STUDIES ON THE CUMULATIVE AND RESIDUAL EFFECT OF ORGANICS FOR RICE-RICE CROPPING SYSTEM

Thesis submitted in part fulfillment of the requirements for the award of the degree of MASTER OF SCIENCE (Agriculture) in Agronomy to the Tamil Nadu Agricultural University, Coimbatore

By

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CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON THE CUMULATIVE AND RESIDUAL EFFECT OF ORGANICS FOR RICE-RICE CROPPING SYSTEM"** submitted in part fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY** to the Tamil Nadu Agricultural University, Coimbatore, is a record of bonafide research work carried out by **Mr.N.SATHEESH** 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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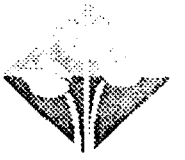
ABSTRACT



ABSTRACT

STUDIES ON THE CUMULATIVE AND RESIDUAL EFFECT OF ORGANICS FOR RICE-RICE CROPPING SYSTEM

By

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Investigation was carried out at Tamil Nadu Agricultural University, Coimbatore from October, 1996 to September, 1997 to evaluate the cumulative and residual effect of organic farming practices in lowland rice-rice cropping system in comparison with conventional farming.

Previously three experiments were carried out in randomized Block Design, replicated thrice during Kharif 1995, Rabi 1995 and Kharif 1996, with various organic treatments. For the purpose of present study, the same treatments of above experiments was followed to study simultaneously both direct and residual effect of organic applied earlier. For this purpose during Rabi 1996 each plot was divided into 2 parts, one part with organics applied and other without organics and during Kharif 1997, each plots are divided to three equal sized plot to study the cumulative effect and residual

effect of previous crops. During Rabi and Kharif season eight organic manures viz., ***Sesbania rostrata***, Azolla, Azospirillum, Neemcake, Poultry manure, Farm yard manure, Press mud and Biogas slurry in various combination were compared against the conventional farming and Rec. NPK (150:50:50 and 120:38:38 kg N, P_2O_5 and K_2O through in organic sources in Rabi, 1996 and Kharif, 1997 respectively). This cropping system experiment was done for two seasons ie., Rabi 1996 and Kharif 1997.

Application of organic manures in various combination especially FYM + Neem cake, FYM + Poultry manure favourably influenced the growth components, yield attributes, uptake of nutrients and grain as well as straw yields of rice.

FYM + Neem cake incorporation increased the Harvest Index (HI), Productivity score (PS), Apparent N Recovery, Agronomic efficiency while application of inorganic fertilizer influenced only PS but not the HI, ANR and AE.

FYM + Neem cake and FYM + poultry manure left significantly higher soil available N after the harvest of both Rabi and Kharif rice crop.

Rice growth attributes where higher with residual effect of FYM + NC, Farm yard manure + Poultry manure and Sesbania rostrata + Poultry manure. The fertilizer applied in conventional farming had no significant effect on growth attributes of the subsequent rice crop.

Application of Farmyard manure + Neem cake and FYM + poultry manure significantly influenced the yield attributes of subsequent rice crop where as Conventional farming did not have any influence.

Application of FYM + Neem cake and FYM + poultry manure recorded higher N, P and K uptake, this leads higher grain and straw yield.

FYM + Neem cake left higher soil available N after harvest of residual crops but the conv. FMg and Rec.NPK treatment left lower amount of soil available N after harvest.

Application of organic manures FYM + Neem cake showed lowest pest population, higher grain quality compared to conv. Fmg. FYM + Neem cake recorded lower BC ratio when compared to con. farming due to higher cost of organics.

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

- Application of FYM @ 22 t ha^{-1} and 7.1 t ha^{-1} neem cake to substitude 150 kg N in Rabi and 19.2 t FYM + 5.7 t ha^{-1} Neem cake to substitute 120 kg N in kharif. This treatment had given higher net return, higher soil nutrient balance and resulted better than conventional farming.

