.0	.996**	.984**
29											1.0	.993**
Yield												1.0

Table 71 . Correlation between $\text{NH}_4^+\text{-N}$ at different days and yield - 1994

Days	$\text{NH}_4^+\text{-N}$ content at different days after transplanting										Yield	
	1	2	3	4	5	9	13	17	21	25		29
1	1	.995**	.996**	.958**	.959**	.967**	.948**	.928**	.928**	.920**	.941**	.951**
2		1.0	.998**	.956**	.957**	.968**	.940**	.915*	.910*	.904*	.925**	.938**
3			1.0	.958**	.960**	.971**	.955**	.936**	.933**	.927**	.943**	.937**
4				1.0	1.0**	.993**	.974**	.953**	.940**	.934**	.962**	.988**
5					1.0	.994**	.976**	.956**	.943**	.938**	.964**	.987**
9						1.0	.992**	.978**	.968**	.966**	.983**	.975**
13							1.0	.996**	.991**	.990**	.996**	.950**
17								1.0	.998**	.996**	.996**	.928**
21									1.0	.997**	.995**	.921**
25										1.0	.995**	.911**
29											1.0	.946**
Yield												1.0

* : Significant at five per cent level
NS : Not significant.

** : Significant at one per cent level

Table 72 . Correlation between NO₃-N at different days and yield - 1993.

Days	NO ₃ -N content at different days after transplanting										Yield	
	1	2	3	4	5	9	13	17	21	25		29
1	1	.88*	.75NS	.51NS	.40NS	.65NS	.75NS	.54NS	.76NS	.89*	.967**	.894*
2		1.0	.909*	.69NS	.61NS	.86*	.89*	.77NS	.87*	.882*	.937**	.893*
3			1.0	.883*	.78NS	.964**	.988**	.9038	.876*	.801NS	.886*	.867*
4				1.0	.976**	.932**	.870*	.979**	.63NS	.46NS	.64NS	.76NS
5					1.0	.851*	.74NS	.957**	.46NS	.288NS	.522NS	.72NS
9						1.0	.969**	.964**	.857*	.701NS	.776NS	.78NS
13							1.0	.886*	.922**	.8298	.878*	.825*
17								1.0	.69NS	.515NS	.672NS	.77NS
21									1.0	.934**	.846*	.66NS
25										1.0	.928**	.73NS
29											1.0	.930**
Yield												1.0

Table 73 . Correlation between NO₃-N at different days and yield - 1994

Days	NO ₃ -N content at different days after transplanting										Yield	
	1	2	3	4	5	9	13	17	21	25		29
1	1	.93**	.448NS	.648NS	.595NS	.831*	.858*	.900*	.844*	.875*	.941**	.910*
2		1.0	.637NS	.638NS	.583NS	.836*	.868*	.838*	.873*	.909*	.924**	.930**
3			1.0	.570NS	.523NS	.584NS	.609NS	.503NS	.669NS	.658NS	.642NS	.65NS
4				1.0	.996**	.927**	.920**	.906*	.370NS	.449NS	.583NS	.865*
5					1.0	.905*	.894*	.879*	.293NS	.378NS	.512NS	.827*
9						1.0	.997**	.972**	.606NS	.701NS	.733NS	.941**
13							1.0	.977**	.642NS	.728NS	.755NS	.964**
17								1.0	.639NS	.711NS	.804NS	.953**
21									1.0	.984**	.934**	.72NS
25										1.0	.928**	.73NS
29											1.0	.930**
Yield												1.0

* : Significant at five per cent level
 NS : Not significant.

** : Significant at one per cent level

Table 74. Net return of the cropping system (Rs ha⁻¹) - 1993 - '94.

Treat.	S ₁		S ₂		S ₃		S ₄		Mean
Main plot	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	
M ₁	140	13073	4701	17308	7877	20246	10384	22794	12065
M ₂	16012	30969	25941	41730	29931	45984	30312	46366	33406
M ₃	16114	31490	25643	41779	30632	46716	31269	47332	33872
M ₄	5377	15880	15108	25905	19342	29755	19917	30430	20214
M ₅	17215	30980	26571	40560	30789	44622	31197	46579	33564
M ₆	15473	30213	23680	39448	27649	43638	27839	43951	31486
Mean	11722	25434	20274	34455	24370	38494	25153	39575	

S mean 18578 27365 31432 32364

F₀ = 20380

F₁ = 34490

Table 75. Net return of the cropping system (Rs ha⁻¹) - 1994 - '95.

Treat	S ₁		S ₂		S ₃		S ₄		Mean
Main plot	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	
M ₁	2080	13579	4846	16853	8549	19927	11911	23321	12633
M ₂	20653	29792	29741	39097	32075	41577	34049	43606	33824
M ₃	19645	28678	27641	36687	32289	41592	33984	43592	33014
M ₄	4918	13977	13413	21945	16950	25554	19965	28476	18150
M ₅	18599	27722	28597	37801	31834	41426	33230	42979	32774
M ₆	16191	25147	23176	32112	27188	36265	30255	39305	28705
Mean	13681	23149	21236	30749	24814	34390	27232	36880	

S mean 18415 25993 29602 32056

F₀ = 21741

F₁ = 31292

4.4.2. Benefit - Cost Ratio (Tables 76 and 77)

Benefit - Cost Ratio (BC ratio) had positive influence due to GLMs application. Application of *Ipomoea reptans* registered the maximum BC ratio in both the years. In 1993 - '94, this was followed by *Calotropis gigantea*, *Sesbania aculeata*, *Leuciana luecocephala* and *Eichhornia crassipes*. During 1994 - '95, *Sesbania aculeata* recorded similar BC ratio as that of *Ipomoea reptans*. This was followed by *Calotropis gigantea*, *Leuciana luecocephala* and *Eichhornia crassipes*.

Levels of N also had influenced the B-C ratio. In both the years, the BC ratio increased with increasing levels of N. The response was seen upto 80 kg N ha⁻¹ in 1993 - '94 and after that the BC ratio remained the same. In 1994 - '95 the response was seen upto 120 kg N ha⁻¹ in increasing the BC ratio. Application of recommended dose of N to Rabi crop appreciably increased the BC ratio of the rice - rice cropping system.

4.4.3. Partial Budgeting (Table 78)

To compare the economical viability of the various green leaf manures and levels of N, partial budgeting technique was imposed. Only the estimated changes were computed with the introduction of the technologies and presented in Table 78.

The information gathered from the table indicated that, after due consideration of the added costs and returns and similarly the reduced costs and returns, the green leaf manure, *Ipomoea reptans* was economically viable as compared to other green leaf manures. Similarly among the levels of N, 80 kg N ha⁻¹ was economically viable.

Table 76. Benefit - Cost Ratio of the cropping system (1993 - '94).

Treatment	S ₁		S ₂		S ₃		S ₄		Mean
Main plot	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	
M ₁	1.01	1.66	1.25	1.86	1.41	1.99	1.52	2.10	1.60
M ₂	1.78	2.44	2.24	2.91	2.41	3.07	2.40	3.05	2.54
M ₃	1.80	2.49	2.25	2.95	2.47	3.14	2.48	3.14	2.59
M ₄	1.26	1.73	1.72	2.17	1.90	2.33	1.91	2.34	1.92
M ₅	1.85	2.46	2.29	2.88	2.47	3.04	2.47	3.10	2.57
M ₆	1.77	2.43	2.16	2.84	2.33	3.00	2.31	2.98	2.48
Mean	1.58	2.20	1.99	2.60	2.17	2.76	2.18	2.75	

S mean 1.89 2.30 2.47 2.47

F₀ = 1.98

F₁ = 2.58

Table 77. Benefit - Cost Ratio of the cropping system (1994 - '95).

Treatment	S ₁		S ₂		S ₃		S ₄		Mean
Main plot	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	F ₀	F ₁	
M ₁	1.11	1.67	1.25	1.82	1.43	1.96	1.59	2.10	1.62
M ₂	1.99	2.36	2.40	2.76	2.48	2.84	2.55	2.90	2.54
M ₃	1.96	2.33	2.32	2.78	2.52	2.87	2.57	2.93	2.54
M ₄	1.23	1.63	1.62	1.98	1.78	2.12	1.90	2.23	1.81
M ₅	1.90	2.28	2.36	2.72	2.49	2.86	2.54	2.89	2.51
M ₆	1.79	2.17	2.11	2.47	2.28	2.63	2.40	2.74	2.32
Mean	1.66	2.07	2.01	2.42	2.16	2.55	2.26	2.63	

S mean 1.87 2.22 2.36 2.45

F₀ = 2.02

F₁ = 2.42

Table 78. Partial budgeting**(1993 - '94)**

Losses (Rs ha ⁻¹)		Gains (Rs ha ⁻¹)	
(M₁ Vs M₂)			
Added costs	1799.5	Added returns	23142.2
Reduced returns	-	Reduced costs	-
	<u>1799.5</u>		<u>23142.2</u>
Estimated change	(+)21342.7		
(M₁ Vs M₃)			
Added costs	1400	Added returns	23260.5
Reduced returns	-	Reduced costs	-
	<u>1400</u>		<u>23260.5</u>
Estimated change	(+)21806.5		
(M₁ Vs M₄)			
Added costs	2020	Added returns	10168.9
Reduced returns	-	Reduced costs	-
	<u>2020</u>		<u>10168.9</u>
Estimated change	(+)8148.9		
(M₁ Vs M₅)			
Added costs	1450	Added returns	22941
Reduced returns	-	Reduced costs	-
	<u>1450</u>		<u>22941</u>
Estimated change	(+)21491		
(M₁ Vs M₆)			
Added costs	1401	Added returns	20822
Reduced returns	-	Reduced costs	-
	<u>1401</u>		<u>20822</u>
Estimated change	(+)19421		

(1993 - '94)

Losses (Rs ha ⁻¹)		Gains (Rs ha ⁻¹)	
(M ₂ Vs M ₃)			
Added costs	-	Added returns	64.3
Reduced returns	-	Reduced costs	399.5
	<u>-</u>		<u>463.8</u>
Estimated change	(+)463.8		
(M ₂ Vs M ₄)			
Added costs	220.5	Added returns	-
Reduced returns	12973.3	Reduced costs	-
	<u>13193.8</u>		<u>-</u>
Estimated change	(-)13193.8		
(M ₂ Vs M ₅)			
Added costs	-	Added returns	-
Reduced returns	201.2	Reduced costs	349.5
	<u>201.2</u>		<u>349.5</u>
Estimated change	(+)148.3		
(M ₂ Vs M ₆)			
Added costs	-	Added returns	-
Reduced returns	2320.2	Reduced costs	398.5
	<u>2320.2</u>		<u>398.5</u>
Estimated change	(-)1921.7		

(1994 - '95)