CONTENTS

ABBREVIATIONS USED

AE	-	Agronomic efficiency
ANR	-	Apparent N Recovery
AT	-	Active Tillering
Az	-	Azolla
BC ratio	-	Benefit Cost Ratio
Conv. Fmg	-	Conventional Farming
CD	-	Critical difference
DMP	-	Dry matter production
FYM	-	Farm yard manure
GDD	-	Growing Degree Day
g	-	gram
ha	-	hectare
HI	-	Harvest Index
K	-	Potassium
LAI	-	Leaf Area Index
m	-	meters
Mha	-	Million hectares
Mt	-	Million tonnes
N	-	Nitrogen
Oms	-	Organic manures
POM	-	Poultry manure
PM	-	press mud
PI	-	Panicle Initiation
PS	-	Productivity score
P	-	Potassium
RDME	-	Relative dry matter efficiency
Sig	-	Significant
t	-	tonnes

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ACKNOWLEDGEMENT

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(N.SATHEESH)

INTRODUCTION

CHAPTER I

INTRODUCTION

India's population growth is exceeding its development in the field of Agriculture. It is likely to 1.7 billion towards the turn of this century. Scientists are on the range of creating yet another green revolution.

Previously efforts for increasing the productivity were confined to the expansive of irrigated areas, cultivars responsive to chemical fertilizers and plant protection chemicals. This of late has deteriorated the earth's resources, particularly in terms micronutrient deficiencies, soil water balance and ground water pollution etc., (Rao and Hanumantha, 1975; Radhakrishna and Ravi, 1990). Efforts had already been made to study the impact of soil degradation, occurrence of pest and diseases, nutrient imbalance in rice-rice cropping system (Sampath, 1990).

Sustainability of production systems in resource rich areas have drawn serious attention of the scientists since there were signs of static yield on two important crops like rice and wheat.

With the advent of inorganic farming and intensive cultivation, Indian soils are denied the sources of organic matter. The depletion of secondary nutrients and micronutrients like Zu, Mu, Bo and Fe has become more conspicuous.

In the interest of sustainable agriculture, to regions soil healths and minimize residue toxicity, a new theory of organic farming was proposed (Kundu and Pillai, 1992). Organic farming is a system integrating relationship between soil, plant, water, soil flora and fauna. Organic farming aims maintaining a healthy soil, providing harmless environment for plant and microbes to exist and maintain biological life cycle alive.

Introduction of high yielding varieties and modern scientific technologies though resulted in increased productivity, in the long run, organic farming is one of the solution to maintain a healthy and sustainable rice ecosystems. This also helps in further pegging down underground water pollution (Sankaran, 1988), increasing levels of food residues (Ukita ***et al***. 1972) which would be economical and highly beneficial over a period of time.

Organic manures in farming has advantages like nutrient conservation, slow releases, improvement of soil physical conditions. For efficient nutrient management in a cropping system, the use of forms of organic resources such as FYM, compost, biogas slurry, green manures, sewage sludge, urban waste, farm waste and crop residue should necessarily be detailed for increasing soil productivity. Keeping in view of nutrient needs of the crop, use of Biofertilizer, microorganisms and biocontrol agents could be considered (Swaminathan, 1987).

Due to the over use of chemical fertilizers and pesticides the soil has deteriorated. Therefore augmenting soil resources is inevitable in rice-rice

cropping system. Utilization of genetically potential variety combined with these efficient management practices would encourage sustained food production and reduce exploitation of fragile soil crop production system in irrigated areas.

Alok kumar ***et al.*** (1995) while emphasising the role played by optimum organic matter in soil fertility desired the burning of crop residues and release of inorganic nitrogen into the atmosphere.

Keeping in view of the above and known possible regions of less productivity in rice, the present study was taken up to develop a proper sustainable ecofriendly rice-rice production system management at economically profitable level with the following objectives.

- To evaluate the rice-rice cropping system under organic farming practices in comparison with the conventional practice.
- To study the effect of organic manures application on the growth, yield attributes and yield of rice-rice cropping system.
- To study the residual effect of different organic manures applied to the previous crop to the succeeding rice crop.
- To study, the effect of organics on quality aspects of rice.
- To study the economics and evolve a best organic farming practice for rice-rice cropping system

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Rice is unique among the major food crops because of its semi aquatic nature 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).