Losses (Rs ha ⁻¹)		Gains (Rs ha ⁻¹)	
(M₁ Vs M₂)			
Added costs	1800	Added returns	22990.5
Reduced returns	-	Reduced costs	-
	<u>1800</u>		<u>22990.5</u>
Estimated change	(+)21190.5		
(M₁ Vs M₃)			
Added costs	1150	Added returns	22280.2
Reduced returns	-	Reduced costs	-
	<u>1150</u>		<u>22280.2</u>
Estimated change	(+)21130.2		
(M₁ Vs M₄)			
Added costs	2020	Added returns	7611.5
Reduced returns	-	Reduced costs	-
	<u>2020</u>		<u>7611.5</u>
Estimated change	(+)5591.5		
(M₁ Vs M₅)			
Added costs	1150	Added returns	21868
Reduced returns	-	Reduced costs	-
	<u>1150</u>		<u>21868</u>
Estimated change	(+)20718		
(M₁ Vs M₆)			
Added costs	1393.8	Added returns	17471.6
Reduced returns	-	Reduced costs	-
	<u>1393.8</u>		<u>17471.6</u>
Estimated change	(+)16077.8		

(1994- '95)

Losses (Rs ha ⁻¹)		Gains (Rs ha ⁻¹)	
(M₂ Vs M₃)			
Added costs	-	Added returns	-
Reduced returns	<u>710.3</u>	Reduced costs	<u>650</u>
	<u>710.3</u>		<u>650</u>
Estimated change	(-)60.3		
(M₂ Vs M₄)			
Added costs	220	Added returns	-
Reduced returns	<u>15379</u>	Reduced costs	<u>-</u>
	<u>15599</u>		<u>-</u>
Estimated change	(-)15599		
(M₂ Vs M₅)			
Added costs	-	Added returns	-
Reduced returns	<u>1132.5</u>	Reduced costs	<u>650</u>
	<u>1132.5</u>		<u>650</u>
Estimated change	(-)482.5		
(M₂ Vs M₆)			
Added costs	-	Added returns	-
Reduced returns	<u>5518.9</u>	Reduced costs	<u>406.2</u>
	<u>5518.9</u>		<u>406.2</u>
Estimated change	(-)5112.7		

Partial budgeting (1993- '94)

Losses (Rs ha ⁻¹)			Gains (Rs ha ⁻¹)	
	(M ₃ S ₁ Vs	M ₃ S ₂)		
Added costs	667		Added returns	4534
Reduced returns	-		Reduced costs	-
	<u>667</u>			<u>4534</u>
Estimated change	(+)3867			
	(M ₃ S ₁ Vs	M ₃ S ₃)		
Added costs	1334		Added returns	5346
Reduced returns	-		Reduced costs	-
	<u>1334</u>			<u>5346</u>
Estimated change	(+)4012			
	(M ₃ S ₁ Vs	M ₃ S ₄)		
Added costs	2001		Added returns	5886
Reduced returns	-		Reduced costs	-
	<u>2001</u>			<u>5886</u>
Estimated change	(+)3885			

Partial budgeting (1994- '95)

	(M ₃ S ₁ Vs	M ₃ S ₂)		
Added costs	667		Added returns	2968
Reduced returns	-		Reduced costs	-
	<u>667</u>			<u>2968</u>
Estimated change	(+)2301			
	(M ₃ S ₁ Vs	M ₃ S ₃)		
Added costs	1334		Added returns	3838
Reduced returns	-		Reduced costs	-
	<u>1334</u>			<u>3838</u>
Estimated change	(+)2504			
	(M ₃ S ₁ Vs	M ₃ S ₄)		
Added costs	2001		Added returns	4358
Reduced returns	-		Reduced costs	-
	<u>2001</u>			<u>4358</u>
Estimated change	(+)2357			

Partial budgeting - Mean for 1993 - '94 and 1994 - '95

Losses (Rs ha ⁻¹)		Gains (Rs ha ⁻¹)	
(M₁ Vs M₂)			
Added costs	1799.75	Added returns	23066.35
Reduced returns	-	Reduced costs	-
	<u>1799.75</u>		<u>23066.35</u>
Estimated change	(+)21266.6		
(M₁ Vs M₃)			
Added costs	1275	Added returns	22770.35
Reduced returns	-	Reduced costs	-
	<u>1275</u>		<u>22770.35</u>
Estimated change	(+)21495.35		
(M₁ Vs M₄)			
Added costs	2020	Added returns	8890.2
Reduced returns	-	Reduced costs	-
	<u>2020</u>		<u>8890.2</u>
Estimated change	(+)6870.2		
(M₁ Vs M₅)			
Added costs	1300	Added returns	22404.5
Reduced returns	-	Reduced costs	-
	<u>1300</u>		<u>22404.5</u>
Estimated change	(+)21104.5		
(M₁ Vs M₆)			
Added costs	1397.4	Added returns	19146.8
Reduced returns	-	Reduced costs	-
	<u>1397.4</u>		<u>19146.8</u>
Estimated change	(+)17749.4		

Mean for 1993 - '94 and 1994 - '95

Losses (Rs ha ⁻¹)		Gains (Rs ha ⁻¹)	
	(M ₂ Vs M ₃)		
Added costs	-	Added returns	32.15
Reduced returns	<u>355.15</u>	Reduced costs	<u>524.75</u>
	<u>355.15</u>		<u>566.9</u>
Estimated change	(+)201.75		
	(M ₂ Vs M ₄)		
Added costs	220.25	Added returns	-
Reduced returns	<u>14176.15</u>	Reduced costs	<u>-</u>
	<u>14396.4</u>		<u>-</u>
Estimated change	(-)14396.4		
	(M ₂ Vs M ₅)		
Added costs	-	Added returns	-
Reduced returns	<u>666.85</u>	Reduced costs	<u>499.75</u>
	<u>666.85</u>		<u>499.75</u>
Estimated change	(-)167.1		
	(M ₂ Vs M ₆)		
Added costs	-	Added returns	-
Reduced returns	<u>3919.55</u>	Reduced costs	<u>402.35</u>
	<u>3919.55</u>		<u>402.35</u>
Estimated change	(-)3517.2		

	(M ₃ S ₁ Vs M ₃ S ₂)		
Added costs	667	Added returns	3751
Reduced returns	<u>-</u>	Reduced costs	<u>-</u>
	<u>667</u>		<u>3751</u>
Estimated change	(+)3084		
	(M ₃ S ₁ Vs M ₃ S ₃)		
Added costs	1334	Added returns	4592
Reduced returns	<u>-</u>	Reduced costs	<u>-</u>
	<u>1334</u>		<u>4592</u>
Estimated change	(+)3258		
	(M ₃ S ₁ Vs M ₃ S ₄)		
Added costs	2001	Added returns	5122
Reduced returns	<u>-</u>	Reduced costs	<u>-</u>
	<u>2001</u>		<u>5122</u>
Estimated change	(+)3121		

DISCUSSION

CHAPTER V

DISCUSSION

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, from June, 1993 to February, 1995 with the twin objectives of evaluating the direct and their residual effect of applied non-conventional green leaf manures and N fertilizers for low land rice. The experimental results presented in Chapter IV are discussed in this chapter.

Experiment 1. Effect of GLMs and levels of N on Kharif rice

In the first year cropping system of Kharif rice followed by Rabi rice, all the green leaf manures under study were incorporated prior to transplanting of Kharif rice at the rate of 45.03 kg N ha⁻¹. In the second year cropping system of 1994 - '95, because of lower moisture content of *Sesbania aculeata*, the total quantity of N added through GLMs was 54.57 kg ha⁻¹. This happened because *Sesbania aculeata* was taken as a standard and applied at the rate of 6.25 t ha⁻¹ in both the years of study. As a result of decreased moisture content of *Sesbania aculeata* in the second year, eventhough with the application of 6.25 t ha⁻¹ of recommended dose, the applied N computed to 54.57 kg ha⁻¹ (Table 6). It was reported by Sriramachandrasekaran (1994) that N added by recommended dose of *Sesbania aculeata* (6.25 t ha⁻¹) may vary depending on the N content as well as moisture content of the fresh GLMs added.

5.1.1. Effect of green leaf manures incorporation on soil NH_4^+ -N and NO_3^- -N content during incubation period.

All the green leaf manures were applied on equal N basis as indicated elsewhere, 10 days prior to transplanting and incorporated into the soil

The data on NH_4^+ -N clearly indicated that application of GLMs increased the NH_4^+ -N content throughout the incubation period of 10 days from the date of incorporation. Among the different green leaf manures, *Sesbania aculeata* released more NH_4^+ -N as compared to other green leaf manures studied (Fig. 7). This variation in NH_4^+ -N released from different green leaf manures could be attributed to chemical composition of the species used as found by Harber and Lynch (1981). They reported that the release of NH_4^+ -N mainly dependent upon CN ratio and lignin content of the applied green leaf manure. However, the NH_4^+ -N content released in the incubation period is not beneficial to the crop, since it is bound to undergo various losses without crop uptake. More over, from the present study, it is clear that *Sesbania aculeata* does not require any incubation period and the transplanting can be done immediately after incorporation.

NO_3^- -N is an important fraction in submerged soils, since it is rapidly taken up by the crop and in the absence of a crop it is susceptible for leaching under flooded condition. Incubation study has indicated certain definite trends of its change. NO_3^- -N content in GLMs applied plots got increased from first day of application up to fourth day. After this period, NO_3^- -N content started declining. Among the different green leaf manures, the release was highest with *Sesbania aculeata* (Fig. 8). Superiority of *Sesbania aculeata* in the present study could be attributed to its higher N content (3.16 and 2.97 % in 1993 and 1994 respectively), which promoted the higher rate of mineralisation and its lower C:N ratio (16:1 and 15 : 1 during 1993 and 1994

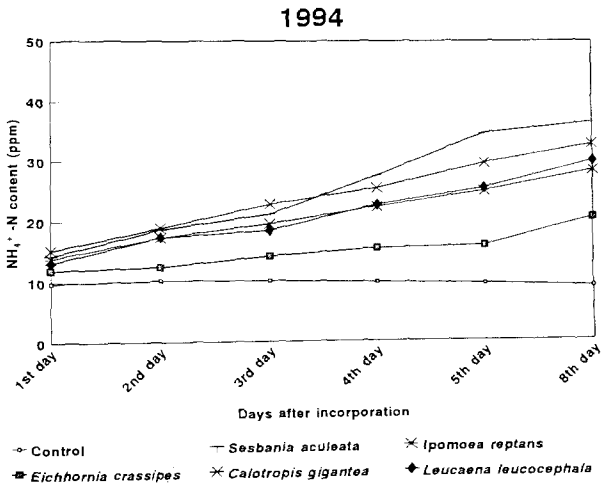
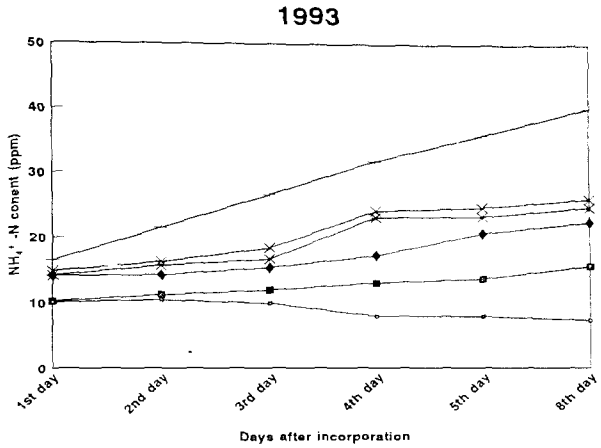


Fig.7. Change in soil $\text{NH}_4^+ -\text{N}$ (ppm) as influenced by GLMs incorporation during the incubation period

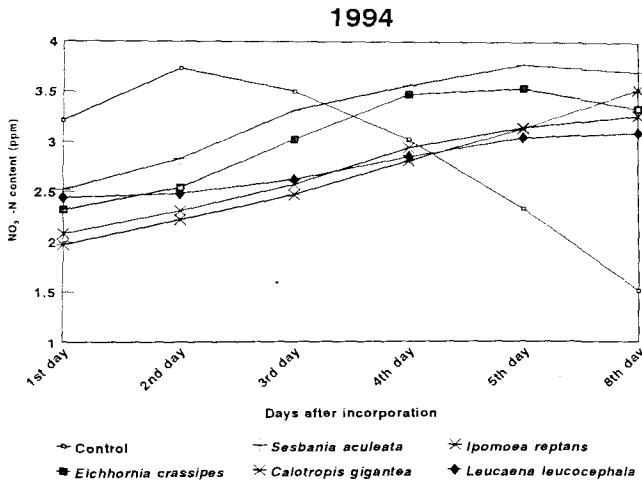
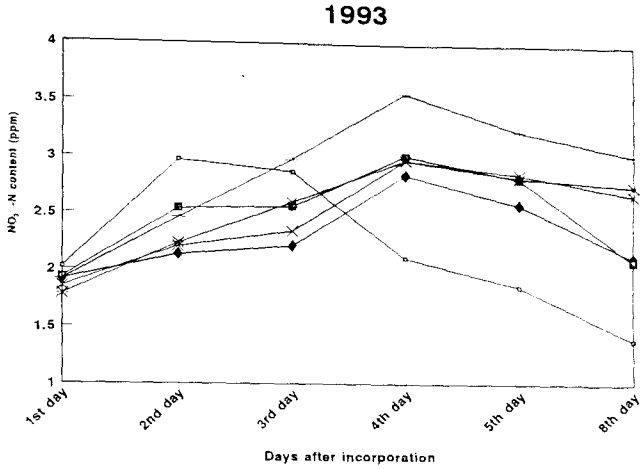


Fig.8. Change in soil $\text{NO}_3\text{-N}$ content (ppm) as influenced by GLMs incorporation during the incubation period

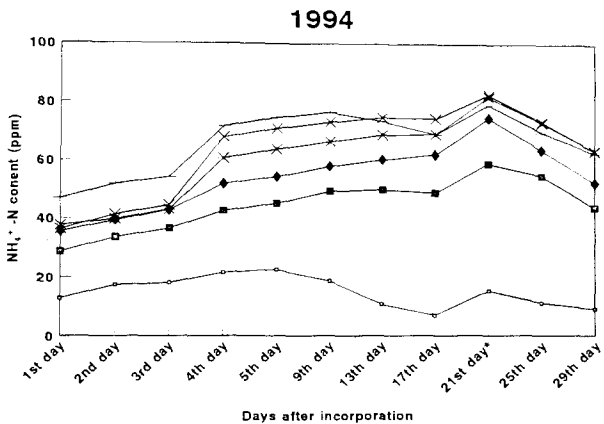
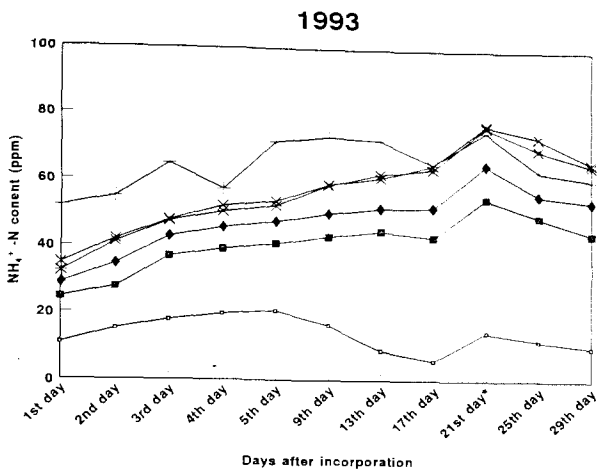
respectively) compared to other organic sources. Stevenson (1986), reported that organic matter with lower CN ratio (7 to 19 : 1) recorded higher mineralisation rate than the others with wider CN ratio. Similar result was reported by Beri *et al.* (1989) and Hameed Khan (1990).

Poor performance of *Eichhornia crassipes* could be attributed to its high lignin content (Tables 4 and 5) as reported by Alexander (1977), Frankenberger Jr and Abdelmagid (1985). It was further reported that lignin content of the plant was an indicator for rate of decomposition under flooded soil condition (Muller *et al.*, 1988, Palm and Sanchez, 1990).

5.1.2. Effect of GLMs and levels of N on soil NH_4^+ -N and NO_3^- -N content after rice transplanting

The two fractions NH_4^+ -N and NO_3^- -N have particular significance in rice culture, since both forms of N are absorbed by the rice plant. However, relative proportion of these are governed by soil factors, climatic conditions and interaction factors (soil temperature, soil pH etc.). In the present study, the data (Tables 12 to 19) indicated that both NH_4^+ -N and NO_3^- -N behaved similarly in relation to treatmental effect. However, the relative proportion of NH_4^+ -N was much higher than NO_3^- -N at different periods.

It was noted that *Sesbania aculeata* released NH_4^+ -N quickly when compared to other green leaf manures and it peaked up to 13 days after planting. The release from *Calotropis gigantea* and *Ipomoea reptans* was little later and the peak was observed on 21st day after planting. *Leuciana leucocephala* and *Eichhornia crassipes* released comparatively lesser NH_4^+ -N than other GLMs studied (Fig. 9). This variation in release of NH_4^+ -N might be due to CN ratio and lignin content, which are different for different green leaf manures studied. *Sesbania aculeata* has the lowest lignin content (9%) and narrow CN ratio where as *Eichhornia crassipes* has



- Control
- *Sesbania aculeata*
- × *Ipomoea reptans*
- *Eichhornia crassipes*
- * *Calotropis gigantea*
- ◆ *Leucaena leucocephala*

Fig.9. Change in soil $\text{NH}_4^+\text{-N}$ (ppm) as influenced by GLMs incorporation after the transplanting of rice crop

the highest lignin content of 22 per cent and wider CN ratio (36 : 1). After 21 days of planting there was reduction in NH_4^+ -N content in all the green leaf manured plots. This might be due to ammonia volatilization (Ponnampertuma, 1978, Ilango, 1989) or due to crop removal as pointed out by Nemeth (1976).

NO_3^- -N content in the treatments started declining after fourth day of transplanting (Fig. 10). This might be due to leaching or denitrification losses and these losses might be least as compared to inorganic N sources (Ramanathan, 1995)

With reference to N levels, higher dose of N recorded significantly higher values of NH_4^+ -N and NO_3^- -N over lower levels. This could be attributed to higher urea hydrolysis mediated by higher urease activity. This view was also held by Venkataraman (1977) and Hameed Khan (1990). Quite a few workers (Siddaramappa and Seshagiri Rao, 1971 ; Black and Waring, 1976) also reported that application of fertilizer N favorably increased the concentration of NH_4^+ -N. This results of increased NH_4^+ -N and NO_3^- -N with increasing N levels were also reported earlier by Prasad and Prasad (1982).

Interaction effect between green leaf manures and N levels was significant. Infact, combined application of urea and GLMs recorded higher NH_4^+ -N and NO_3^- -N. This indicates that urea hydrolysis was facilitated to a larger extent in the presence of easily decomposable green leaf manures. This is scientifically called as priming effect (De Laune and Patrick, 1970) or Added Nitrogen Interaction(ANI) as explained by Jenkinson *et al.*, (1985). Similar effect on mineralisation of applied urea in the presence of GLMs was also reported by many workers (Beri and Brar, 1975; Fenn *et al.*, 1987; Nagarajah, 1987; Hameed Khan, 1990).

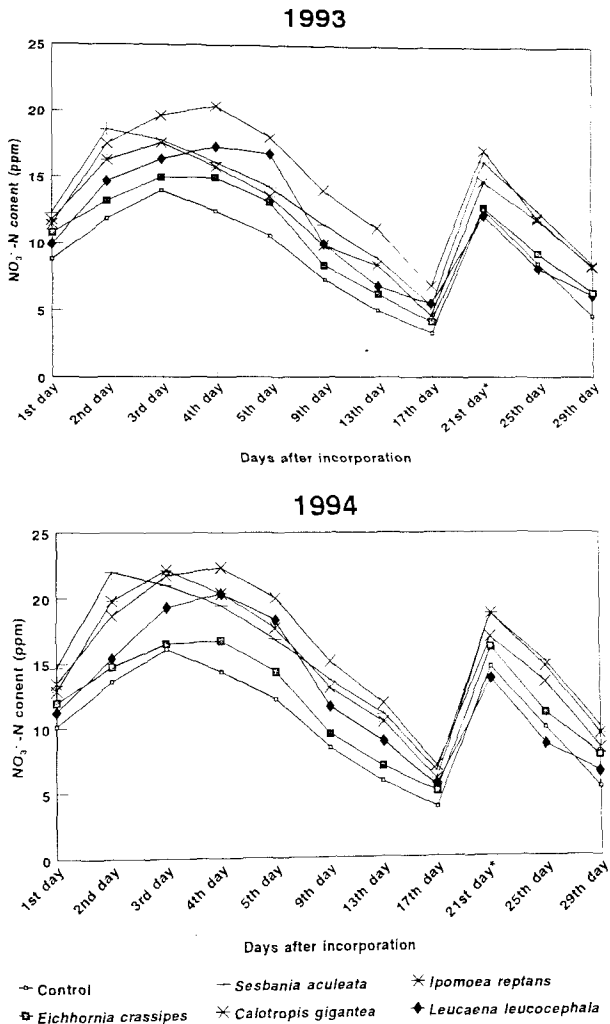


Fig.10. Change in soil $\text{NO}_3\text{-N}$ (ppm) as influenced by GLMs incorporation after the transplanting of rice crop

GDD and rainfall during crop growth period

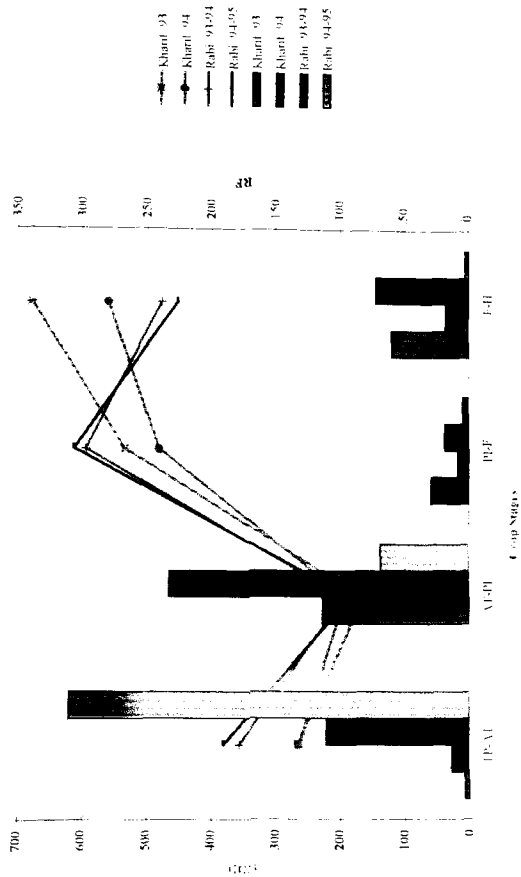
For the purpose of relating the weather that existed during different growth phases of seasons with N uptake, one weather element (Rainfall) and one weather product (GDD) have been documented and presented in Fig.10a.