Excessive use of chemical fertilizers and pesticides in agriculture has come into severe criticism by the environmentally conscious people who opine that the increase in agricultural production was achieved at the cost of soil health (Mattingly, 1974; Marshall, 1977; Cooke, 1982 and Arden-Clarke and Hedges, 1988). The gravity of environmental degradation because of faulty agricultural practices has set several experts to focus attention on ecologically sound, viable and sustainable farming systems. There has been a series of scientific and policy conferences on this issue (Venkataramani, 1991). One such system which will help to overcome the problems of soil and environemntal degradation is "ORGANIC FARMING" which aims at co-operating rather than confronting with the nature. In view of the above, the available literature on organic farming, organic manures, green manuring and biofertilizers and their direct and residual effect on crop growth, soil fertility, crop quality, economics and management of pests and diseases with particular reference to rice are reviewed in this chapter.

2.1. Organic farming concept

According to Lampkin, 1990 organic farming is not mere non-chemicalism in agriculture, but it is a system of farming based on integral relationship with nature. The principal elements to be considered while practising organic farming are i) create a healthy soil ii) make nutrient and energy flow in soil ecosystem iii) Keep the biological life in the cycle and iv) provide sustainable yield.

According to United State Department of Agriculture report (1980), organic farming is a production system which avoids the use of synthetically compounded fertilizers, pesticides, growth regulators and live stock feed additives. Organic farming system generally rely upon crop rotations, crop residues, animal manures, legumes, green manures, off- farm organic wastes, mechanical cultivations, mineral bearing rocks and biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests.

2.2. Organic farming in crop productivity

Increased use of fertilizer in improved varieties with meticulous irrigation program are the key factors on the growth of crop production in Asia and else where. Organic manures are traditionally important source of nutrients, declined in relative importance with the rapid use of chemical fertilizers. However, interest in the potential for use of organic manure had been renewed due to the oil price stocks that resulted in sharp increase in fertilizer price during 1970's (Rosegrant and Rousmasset, 1985). Sun and Hsieh (1993) observed that application of composted Poultry manure gave a

similar grain yield (7.43 t/ha^{-1}) of rice as that from conventional farming (7.43 t ha^{-1}) which depended solely on chemical fertilizer. Wang-Kai-Rang *et al.* (1994) reported that yields were higher with organic culture in both early and late rice varieties.

Sharma and Mittra (1989), reported 28 per cent yield increase due to organic manure application. Recent studies made by Kenchaiah (1997), clearly indicated that application of FYM + Neem cake markedly improved the rice grain yield and the percentage increase was 36.0, 8.0 and 11.0 during Kharif '95, Kharif '96 and Rabi '95 respecitvely.

2.3 Organic farming on soil properties, crop nutrition, and microbial activity

The influence of organics manure 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 in Indian Agricultural Research Institute, New Delhi indicated the cumulative effect of farm yard manuring in various cropping systems (Ghosh, 1981). Mahapatra *et al.* (1981) reviewed the rice-rice sequence experiments under AICARP (1988) and All India co-ordinated 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 physical properties over a period of time and the nutrient supply was increased.

While comparing soils of two neighbouring farms of one conventional and another organic, Reganold ***et al.*** (1987), found that the soil loss since 1948 was 16 cm greater on the conventionally managed soil.

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 into the soil, considerable quantities of nutrients would be added to the soil, which gradually became available to the subsequent crop on decomposition (Srinivasulu Reddy, 1988). Biodynamic farming practices for 14 years changed little nutrient status, humus content and pH of the soil and the activity of micro-organisms have increased while P and K content slightly decreased (Buchner, 1993).

According to Reganold and Palmer (1995) biodynamic pasture fields had soils of higher biological activity (ie) more organic matter, microbial activity and earth worms than the soils of biodynamically or conventionally cropped fields. They further reported that biodynamic farming system had better soil quality and it improved biological soil properties and increased crop root growth. (According to Kenchaiah (1997), the microbial population was increased by FYM + Poultry manure and ***Sesbania rostrata*** + Poultry manure application.) Recently Kenchaiah (1997) observed higher soil available N content by application of FYM + Neem cake than conventional farming.

Tropical soils are normally low in organic matter, which contributes much to the productivity of soil 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 soil (Regnald and Palmer, 1995).

Increased organic matter status of soil due to incorporation of organic manures and pulses residue in a crop sequence had been reported by many authors (Purushothaman, 1979; Chaudhary and Bathla, 1985; Rajeshwari, 1990; Wander ***et al.***, 1995).