The comparison between GDD of Kharif, 1993 and Kharif, 1994 indicated that the total GDD computed for Kharif, 1993 was comparatively greater than the GDD obtained during Kharif, 1994. In all stages of Kharif, 1993, the GDD was more than that of the GDD obtained for the rice crop of Kharif, 1994. Since the GDD is the product from temperature which has got greater control on the growth of the plants through enzyme activities. It was reported by De Datta (1981) that solar radiation should not be a limited one from Panicle initiation to 10 days earlier to harvest. In the present investigation, The temperature, an output of solar radiation was greater through GDD from panicle initiation to harvest stage of Kharif, 1993 over Kharif, 1994. This might have influenced for greater biomass production with greater N uptake for the rice crop grown during Kharif, 1993. Added to this optimal rainfall also was recorded for Kharif, 1993 rice crop.

Similarly the same climatological science was observed for the rice crop grown during Rabi, 1994 -'95 as compared to the rice crop of Rabi, 1993 -'94. Hence increased biomass with higher N uptake was noted for the rice crop grown during Rabi, 1994 -'95.

Hence the present study indicated that the crop depended mainly upon the effective utilisation of temperature prevailed during the cropping period as evidently proved by Arjunan *et al.*, (1993).

GDD and RF during different crop stages



5.1.3. Effect of GLMs and levels of N on growth attributes of rice

Application of either GLMs or fertilizer N led to a noticeable increase in plant height when compared to unfertilized control (Tables 20 and 21). This observation lends evidence to the fact that, application of N played a pivotal role in enhancing the growth rate of a crop. Taller plants were obtained with *Sesbania aculeata* and *Calotropis gigantea* applied treatments. This might be due to better N release from the above green leaf manures as explained in 5.1.1 and 5.1.2. Similarly taller plants were obtained with higher N level. Taller plants usually provide a better ventilated canopy and CO₂ exchange might be improved (Novoa and Loomis, 1981). The beneficial effect of N and the integrated use of GLMs and fertilizer N on rice growth in terms of increased plant height was reported by Premsekar (1993), Ramanathan (1995) and Singh and Singh (1995).

All the growth attributes Viz., plant height, leaf area index and dry matter production were increased with the application of GLMs and fertilizer N. With the conjunctive use of GLMs and fertilizer N, there would have been a balanced N supply to the crop with minimum losses, when the crop need it most. Thus the integrated N source exerted a favorable influence on the growth attributes of rice.

Nitrogen levels and green leaf manures had significant influence on LAI compared to control (Tables 22 and 23). Application of *Sesbania aculeata* along with 120 kg N ha⁻¹ produced highest LAI. Application of higher levels of N either through inorganic or organic sources increased the leaf length as well as breadth (Sriramachandrasekaran, 1994). In the present study also, better utilization of N resulted in higher leaf surface area and there by higher LAI in the integrated N

management treatments. At higher LAI, plants become photosynthetically more active (Sharma and Mittra, 1988). Beneficial effect of N application on LAI was also reported by Yoshida (1981), Panda and Rao (1991) and Budhar (1994).

Total DMP increased steadily with time and reached the maximum at harvest (Tables 24 and 25). Application of GLMs and fertilizer N produced statistically measurable increase in all the crop growth stages over their respective control (Fig. 11). DMP tended to increase progressively with increased N levels and maximum DMP was recorded at 120 kg N ha⁻¹. Conjunctive use of GLMs and fertilizer N recorded the highest DMP. Incorporation of GLMs would have enhanced the level of N availability in the rice rhizosphere of the soil at the initial stage of the crop and application of fertilizer N might have added synergistic effect on the N utilization of rice in influencing the DMP (Watanabe, 1984). Increased levels of applied N resulted in its greater absorption and utilization, which accumulated the assimilates for faster growth of rice. This in turn, improved the vegetative growth as indicated by taller plants and larger LAI. In the presence of adequate N and larger surface of the source, the dry matter accumulation increased at a rapid rate (Sharma and Das, 1994).

5.1.4. Effect of GLMs and levels of N on yield attributes of rice and yield

The yield parameters viz., number of panicles per unit area, panicle length and filled grain percentage were positively influenced by GLMs and levels of N (Tables 26 and 27). In turn yield is also greatly affected, since it is the dependent character of these yield parameters.

Steady supply of N due to mineralisation of GLMs increased the productive tillers production, resulting in higher number of panicles per unit area. Availability of adequate N promotes the supply of assimilates to sink, thus increasing the length of panicles. Steady supply of N due to gradual mineralisation of GLMs enables the rice

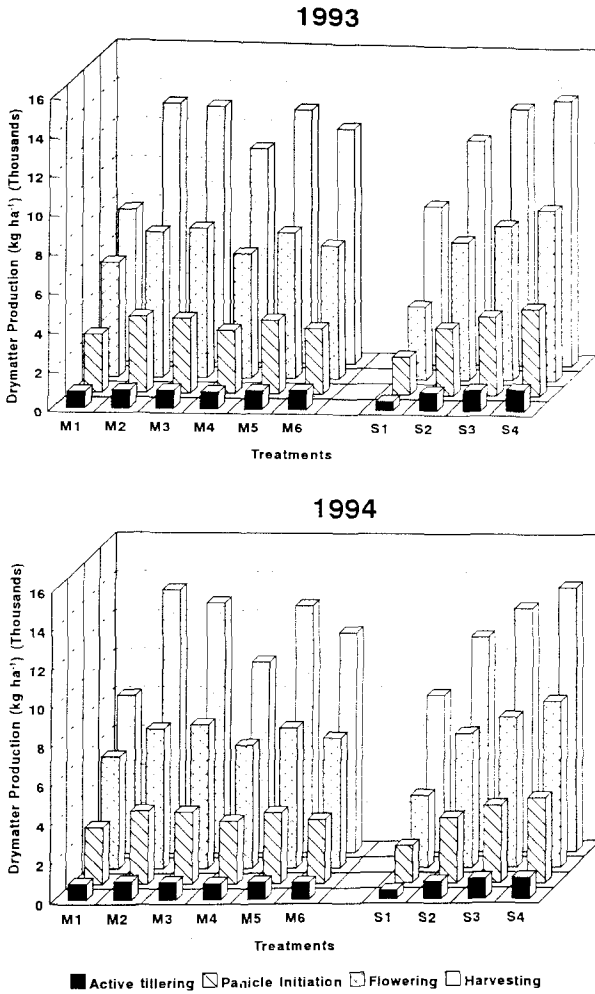


Fig.11. Effect of different GLMs and N levels on the drymatter production at different growth stages

plant to maintain the optimum N content for various physiological processes improving the yield structure. Matsushima (1980) stated that early the tillers emerge after transplanting, more they contribute towards the yield. Proliferation of tillers soon after transplanting is important for increasing the yield (Budhar et al., 1994). De Datta (1981) reported that N absorbed by the plant from tillering to PI helped rice plant to produce more number of productive tillers. In the present study also enhanced nutrient uptake was observed as a consequence of better nutritional environment offered through cumulative effect of green leaf manuring + fertilizer N which resulted in more number of panicles per unit area.

Thousand grains weight was not significantly influenced by the green leaf manures and levels of N studied as the weight of individual grain is mainly influenced by the genetic make up of the plant as compared to other environmental factors (Bhardwaj *et al.*, 1981; Narayanasamy, 1994).

Adequate N supply through GLMs and fertilizer N, promoted the supply of assimilates from the source to sink which resulted in improving the yield attributes. Continuous and steady supply of N in to the soil solution to match the required absorption pattern of rice plant, enables to meet the nutrphysiological processes, which in turn improves the yield (Srinivasulu Reddy, 1988). In the present study also it was evident that combined application of GLMs and fertilizer N improved the absorption of N from the soil, which inturn increased the nutrients uptake, there by increasing the yield attributes and yield (Tables 28 and 29).

Application of GLMs at the basal with small booster dose of inorganic N fertilizer as well as split application of adequate quantity of fertilizer N at critical stages of crop growth matched with the N requirement of the crop leading to formation of higher yield.

De Datta (1981) stated that N absorbed by the plant from tillering to PI, helped rice plant to increase its number of tillers and panicle and that absorbed during PI to flowering increased the number of filled spikelets per panicle. Matsushima (1980), stated that increasing level of N increased the grain filling percentage. Similar results were expressed by Dhal and Misra(1993). In the present investigation also, it was found that numbers of filled grains were high with GLMs application along with higher level of N. It has been documented that GLMs nitrogen is least subjected to N losses and combination of lower rates of fertilizer N with adequate quantity of GLMs appears to be more rational method of N supply to rice (Meelu *et al.*, 1985; Westcott and Mikkelson, 1988).

5.1.5. Effect of GLMs and levels of N on nutrient uptake

The plant samples at different stages were analysed for N, P and K contents and the data on uptake are presented in chapter IV. The uptake values are dependent not only on the concentration of nutrient element but also on the dry matter yields. However, higher uptake values could be mediated either through increased concentration of nutrient or increased dry matter yield.

Nitrogen appears to be the crucial element as Indian soils are generally deficient in N and addition of GLMs, particularly affect the available N status in the soil. The results indicated that GLMs, in general resulted in significantly higher values of N uptake, irrespective of the stages (Tables 36 and 37). In grain yield too, the same trend was noticed. *Sesbania aculeata* again proved superior in this regard. *Sesbania aculeata* not only resulted in higher available N status in the soil but also produced significantly higher dry matter, straw and grain yields. Thus, the effect is additive on N uptake by the crop. The results also indicated that *Calotropis gigantea* and

Ipomoea reptans were comparable with *Sesbania aculeata*. Swarup (1987) and Rabindra *et al.* (1989), also reported higher N uptake due to *Sesbania aculeata* alone as compared to other organic sources.

Among the green leaf manures, *Eichhornia crassipes* applied rice was noticed to register lower N uptake. It might be due to higher lignin content and N release pattern through decomposition from *Eichhornia crassipes*. It should also be pointed out that all the green leaf manures in the present study were evaluated on the basis of equal quantity of N. This implies that quantum of green leaf manures added to the soil varied, though N equivalent was maintained for all the treatments. Hence the difference was specifically due to nature of green leaf manures, its lignin content, carbon content and other chemicals.

The contribution of N by the green leaf manures were computed from the mean N uptake in control as well as in green leaf manure applied plots and represented in Fig. 12.

Sesbania aculeata contributed more N when compared to other green leaf manures. This might be due to quick release of N from the added green leaf manure. *Calotropis gigantea* and *Ipomoea reptans* also registered higher N contribution. The combined contribution of N from green leaf manures was 53.5 per cent. The lowest N contribution was seen from *Eichhornia crassipes*. The possible reason might be the higher lignin content in *Eichhornia crassipes* which led to delayed decomposition. The importance of N contribution by green manures was also reported by Babu (1995).

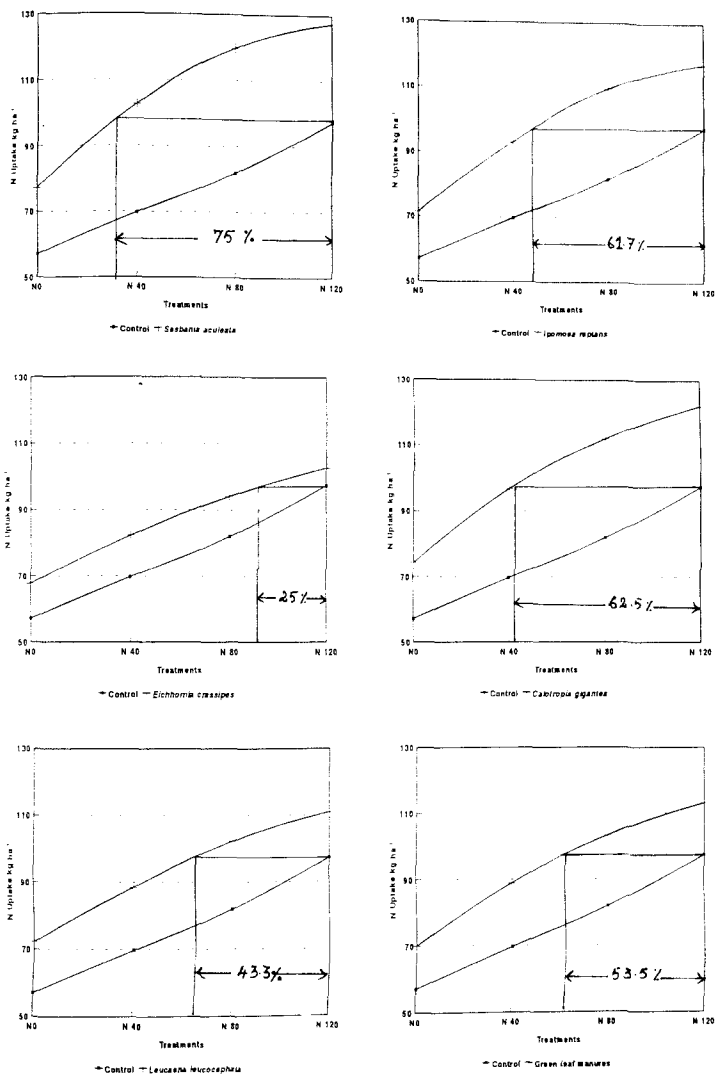


Fig.12. Contribution of N from green leaf manures

In respect of P, a similar trend was noticed. Green leaf manures in general, recorded significantly higher P uptake over control (Tables 38 and 39). Increased availability of P in the soils could have been brought by not only the decomposition products of GLMs (Sharma and Mitra, 1988), but also by synergistic effect existing between N and P. Venkateswara Rao and Govindarajan (1960), reported that green leaf manuring helps in increased utilization of fertilizer P. P content of the added organic matter is perhaps the most important factor in regulating the release of P (Singh and Jones, 1976). Hundal *et al.*, (1987), stated that in water logged soil GLMs increases availability of P, through the mechanism of reduction, chelation and favorable changes in soil pH. Alexander (1977), reported that release of P was most rapid under conditions favoring ammonification. In the present study also it was evident, application of GLMs favorably influenced the P uptake of rice crop.

More or less similar trend in respect of K uptake by the rice crop was observed (Tables 40 and 41). Increased K uptake in rice due to addition of GLMs was earlier reported by Swarup (1987) and Sriramachandrasekaran (1994). The increase in K availability could be due to priming effect on K besides the direct contribution of K by green leaf manures. The leguminous green leaf manures have a strong ability to absorb the rather inaccessible K in the soil (Gu and Wen, 1981).

Increase in levels of N increased the N, P and K uptakes of rice plant in the present investigation. This might be due to increase in dry matter at higher level of N applied as reported by Budhar (1994).

5.1.6. Effect of GLMs and levels of N on the use efficiency of N

The various parameters of use efficiency of N were influenced by GLMs as well as levels of N.

Agronomic Efficiency (AE) indicates the quantity of rice production per unit quantity of N applied and this is also termed as productive efficiency and often expressed as the product of efficiency of absorption and efficiency of utilization. In the present study, AE was improved when the GLMs was combined with lower level of N (40 kg N ha^{-1}). This only shows that GLMs, apart from contributing organic N, improved the efficiency of fertilizer N also. Combination of GLMs with higher levels of N ($> 40 \text{ kg N ha}^{-1}$) tend to show lower AE (Tables 42 and 43). This is because with increased quantity of N application, the losses of N from lowland rice soil and flood water become larger and inevitable. Such interactive effect of organic and lower levels of inorganic sources of N, leading to higher AE was reported by Morris *et al.* (1986b) and Babu (1995).

Physiological Efficiency (PE) is the quantity of grain produced per unit quantity on N absorbed by the crop and it indicates the efficiency of utilization of absorbed N. No clear trend was noticeable in PE due to application of different green leaf manures (Tables 44 and 45). Application of lower levels of N recorded higher PE, when compared to higher N levels. In general rate of uptake of N decreased at higher level of N supplied, since a greater amount of N applied is lost through several mechanism of N losses in low land rice ecosystem (Saravanan, 1990).

Apparent N Recovery (ANR), which indicates the efficiency of absorption of applied N. GLMs tended to increase the ANR (Tables 46 and 47) and this could be explained as follows: The ANR was computed based on difference between uptake of specific treatment and control. With green leaf manuring, the uptake of N by rice was fairly high. GLMs might have contributed considerable quantity of N upon mineralisation making more N available to plants. Naturally ANR becomes higher with increased N availability. ANR decreased with higher level of fertilizer N, as indicated else where.

Nitrogen Harvest Index (NHI), indicates the proportion of N taken up by the crop that is utilised for grain production and may be considered as an indicator of translocation from source to sink. Application of GLMs positively influenced NHI, by making steady supply of N to rice crop (Tables 48 and 49). In rice crop most of the assimilates produced in the post flowering stage would be utilised for grain formation and more than 75 per cent of grain yield is decided by the amount of photosynthesis that occurs after flowering. The N uptake was enhanced by GLMs through out the crop growth period (Tables 36 and 37), and this would have enhanced NHI in GLMs applied treatments. Increased NHI due to application of GLMs was also reported by Siddeswaran (1992). In contrast to the above three parameters Viz., AE, PE and ANR, the increase in N level increased the NHI. Higher values of NHI, at higher levels of N application has been reported by Chandrasekaran (1984) and Srinivasulu Reddy (1988).

5.1.7. Post harvest soil available N and N balance after Kharif rice.

Incorporation of GLMs and levels of N exerted considerable influence on post harvest soil available N status (Tables 50 and 51). Whenever green leaf manuring was done, there was an improvement in soil available N content, when compared to its control. This is attributable to release of N from the green leaf manures incorporated, due to steady and slow mineralisation process. Among the green leaf manures, *Ipomoea reptans*, *Leuciana huecocephala* and *Calotropis gigantea* left significantly higher soil available N. The green leaf manure contains two fractions. One which undergoes decomposition at a faster rate and release N to the current crop and the second which is fairly resistant to decomposition, but mineralise at a slower rate (Bouldin, 1988). The second fraction of GLMs might have contributed to the improvement in the post harvest soil available N status in the case of *Ipomoea reptans*, *Leuciana huecocephala* and *Calotropis gigantea*.

When no fertilizer N was applied, it showed a drastic reduction, while it showed a marginal reduction with application of 40 kg N ha⁻¹ and there was no appreciable change when 80 kg N ha⁻¹ was added. There was an improvement in available N at 120 kg N ha⁻¹. This indicates that rice removed its N uptake from fertilizer N, leaving soil N unutilised and hence higher soil available N was recorded.

The soil available N balance (Tables 52 and 53) showed a net loss when either fertilizer N alone or GLMs alone was added. This brings out the unsustainability of the treatment. With 40 kg N ha⁻¹, it showed a slight improvement in net balance when *Ipomoea reptans* or *Calotropis gigantea* or *Leuciana leucocephala* were added as green leaf manures. In the case of *Sesbania aculeata* and *Eichhornia crassipes*, 80 kg N ha⁻¹ showed a positive N balance. The total quantity of N removed from different treatments ranged from 58.8 to 124.2 kg ha⁻¹ in 1993 and 48.4 to 130.7 kg N ha⁻¹ in 1994. This quantity of N would have been made available from the native soil pool by mineralisation of GLMs and from fertilizer N. In the case of negative N balance, N released upon mineralisation of GLMs and through application of fertilizer was not sufficient to meet the requirement of the crop in question resulting in N depletion of soil available N.

Experiment II. Residual study

5.2. Residual effect of applied GLMs and fertilizer N on Rabi crop.

5.2.1. Growth attributes

The residual effect of GLMs applied to Kharif rice on growth attributes of Rabi season rice was well pronounced in terms of plant height and LAI (Table 54) during flowering and DMP at different growth stages (Tables 55 and 56) of rice. This might

be due to higher post harvest soil available N after Kharif rice in the case of GLMs applied plots. Among the different green leaf manures, the effect was more in *Leuc^osternum luecocephala*, *Calotropis gigantea*, *Ipomoea reptans* and *Sesbania aculeata* applied treatments. *Eichhornia crassipes* registered higher growth attributing characters than control, however, it was not comparable with the other four green leaf manures due to its higher lignin content which resisted decomposition.