2.4. Organic Farming contribution to crop quality

Application of organic manures promoted the eating quality and the average value of 1000 grain weight in rice (Buchner, 1993) than conventional farming. Hsieh (1995) also observed that the eating quality of organic rice was better than conventional farming. According to Hagner (1994), the 'bio-products' differed little from conventional products either in nutrition N taste.

Average protein content of wheat increased to 11 per cent by application of cattle slurry at $18m^3$ per hectare twice (Buchner, 1993).

Organic manures application plays an important role with the taste issue, growth rates and physiological maturity at harvest (Samaras, 1977, Abele, 1987).

Nitrate concentration in organically produced crops were lower compared to conventional farming (Bredermann, 1985) and also the vegetable product has higher protein nitrogen than nitrate nitrogen.

2.5. Sustainability and economics of organic farming

Issues of sustainability are commanding more attention from agricultural scientists. Sustainability can be defined in various ways. One recent definiton that seems useful was proposed by Arden Clarke and Hedge, (1988), "A sustainable agriculture system is one that can indefinitely meets demands for food and fiber at socially acceptable economic and environmental costs".

Several farm management studies in the united states have shown that alternative farming system can achieve net returns which are comparable to those of conventional farming (Kraten 1979; Goldstein and Young, 1987) organic farming produced two per cent low crop value per acre than the conventional farming. However, higher input costs on the conventional farms meant that the net return for organic farm was 22.4 per cent higher (Kraten, 1979). Sellem ***et al*** (1994) reported that vegetable on organic farming showed positive profit per hectare. Studies comparing organic and conventional grain production systems have shown organic farming to be more energy efficent (Kraten, 1979; Lockeredz ***et al.***, 1981; Pimentel, 1984).

2.6. Effect of organics in rice production

In the modern intensive agriculture with the advent of hybrid and high yielding varieties, the use of chemical fertilizers without the addition of organic manure has almost rendered the soil unfit for further cultivation. About 60 per cent of agricultural land currently under cultivation suffer from serious problems of soil health, mainly due to indiscriminate use of chemical fertilizer (Gunjal, 1991).

Soil receiving organic manures regularly, needs no application of secondary and micro nutrients (Kumarasamy, 1990). Intensive cultivation without the addition of organic manures affects the crop productivity. Locally available manures are cheaper and more effective than chemical fertilizer (Natarajan ***et al.***, 1991). Manickam (1993) opined that the use of organic manures in combination with inorganic fertilizers increased the crop production without imparting soil health and the use of organic manures is a pre-requisite for sustained crop production (Pushpavalli ***et al.***, 1993).

Rajamannar ***et al.*** (1995), also opined that combined application of organic manures with the recommended levels of N increased the grain and straw yields of rice over sole application of organic manures or N. Datta ***et al.***, (1996), concluded that combined application of organic manures increased the soil nitrogen and agronomic efficiency over the sole application of organic manures.

Research work in organic N supplementary manures Green manure, FYM, Biogas slurry, Poultry manure, Press mud, neem cake and biofertilizers

their role, effect on growth, yield component and yield and nutrient uptake by lowland rice are reviewed in the following sections.

2.7. Green manure in rice production

Green manuring is a feasible alternative to the use of N fertilizers. The importance of green manuring in agriculture has been recognized as early as 500 BC in India (Kakde, 1965). The incorporation of ***Sesbania aculeata*** and ***Sesbania rostrata*** could replace or save 40-120 kg N ha^{-1} (Palaniappan ***et al***, 1987; Meelu and Mooris, 1988). ***Sesbania rostrata*** is a widely grown green manure due to its high N fixing capacity and to withstand wide range of soil condition (Ladha ***et al.***, 1988). The use of leguminous green manures reduced the application of fertilizer N and increased the crop yield (Carsky ***et al.***, 1990). Palaniappan ***et al.*** (1990) found that ***Sesbania aculeata*** and ***Sesbania rostrata*** were the potential green manure crops for rice growing season. Regular practice of green manuring over a long period not only improve the soil fertility, but also resulted in noticeable residual effect in intensive cropping system (Palaniappan ***et al.***, 1990). In addition to this Ghosh and Sharma (1996), concluded that the green manure on long term effect result in a very high residual effect than other organic sources.

2.7.1 Effect of green manures on growth, yield components and yield of rice.

Application of N either through fertilizers or green manures increased the plant height (Srinivasalu Reddy, 1988; Ramasamy ***et al.*** 1988), tiller production (Krishnakumar, 1986; Diack, 1986), leaf area index and

drymatter production (Balasubramanian and Palaniappan, 1989; Vaiyapuri *et al.*, 1995; Sangakkara, 1996).

Many experimental evidences proved that the positive influence of green manuring in increasing the yield attributes and yield of rice with varying magnitudes have been reported by (Ventura *et al.* 1987; Saravana Pandian and Rani Perumal 1994; Veerabadran and Solaiappan, 1996). Green manuring increased the yield attributes like number of panicles, filled grains panicle^{-1} and thousand grain weight (Singh *et al.*, 1990; Becker *et al.* 1991). Matiwade and Sheelavantar (1994) proved that high yielding ability of rice with green manuring of ***Sesbania rostrata*** alone and coupled with the recommended dose of N attributed to higher number of panicles per tiller, panicle length, grains per panicle and thousand grain weight, compared with the recommended dose of N alone.

Abrol and Palaniappan, (1988) observed that green manured plots registered 200 per cent higher grain yield over control. Green manure application significantly increased the grain and straw yields and recorded an additional yield of 0.6 and 1.1 t ha^{-1} respectively. Palaniappan and Reddy, (1990), obtained 9-10 t ha^{-1} of grain yield with the combined application of N (120 kg N ha^{-1}) and ***Sesbania aculeata*** (5-18 tha^{-1}). Incorporation of ***Sesbania aculeata*** @ 5 t ha-1 increased the grain yield by 42.8 per cent (Raju and Anand Reddy, 1991). Sharma and Kuhad (1993) obtained 8.7 t ha-1 of grain yield with the application of 120 Kg N ha^{-1} and ***Sesbania aculeata***. Application of 100 Kg N ha^{-1} as green manure gave higher grain yield (Budhar, 1994). Rao and Moorthy (1994) obtained higher

grain yield in lowland rice applied with ***Sesbania aculeata***. The grain yield and N uptake increased with levels of green manures maximum with 12.75 t ha^{-1} (Vaiyapuri ***et al.*** 1995; Budhar and Palaniappan,1996; Veerabhadhran and Solaiappan, 1996).

2.7.2 Effect of green manuring on nutrient uptake by rice.

Green manure application increased major nutrient uptake by rice (Roy and Jha, 1987). Green manuring significantly increased the N uptake in grain and straw (Bharadwaj and Dev, 1985), and it enhanced the availability of N,P and K, which resulted in increased uptake (Swarup, 1987; Balasubramanian ***et al.***, 1991). Application of ***Sesbania rostrata*** recorded higher availability of N which increased the uptake (Diekmann ***et al.***, 1993; Sri Ramachandrasekaran and Ravichandran, 1995; Singh ***et al.***, 1996; Cassman ***et al.***, 1996; Nooye and Drefus, 1996).

2.8. Farmyard manure in rice production

Organic manures are bulky in nature but supply the nutrients in small quantities (Gaur ***et al.***, 1984). Among them FYM is the commonly used organic manure and it proved its ability in enhancing various aspects of crop production. The beneficial effects of FYM on various physico-chemical properties of soil and to sustain high levels of yield were reported by several workers (Malathi, 1989; Panda and Sahoo, 1989; Soni and Sikarwar, 1991). Farm yard manure is an efficient source of organic manure which is able to supply the plant nutrients, particularly (Sharma and Mittra, 1992; Alok kumar ***et al.***, 1995) was well documented.

2.8.1. Effect of Farmyard manure on growth, yield components and yield of rice

Application of FYM @ 10 t ha^{-1} increased the plant height, number of tillers $hill^{-1}$ and DMP (Rangarajan and Muthukrishnan, 1976; Jha ***et al.***, 1978). Udayasoorian (1988), also observed a positive influence by FYM on rice plant height, number of tillers per hill and dry matter production.

Beneficial effects in FYM with increased plant height, LAI and higher DMP over other organics were observed by Ramasamy (1990). FYM application @ 10 t ha^{-1} significantly increased the growth components, viz., number of leaves per hill and tillers per hill (Rajput and Warsi, 1991). Jose Mathew ***et al.*** (1994) observed that combined N application of FYM @ 10 t ha^{-1} and other organic sources increased the vegetative growth. According to Singh ***et al.*** (1996) application of FYM @ 20 t ha^{-1} significantly increased the plant height, LAI and tillers per hill.