Fertilizer N applied to Kharif rice did not show any effect on growth parameters of Rabi crop, indicating that there is no residual effect for applied N on the subsequent crop.

Between N applied and not applied plots of Rabi rice, the results were in favour of 100 kg N ha⁻¹. This might be due to complementarity of applied N to native soil N in the above condition.

5.2.2. Yield attributes and yield

The residual effect of green leaf manuring to wetland rice is generally measured in terms of grain yield of succeeding crop and the residual effect is often location specific, which mainly depends on the climatic conditions prevailed in that location (Singh *et al.*, 1991). In the present study, application of GLMs to the Kharif rice showed a favorable residual effect on yield attributes (Tables 57 and 58) and yield (Table 60) of subsequent Rabi season rice. The residual effect on Rabi season rice grain yield was 6 to 27.7 and 14.6 to 31.1 per cent during 1993 - '94 and 1994 - '95 respectively. These increases were statistically significant. The residual effect on the second crop is true to the hypothesis put forth by Bouldin (1988), that organic amendments contain a component that slowly decomposes over several years and could be measured only after sufficiently long period.

Among the different green leaf manures, the yield attributes and yield were higher in *Ipomoea reptans*, *Leuciana huecocephala* and *Calotropis gigantea* applied plots followed by *Sesbania aculeata* and *Eichhornia crassipes*. The probable reason might be explained like this: *Ipomoea reptans*, *Leuciana huecocephala* and *Calotropis gigantea* applied plots had more of slowly decomposable organic components because of higher lignin content and CN ratio which contributed for yield increase during second season, where as *Sesbania aculeata* which had a lower lignin content and narrow CN ratio decomposed quickly and released most of the organic N for the Kharif crop itself (Tables 12 -19). In the case of *Eichhornia crassipes* in both the seasons, the effect was not shown much and the reason might be due to the higher lignin content which might resist decomposition even after second crop, possibly the benefit may accrue to third crop, which is not studied in the present investigation.

The reports of previous workers on the residual effect of green leaf manuring are often contradictory. Many workers recorded a favorable residual effect (Meelu *et al.*, 1986; Morris *et al.*, 1989; Malathi, 1989; Maskina *et al.*, 1990; Siddeswaran, 1992), while others (Morris *et al.*, 1986b; Westcott and Mikkelsen, 1987; Srinivasulu Reddy, 1988) didn't find any residual effect. The differences in the residual effect observed by the earlier workers have been attributed to the quantity of GLMs applied (Morris *et al.*, 1989; Buresh and De Datta, 1991). It was also found that the residual effect of green leaf manures is location specific as reported by Singh *et al.*, (1991) and hence this contradictory views arised. Under tropical conditions, the residual effect are likely to be smaller than under temperate climate (Singh *et al.*, 1991) because increased microbial activity as a result of increased solar radiation. The residual effect of GLMs on the second crop of rice would be very small when only one application is made in a year, but the cumulative effect of several annual applications are expected to bring appreciable residual effect (Bouldin, 1988).

5.2.3 Nutrient uptake and use efficiencies.

The residual effect of applied GLMs to Kharif rice on the uptakes of N, P and K by Rabi rice crop was noticed (Table 59). Among the green leaf manures, *Leuciana leucocephala*, *Ipomoea reptans*, *Calotropis gigantea* and *Sesbania aculeata* increased the N, P and K uptakes. Application of the above green leaf manures, not only resulted in higher available N, P and K status in the soil, but also produced significantly higher dry matter as well as higher grain yield which resulted in higher nutrient uptake.

Application of different levels of N to Kharif rice also influenced the nutrient uptake. This could be attributed to the higher availability of post harvest soil available N left after the Kharif rice crop which was effectively utilised for the growth of Rabi season rice. Similar results of increased nutrient uptake due to increased level of N was also reported by Sharma and Mittra (1988) and Siddeswaran (1992).

Carry over effect of green leaf manures was noticed in different use efficiencies Viz., Physiological Efficiency (Tables 63 and 64) and Apparent N Recovery (Tables 65 and 66), where as the effect was variable with regard to Agronomic Efficiency (Tables 61 and 62). The improvement in PE and ANR in green leaf manured plots might be due to steady supply of organic N from slowly decomposable organic matter fraction of GLMs applied to Kharif rice crop.

5.2.4. Soil fertility after rice - rice cropping system.

Incorporation of GLMs as well as application of fertilizer N exerted considerable influence on the soil fertility status (Table 67).

Green leaf manuring improved the soil available carbon content from 0.61 to 0.64 per cent in the case of *Leuciana luecocephala* during 1993 - '94 and from 0.63 to 0.649 per cent in the case of *Sesbania aculeata* during 1994 - '95. The data also revealed that the soil organic carbon content was improved when ever GLMs (except *Eichhornia crassipes*) was incorporated. Bhardwaj and Dev (1985), recorded increased soil organic carbon due to *Sesbania aculeata* incorporation to rice. A part of GLMs which is fairly resistant to immediate decomposition but mineralise at a slower rate might have contributed to the improvement in the soil organic carbon status (Bouldin, 1988). Soil organic carbon may also increase with the application of fertilizer N, but this is always inconsistent.

Green leaf manuring as well as N levels showed a significant influence on soil available N. When ever green leaf manuring was done, there was an improvement in the soil available N content. Slow decomposition of GLMs leads to steady N release to meet the requirement of rice crop at critical stages. Even after the growing period GLMs would continue to mineralise N, which would add to the soil pool (Bouldin, 1988). This helped in maintaining the soil available N, inspite of the depletion by the rice crop. This was well pronounced with the incorporation of GLMs along with fertilizer N. Eventhough the rice crop depleted the soil N by its high uptake, the steady supply of N by GLMs maintained the level of available N in the soil at a fairly high level.

Among the green leaf manures, at the end of second crop, the soil available N content was the highest with the application of *Calotropis gigantea* and *Leuciana luecocephala* . This was followed by *Ipomoea reptans* and *Sesbania aculeata* . This brings out the beneficial effect of green leaf manuring in improving the soil N fertility in course of time for sustaining high productivity of the intensive cropping system followed.

When fertilizer N was not applied, the soil available N showed a drastic reduction. Application of 80 and 120 kg N ha⁻¹ stood on par with regard to post harvest soil available N. This indicates that application of 50 per cent of the fertilizer N along with adequate quantity of GLMs would improve the soil fertility status.

Soil available N balance after rice - rice crop sequence (Tables 68 and 69) indicated that green leaf manuring along with 80 to 120 kg N ha⁻¹ during Kharif season as well as application of 100 kg N ha⁻¹ to Rabi season improved the soil available N status, when compared to pre experimental level. There was a sharp decrease if no fertilizer was applied to Rabi crop. This indicates that the nitrogen which was released from GLMs and residual effect of applied N to Kharif crop was not sufficient to meet the Rabi crop N requirement which resulted in depletion of soil N status.

In general, incorporation of GLMs would cause increase and rapid production of CO₂ which in turn enhanced the solubility of calcium in the soil. Calcium ions replace Sodium ions on the exchange complex resulting in pH favorable to rice culture (Shivkant and Rajkumar, 1992). Hence, by integrating the fertilizer N along with GLMs, the losses of N through volatilisation and leaching are minimized. This improves the available N status of the soil. Huang *et al.* (1981), reported that buried GLMs act as a slow release fertilizer and conserve nutrients for longer period.

Green leaf manuring improved the soil available P. Under flooded conditions much of the soil P itself would become available to the rice crop. Insoluble P in the soil would be solubilised to some extent by the organic acids produced by the decomposing green leaf manures (Ventura *et al.*, 1987). Contribution from green leaf manures would also play a role in supplying P to the soil (Singh *et al.*, 1988). All these factors increased the post harvest available P in the GLMs applied soils.

In the case of K also, plots applied with green leaf manures did exhibit increased availability. Besides, the soil was also high in available K. Better growth of crops with higher N supply resulted in increased K uptake. GLMs also contributed K to the soil which probably resulted in high available K in GLMs applied plots.

Among the different levels of N applied to Kharif rice, the post harvest P and K were reduced at higher level (120 kg N ha^{-1}) when compared to lower level (40 kg N ha^{-1}) of N. This might be due to enhanced uptake of P and K at higher levels of N which promoted higher DMP and yield.

5.2.5. Integrated nutrient management

Integrated nutrient management involving judicious use of various sources of plant nutrients such as chemical fertilizers, organic sources and biofertilizers help to maintain or improve soil fertility and sustain crop production. It also helps to enhance the nutrient use efficiency of fertilizers and thereby contribute to environmental conservation through decreased pollution of ground and surface water resources.

The escalating cost of chemical fertilizers and dwindling fossil-fuel resources needed for the manufacture of N fertilizers, leave us with no option, but to fully exploit the potential alternative sources of plant nutrients. Renewable resources like GLMs is of great importance in this context. The crop responses to organics is often not as spectacular as for the fertilizer. The supplementary and complementary use of organics, besides improving soil physico-chemical properties, increase the use efficiency of applied fertilizer (Buresh and De Datta, 1991).

In the present study, inclusion of GLMs to the rice-rice cropping system showed beneficial effect on the yield and productivity of the cropping system as well

as on soil fertility. Green leaf manuring to Kharif season rice enhanced the grain yield by about 45 to 76 per cent while the residual effect was to the tune of 3.5 to 58 per cent for the Rabi season rice. Earlier studies showed that economy of fertilizer N through green leaf manuring ranged from 30 to 80 kg ha⁻¹ under varied situations and in most instances, it is around 50 to 60 kg N ha⁻¹. (Ladha *et al.*, 1988, Srinivasulu Reddy *et al.*, 1990).

5.2.6. Economic analysis

Green leaf manuring and fertilizer N at different levels influenced the economics of rice - rice cropping system comprehensively. BC ratio increased with the integrated N management practice. Application green leaf manures along with 80 kg N ha⁻¹ recorded the highest BC ratio (Tables 76 and 77). Among the combination, application of *Ipomoea reptans* (8 t ha⁻¹) with 80 kg N ha⁻¹ recorded higher BC ratio followed by *Calotropis gigantea* (6.5 t ha⁻¹) + 80 kg N ha⁻¹ and this is followed by *Sesbania aculeata* (6.25 t ha⁻¹) + 80 kg N ha⁻¹, the conventional method. This increased BC ratio under *Ipomoea reptans* + 80 kg N ha⁻¹ was due to lesser cost towards the green leaf manure as compared to *Sesbania aculeata* which included cost of its cultivation.

5.2.7. Partial budgeting

The tool partial budgeting, is being employed to pick out the best bet treatment based on the highest difference between the added cost + reduced returns and added returns + reduced cost. In the present investigation, all the GLMs treatments were evaluated against control. The results indicated, highest estimated change of Rs. 21495.35 was obtained under *Ipomoea reptans* applied treatment. This was mainly due to lesser added cost and higher additional return. However, *Sesbania aculeata* and *Calotropis gigantea* also recorded higher estimated changes of Rs.21266.6 and Rs.21104.5 respectively next to *Ipomoea reptans*.

Similarly, the non-conventional green leaf manures were evaluated with the standard Viz., *Sesbania aculeata* . The results indicated that *Ipomoea reptans* recorded positive estimated change (+ 201.75) This was due to lesser cost towards the green leaf manure as compared to *Sesbania aculeata* which included cost of its cultivation. The other comparable non-conventional green leaf manure was *Calotropis gigantea*, which recorded the minimum negative estimated change (- 167.1).

SUMMARY AND CONCLUSION

CHAPTER VI

SUMMARY AND CONCLUSION

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore from June, 1993 to February, 1995 with the objectives of evaluating the direct and residual effects of non-conventional green leaf manures applied to the first season rice in the rice - rice cropping system in conjunction with different levels of N from inorganic source. The experiment was laid out in split plot design, replicated thrice during Kharif season to study the direct effect of applied green leaf manures and different levels of N and in split-split plot design replicated thrice during Rabi season to study the residual effect of green leaf manures and applied N to Kharif rice. During Kharif, four non-conventional green leaf manures viz., *Ipomoea reptans*, *Eichhornia crassipes*, *Calotropis gigantea* and *Leucaena leucocephala* were compared against the conventional GLM, *Sesbania aculeata* in addition to one control (no GLM application). Four levels of N (0, 40, 80 and 120 kg N ha⁻¹) were also included along with different green leaf manures as treatments. Green leaf manures were incorporated 10 days prior to transplanting of Kharif rice crop. The cropping system study was carried out during 1993 - '94 and 1994 - '95. The release pattern of NH₄⁺-N and NO₃⁻-N were studied during incubation period and after transplanting of Kharif rice. During Rabi season, each sub plot of Kharif main treatment was divided into two to accommodate two extra treatments viz., 0 kg N ha⁻¹ and 100 kg N ha⁻¹. This was done to study the residual effect. The conclusions drawn from the study are summarised here under.

Application of green leaf manures increased NH₄⁺-N content throughout the incubation period. *Sesbania aculeata* released higher NH₄⁺-N when compared to other green leaf manures. The NO₃⁻-N content increased upto fourth day after

incorporation and then started declining in green leaf manures applied plots. In control, declining was noticed from the second day onwards. This was observed in both the years of study.

After transplanting of Kharif rice crop, application of green leaf manures irrespective of their Genus increased $\text{NH}_4^+ \text{-N}$ significantly over control throughout the observation period. *Sesbania aculeata* released $\text{NH}_4^+ \text{-N}$ quickly as compared to other green leaf manures and the peak reached at 13 days after planting. The release from *Calotropis gigantea* and *Ipomoea reptans* was little later and the peak was observed on 21st day after planting. *Leucaena leucocephala* and *Eichhornia crassipes* released comparatively lesser $\text{NH}_4^+ \text{-N}$ than other green leaf manures studied. In all the green leaf manures, $\text{NO}_3^- \text{-N}$ content increased upto fourth day and started declining there after.

The nitrogen levels applied to Kharif rice crop did show that higher values of $\text{NH}_4^+ \text{-N}$ and $\text{NO}_3^- \text{-N}$ were obtained under higher levels of N over lower levels. Combined application of N and green leaf manures recorded higher $\text{NH}_4^+ \text{-N}$ and $\text{NO}_3^- \text{-N}$ release after transplanting of rice crop.

Conjunctive use of either *Sesbania aculeata* or *Calotropis gigantea* with 120 kg N ha^{-1} resulted in taller plants, larger LAI and greater DMP. The Relative Dry Matter Efficiency was also improved with the application of green leaf manures.

Application of green leaf manures and levels of N significantly increased the yield parameters over control. *Calotropis gigantea* or *Sesbania aculeata* or *Ipomoea reptans* with 120 or 80 kg N ha^{-1} had increased number of productive tillers per unit area, panicle length and filled grain percentage. No significant difference was recorded for test weight of grain due to green leaf manures and levels of N studied. Application of green leaf manures significantly influenced the N uptake over control.

Higher N uptake was seen where *Sesbania aculeata* was incorporated to Kharif rice followed by *Calotropis gigantea* which was at par with *Ipomoea reptans*. *Leucaena leucocephala* and *Eichhornia crassipes* applied treatments registered lower N uptake. N application markedly increased the N uptake and the highest value was found with 120 kg N ha⁻¹. However, it was at par with 80 kg N ha⁻¹ during 1993. Lowest N uptake was recorded in control plot. Conjunctive use of N at 120 kg N ha⁻¹ with *Sesbania aculeata* recorded the maximum N uptake. Among the non-conventional green leaf manures, *Calotropis gigantea* was comparable with *Sesbania aculeata*, but superior than *Ipomoea reptans*, *Leucaena leucocephala* and *Eichhornia crassipes*.

P and K uptake followed the similar trend as that of N uptake. Green leaf manures, in general, increased the P and K uptake over control.

Application of N through green leaf manures increased the grain yield significantly. Incorporation of *Sesbania aculeata* increased the rice grain yield in both the years of study. However, it was at par with *Calotropis gigantea* and *Ipomoea reptans* applied treatments. Rice grain yield increased with increase in N application. Application of 120 kg N ha⁻¹ increased the grain yield to 70 and 71 per cent over absolute control during 1993 and 1994 respectively. Combined application of *Sesbania aculeata* or *Calotropis gigantea* or *Ipomoea reptans* as green leaf manures source along with 120 kg N ha⁻¹ registered maximum grain yield. However, it was comparable with green leaf manures + 80 kg N ha⁻¹. In the absence of any green leaf manures, higher level of N (120 kg N ha⁻¹) alone had produced non-statistical comparable rice grain yield at par with green leaf manures application alone.

Straw yield followed the similar trend as that of grain yield and application of *Sesbania aculeata* or *Ipomoea reptans* or *Calotropis gigantea* significantly increased

the straw yield. N supply consistently increased the straw yield upto the highest level of 120 kg N ha⁻¹ tried, though the rate of increase was not commensurating with increase in N levels.

Green leaf manures incorporation increased the harvest index and different levels of N did not alter the HI in both the years.

Productivity score increased with the *Sesbania aculeata* followed by *Ipomoea reptans* and *Calotropis gigantea* application. This was followed by *Leucaena leucocephala* and *Eichhornia crassipes*. Increasing levels of N increased the productivity score and the response was seen upto 120 kg N ha⁻¹.

Relative yield index was maximum when *Sesbania aculeata* was incorporated. This was followed by *Calotropis gigantea*, *Ipomoea reptans*, *Leucaena leucocephala* and *Eichhornia crassipes*. The Relative yield index increased with increasing levels of N.

Agronomic Efficiency was improved by the application of green leaf manures but not with greater variation between them. Based on the mean values of AE, 40 kg N ha⁻¹ gave higher AE (41.69 in 1993 and 36.22 in 1994) than 80 kg (30.77 and 27.04) and 120 kg N ha⁻¹ (22.08 and 22.14).

In respect of Physiological Efficiency, difference was absent between the green leaf manures application and control. Levels of N followed the similar trend as that of AE.

Application of *Sesbania aculeata* improved the apparent N recovery to a greater level. This was followed by *Calotropis gigantea*, *Ipomoea reptans*,

Leucaena leucocephala and *Eichhornia crassipes*. Lower ANR was registered by control (no green leaf manures). Maximum ANR was recorded at lower levels of N. Green leaf manures with 40 kg N ha⁻¹ registered the highest ANR.

Incorporation of green leaf manures registered the highest N harvest index than their control. *Sesbania aculeata*, *Ipomoea reptans*, and *Calotropis gigantea* registered non-statistical comparable NHI. This was followed by *Leucaena leucocephala* and *Eichhornia crassipes*. Higher NHI value was recorded with 120 kg N ha⁻¹.

Green leaf manuring left higher post harvest soil available N, compared to control. Among the green leaf manures, *Ipomoea reptans*, *Leucaena leucocephala* and *Calotropis gigantea* left significantly higher soil available N. The increase was 8.86, 8.19 and 7.01 per cent during 1993 and 13.26, 11.83 and 10.83 per cent during 1994 respectively over control. Increasing levels of N had increased post Kharif harvest soil available N. The increase was 6.04, 10.02 and 14.25 per cent in 1993 and 4.83, 8.08 and 13.07 per cent in 1994 corresponding to 40, 80 and 120 kg N ha⁻¹ respectively over control. Combined application of *Ipomoea reptans* + 120 kg N ha⁻¹ registered the maximum post harvest soil available N.

Computed N balance after Kharif rice was positive when green leaf manures + inorganic fertilizer were combined. Maximum net gain was observed for *Ipomoea reptans* + 120 kg N ha⁻¹ followed by *Calotropis gigantea*, *Leucaena leucocephala*, *Eichhornia crassipes* and *Sesbania aculeata* with the same N level.

In general, soil available N showed a net loss even in higher levels of N, if green leaf manures were not combined. Similarly green leaf manures alone also resulted in negative N balance.

In Rabi season, the carry over effect of different green leaf manures and fertilizer N was studied and presented below.

Residual effect on Rabi rice plant height and LAI was higher in *Leucaena leucocephala*, *Calotropis gigantea* and *Ipomoea reptans* applied plots to Kharif rice. Carry over effect of applied fertilizer at all N levels were not significant. Application of 100 kg N ha⁻¹ to Rabi crop alone had increased the plant height and LAI to a considerable extent as compared to no N application to Rabi rice.

Green leaf manuring done to Kharif rice had exerted a significant influence on DMP of Rabi rice at all the four growth stages. Residual effect of *Ipomoea reptans*, *Leucaena leucocephala*, *Calotropis gigantea* and *Sesbania aculeata* was observed through out the growth period of Rabi rice and the effect of these green leaf manures on DMP was comparable. Levels of N applied to Kharif rice had no effect on Rabi rice DMP. Fertilizer application to Rabi rice appreciably increased the DMP over its control (no fertilizer application)

Application of *Calotropis gigantea* , *Sesbania aculeata* , *Ipomoea reptans* and *Leucaena leucocephala* and higher levels of N (120 kg N ha⁻¹) applied to Kharif crop increased the productive tillers per unit area, panicle length and filled grain percentage of Rabi rice crop. Levels of N studied on Kharif crop did not have any influence on the above parameters. Recommended level of fertilizer application to Rabi crop improved the yield attributes. The filled grain percentage was increased to the tune of 18.62 per cent over no fertilizer application to Rabi crop.

Thousand grains weight was unaltered in Rabi rice due to green leaf manures as well as by levels of N applied to Kharif rice crop. However recommended level of N application to Rabi rice significantly increased thousand grains weight (19.61 g) over no N treatment (17.63 g).