Application of 5 t of FYM ha^{-1} recorded higher grain and straw yield (Jose mathew ***et al.***, 1993). The number of panicles m^{-2} significantly increased with FYM at 5.54 t ha^{-1} (Sharma and Sharma, 1994).

The highest yield was obtained in rice with FYM @ 10 t ha^{-1} (Gupta ***et al.*** 1995). (Alok Kumar ***et al.***, 1995), opined that 50 per cent recommended N through fertilizer and 50 per cent as FYM increased the grain yield.

2.8.2. Effect of Farm yard manure on nutrient uptake by rice

Verma and Bhagat, (1993) found that the incorporation of FYM significantly increased the N, P and K contents in grain and straw. Farm yard manure was found to be superior in increasing the N, P and K uptake by rice (Alok Kumar ***et al.*** 1995). As indicated by Brar ***et al.*** (1995), addition of FYM had a cumulative effect on nutrient uptake by rice. The uptake of nutrients was more under FYM application in combination with pig manure, Poultry manure, pressmud (Gupta ***et al.*** 1995; Ghosh, 1996; Hedge, 1996).

2.9. Azolla in rice production

The most important bio-fertilizer for flooded rice is Azolla which can be used as a green manure before transplanting and also as dual crop after transplanting. Azolla enriches the soil with organic carbon and also provide other nutrients element (Singh, 1982; Liu Chang Chu, 1984; Thangaraju and Kannaiyan, 1993). Nitrogen fixation by Azolla as well as yield of rice are generally higher in green manuring and dual cropping (Singh, 1992; Singh and Singh, 1995).

2.9. Effect of Azolla on growth, yield components and yield of rice

Application of Azolla increased the plant height and number of tillers in rice (Singh and Singh,1988; Kalita and Sarma, 1994). Application of Azolla at 5 t ha^{-1} increased the plant height and tiller number (Mandal ***et al.***, 1993).

Application of Azolla at 10 t ha^{-1} increased the yield attributes (Bijan mandal ***et al.***,1993). Azolla manuring significantly increased panicle weight

and thousand grain weight (Solaiman ***et al.***, 1994). Inoculation of Azolla at 2 t ha^{-1} one week after transplanting produced more panicle m^{-2} (Singh and Singh, 1995).

Increase in grain yield due to the addition of Azolla were reported by (Ventura ***et al.*** 1987). Similarly, higher grain yield was recorded with 50 per cent applied through Azolla @ 10 t ha^{-1} Azolla with 100 per cent recommended fertilizer (Mandal ***et al.***, 1993, Kaur, 1993) and 75 kg N as urea ha^{-1} and 10 t of fresh Azolla ha^{-1} (Rakotonaivo, 1988; Jeyaraman 1991).

2.9.2. Effect of Azolla on nutrient uptake by rice

Singh (1979) observed higher N uptake in Azolla treated plots than in plots with split application of urea alone. Mahapatra ***et al.*** (1987) found that N uptake was maximum with split application of urea at 75 kg N ha^{-1} through Azolla with 25 kg N ha^{-1} through urea. It was also noticed that Azolla dual culture in rice when planted in double narrow rows increased not only the N uptake but also supplied substantial quantity of K to rice crop (Liu chang chu, 1984). Kovacs (1995), found that N uptake was maximum with split application of Azolla and urea.

2.10. Azospirillum in rice production

Azospirillum is one of the most important associative bacterium found in the rhizosphere of the various grass species, capable of fixing atmospheric N to improve the productivity by supplying N. In wetland rice, the benefits of inoculation of Azospirillum has been reported by several

workers (Subha Rao *et al.*, 1979; Rao and Rao, 1984; Watanabe and Lin, 1984; Hedge and Dwivedi, 1994).