N, P and K uptakes in Rabi rice crop were higher in *Ipomoea reptans*, *Leucaena leucocephala*, *Calotropis gigantea* and *Sesbania aculeata* applied plots of Kharif rice. Application of 120 kg N ha⁻¹ to Kharif rice had recorded maximum N, P and K uptakes in Rabi rice and it was comparable with 80 kg N ha⁻¹. Application of 100 kg N ha⁻¹ to Rabi crop also had increased the N, P and K uptakes.

Application of green leaf manures to Kharif crop, increased the Rabi rice grain yield from 12.9 to 78.8 per cent over control. Application of *Leucaena leucocephala*, *Ipomoea reptans*, *Calotropis gigantea* and *Sesbania aculeata* increased the grain yield of Rabi rice to a greater extent. Levels of N studied for Kharif rice didn't exert any significant influence on the grain yield of Rabi rice during 1994, where as there was a response for N application during 1993. 100 kg N ha⁻¹ to Rabi crop significantly influenced the grain yield and produced 124 and 72 per cent increased yield during 1993 and 1994 respectively over no N application.

Straw yield exposed similar trend as that of grain yield for Rabi rice.

Green leaf manuring applied to Kharif rice in general improved the soil fertility status after the harvest of Rabi rice. Incorporation of green leaf manures increased the organic carbon content also. Fertilizer application done to Kharif rice did not exhibit any influence on the organic carbon content of soil after the harvest of the Rabi rice.

Application of green leaf manures to Kharif crop increased the soil available N, P and K after rice - rice cropping system. *Calotropis gigantea*, *Leucaena leucocephala* and *Ipomoea reptans* left more soil N. Application of green leaf manures + 120 kg N ha⁻¹ or 80 kg N ha⁻¹ improved the soil available N. Application of 100 kg N ha⁻¹ to Rabi rice improved the soil available N status but decreased the P and K status after rice - rice cropping system.

Application of green leaf manures along with 80 or 120 kg N ha⁻¹ during Kharif season + 100 kg N ha⁻¹ to Rabi season rice improved the soil available N which led to a positive N balance after rice - rice cropping system. This was observed in both the years of study.

Application of green leaf manures as well as fertilizer N to both Kharif and Rabi rice increased the net return.

The BC ratio was the highest when *Ipomoea reptans* + 80 kg N ha⁻¹ were incorporated and applied respectively to Kharif crop + 100 kg N ha⁻¹ to Rabi rice crop. It was comparable with the BC ratios obtained under *Calotropis gigantea* or *Sesbania aculeata* with the same inorganic fertilizer level. This was followed by *Leucaena leucocephala* and *Fichhornia crassipes* with the same level of N.

In conclusion, the integrated use of green leaf manures and fertilizer N showed a beneficial effect on growth components, yield attributes, uptake of nutrients and grain as well as straw yield of Kharif season rice. The favourable effect was evident upto 80 kg N ha⁻¹ along with green leaf manures application. Conjunctive use of green leaf manures and 80 kg N ha⁻¹ to Kharif crop and 100 kg N ha⁻¹ to Rabi crop increased growth and yield attributes as well as yield of Rabi crop, resulted in higher BC ratio. Green leaf manuring improved the soil organic carbon and available N, P and K. Application of fertilizer N improved the soil available N but reduced the P and K. Based on these results the following recommendations are made.

Considering the biological performance and economical performance of rice - rice cropping system studied for two continuous years, the best bet treatment generated from these experiments for recommendation is, Application of *Ipomoea reptans*, a non-conventional green leaf manure at the rate of 8 t ha⁻¹ in combination

with 80 kg N ha^{-1} applied to Kharif rice in addition to 100 kg N ha^{-1} to Rabi rice. This combined treatment had given higher BC ratio and also passed out from the partial budgeting. Further, this treatment had maintained positive balance in respect of N, P and K. In the absence of *Ipomoea reptans*, the best bet alternative non-conventional green leaf manure would be *Calotropis gigantea*.

FUTURE RESEARCH NEEDS

To meet the current shortage of chemical fertilizers caused by energy crisis and socio economic constraints, it has become desirable to conserve the organic manures and recycle them in to the soil to increase the efficiency of soil nutrients in addition to maintain the fertility and productivity. In this context, the green leaf manuring, a renewable source of organic manure has a larger potential to augment the nutrient supplies. Studies are needed to identify the factors responsible for crop responses to green leaf manuring and to develop sound scientific strategies for this practices

Based on the results of the present study, the following are some of the research areas suggested for the future study.

In the present study, incorporation of *Ipomoea reptans* and *Calotropis gigantea* found promising in influencing the rice grain yield and BC ratio in a cropping system of rice followed by rice. This recommendation has come up against the conventional method of growing *Sesbania aculeata* and incorporation. This study indicated the potential of non-conventional green leaf manures like *Ipomoea reptans* and *Calotropis gigantea*. In nature, similar materials exist unnoticedly. Such manures should be brought out and studied to meet the future energy crisis.

The study indicated that $\text{NH}_4\text{-N}$ release from green leaf manures were more during the initial stage of crop growth (Up to 21 days). Hence studies on whether we can skip the basal application of inorganic N source, if the green leaf manure is applied, is warranted.

From the present study, it is clear that the release of N from *Eichhornia crassipes* is delayed even up to second crop after its incorporation. Hence, some added chemicals may be identified in order to make the green leaf manures to release the N to the crop for which it is applied.

Studies on correct time and method of incorporation of different green leaf manures may be taken up.

Long term effects of integrated N management on soil productivity and sustainability may be studied.

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

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APPENDICES

APPENDIX I

Weather data during the cropping period of 1993-'94

Standard week	Rainfall (mm)	Max. Temp (°C)	Min. Temp (°C)	RH (0722) (%)	RH (1422) (%)	Evaporation (mm)	Sunshine (Hours)
19	-	38.1	24.6	78	36	7.2	9.5
20	22.6	34.5	22.1	86	48	6.9	6.6
21	2.5	34.2	23.5	81	47	5.3	4.7
22	-	34.9	23.6	83	41	6.5	4.1
23	12.2	32.6	24.3	76	51	6.9	4.4
24	6.0	31.7	24.5	76	53	6.7	5.1
25	3.7	32.6	23.2	77	44	7.0	8.2
26	1.0	32.7	23.2	75	47	8.3	7.3
27	2.3	31.5	22.6	72	47	7.1	3.8
28	-	31.1	24.3	63	48	7.9	2.9
29	2.7	32.0	22.7	81	45	6.9	6.8
30	24.5	33.2	22.9	74	59	7.1	3.9
31	-	31.6	24.1	63	48	8.6	5.5
32	2.0	32.3	23.6	77	48	6.9	5.2
33	3.0	32.0	22.9	74	48	7.4	6.4
34	10.6	32.6	21.8	78	47	7.9	7.2
35	36.6	30.3	22.2	89	59	3.9	4.9
36	3.0	31.1	21.3	89	42	4.9	2.1
37	7.0	32.8	22.0	84	46	4.5	6.3
38	-	33.3	22.0	83	41	5.9	5.9
39	1.6	33.9	21.7	76	40	7.3	7.7
40	30.8	31.8	22.5	88	58	4.9	5.3
41	30.0	30.8	22.3	91	61	3.8	3.7
42	58.3	30.1	22.5	90	58	2.2	5.4
43	19.3	30.4	21.9	89	54	3.1	6.2
44	29.1	29.8	22.7	88	61	4.2	4.1
45	112.1	27.6	21.8	88	76	1.9	2.3
46	124.6	28.7	21.5	92	67	2.3	6.4
47	-	29.1	20.5	89	55	3.3	6.1
48	1.5	28.1	19.8	86	55	3.1	4.5
49	17.1	27.4	20.4	90	65	3.2	3.6
50	-	29.0	18.3	89	46	3.7	6.9
51	-	27.1	19.3	89	64	2.4	0.9
52	-	27.5	19.5	86	54	3.2	5.5
1	-	29.1	19.1	89	49	4.1	8.3
2	0.2	28.4	19.1	88	51	3.8	6.6
3	72.5	29.7	21.5	89	60	3.2	6.3
4	-	29.0	16.8	90	39	4.3	8.3

APPENDIX II

Weather data during the cropping period of 1994-'95

Standard week	Rainfall (mm)	Max. Temp (°C)	Min. Temp (°C)	RH (0722) (%)	RH (1422) (%)	Evaporation (mm)	Sunshine (Hours)
19	4.5	35.7	23.5	77	43	7.0	9.9
20	10.5	35.3	24.1	81	48	6.5	8.2
21	9.8	35.4	23.8	79	45	7.2	7.7
22	14.3	32.3	23.6	72	57	6.2	6.1
23	8.6	29.7	23.6	78	60	5.0	1.9
24	2.1	30.4	24.0	71	52	5.9	2.5
25	-	32.7	23.8	67	42	8.7	8.5
26	10.9	31.4	23.8	66	50	6.7	3.1
27	2.5	32.7	22.4	77	52	6.0	4.3
28	112.7	28.8	22.8	77	67	4.1	1.3
29	-	29.7	23.2	68	54	6.9	3.6
30	1.7	30.3	23.0	78	58	4.6	1.5
31	7.5	29.3	22.7	79	53	5.2	2.8
32	-	32.2	21.8	84	49	6.0	6.1
33	0.8	31.5	22.2	81	49	5.8	3.9
34	-	32.4	21.8	83	51	5.3	2.8
35	5.0	30.3	23.1	71	59	5.5	3.2
36	12.2	31.4	22.9	78	55	6.7	6.6
37	-	32.1	20.9	84	52	6.0	7.6
38	-	33.8	20.8	80	42	7.1	9.8
39	33.9	32.6	22.6	88	54	4.4	5.7
40	37.8	30.1	22.4	85	64	4.4	4.3
41	6.1	32.1	22.3	84	56	4.5	7.9
42	32.3	30.5	22.0	89	61	3.8	5.8
43	161.3	28.9	21.8	90	69	2.0	4.7
44	119.9	28.9	21.8	90	73	2.6	4.3
45	48.7	26.7	21.0	78	74	2.4	2.1
46	20.0	27.6	21.3	75	70	2.9	4.8
47	1.6	28.9	20.4	85	61	2.8	5.9
48	-	29.8	17.8	89	61	3.3	8.2
49	-	28.6	15.6	89	54	3.4	9.4
50	-	28.7	18.5	86	57	3.6	9.1
51	1.6	28.7	16.9	84	60	3.4	5.0
52	-	28.7	21.3	86	56	3.7	7.1
1	1.0	28.2	16.8	89	53	3.4	5.6
2	1.8	30.1	21.1	87	57	2.3	7.0
3	1.0	29.0	20.5	87	66	4.2	5.8
4	-	30.4	17.9	86	38	4.6	8.5