2.10.1. Effect of Azospirillum on growth, yield components and yield of rice

Dewan and Subha Rao (1979) observed that inoculation of Azospirillum on rice increased the bio-mass of rice seedlings under pot culture experiments. Nayak *et al.* (1986) reported that the effect of inoculation of two rice varieties with Azospirillum mutants increased the plant height and leaf area index. The effect of inoculation on rice varieties with Azospirillum mutants increased the dry matter accumulation in rice (Karthikeyan, 1981), plant height, flowering, grain filling, dry weight of root, shoot and grain yield, Azospirillum inoculation on two rice varieties increased the dry weight of root and shoot and grain of both varieties (Nayak *et al.*, 1986).

The mean grain yield of rice at 50 per cent N level(Balasubramanian and Kumar, 1987) and with 75 kg N ha^{-1} (Gopalswamy and Vidhyasekaran, 1987) with Azospirillum was equal to the yield with 100 per cent N fertilizer alone. Hedge and Dwivedi (1994) reported that in 48 out of 108 trials in Kharif, 31 out of 55 trials in Rabi revealed that inoculation of Azospirillum to rice can save 25 to 50 per cent of recommended fertilizer N. Azospirillum combined with ***Sesbania aculeata*** registered higher yield than control (Saravana Pandian and Rani Perumal 1994). Inoculation of Azospirillum and 153 kg N ha^{-1} gave a yield equal to those given by 205 kg N ha^{-1} at 25 per cent reduction in N applied plots (Hernandez *et al.* 1994).

2.11. Pressmud in rice production

Pressmud a 'by product' obtained during sugar manufacturing, on application improved the soil properties besides reducing exchangeable sodium percentage (Clarson ***et al.***, 1983). Pressmud enriches the soil with organic carbon N and other nutrients (Asio ***et al.***, 1983; Namdeo ***et al.*** 1989).

2.11.1. Effect of pressmud on growth, yield components and yield of rice

Application of pressmud @ 10 t ha^{-1} increased the height, number of tillers ha^{-1} and DMP Jeyabal ***et al.***, (1990). Abubacker and Rao, (1995) also observed a positive influence by pressmud on rice dry weight, chlorophyll content, protein and starch.

Beneficial effects of pressmud for increased leaf area, herbage weight and maturity in rice were reported by Asio ***et al.*** (1983). Pressmud application @ 10 t ha^{-1} significantly increased the yield attributes viz., panicle number, panicle length, filled grains per panicle and grain and straw yields (Jeyabal ***et al.***, 1990).

According to Venkataraman, (1991) application of pressmud gave a grain yield of 5.29 t ha^{-1} than application of coirpith. Improvement in yields of several crops following Press mud applications have been reported by many others (Asio ***et al.***, 1983; Namdeo ***et al.***, 1989; Dubey, 1992; Sinha and Sakal, 1993; and Jain and Tiwari, 1995).

2.12. Biogas slurry in rice production

Among the organics Biogas slurry is the commonly used organic manure and it proved its ability in enhancing various aspects of crop production. The benefical effect of Biogas slurry on various physico-chemical properties of soil and to sustain high levels of yield were reported by several workers (Jagadeesh ***et al.***, 1994; Lakhdive, 1994; Jagpal Singh ***et al.***, 1996). Biogas slurry is an efficient source of organic manure which supply the plant nutrients, particularly N (More, 1994) was well documented.

2.12.1. Effect of Biogas slurry on growth, yield components, and yield on rice

Application of Biogas slurry increasead the plant height, number of tillers and also the yield attributes of panicle length, number of filled grains (Santhankumar, 1993).

Application of Biogas slurry at 15 t ha^{-1} with split dose of 100 kg N increased the yield (Santhankumar, 1993) Biogas slurry @ 40 t ha^{-1} application significantly increased yield to 6.75 t ha^{-1} (Gnanamani and Bai, 1994). Increase in grain yield due to the addition of slurry was reported by (Debnath ***et al.***, 1996 and Jagpal Singh ***et al.*** 1996).

2.13. Poultry manure in rice production

Poultry manure is a feasible alternative to use of N fertilzers. Poultry population in India is estimated to be 207.7 million and the manure available

from the same is estimated to be 5.2 M.t (Anonymous, 1990). Maskina *et al.* (1988), reported that the application of Poultry manure @ 80 kg N/ha increased organic carbon content of the soil, but also resulted in noticeable residual effect in intensive cropping system.

2.13.1. Effect of Poultry manure on growth, yield components and yield of rice

Application of N through Poultry manure increased the plant height, and yield attributes like panicle m^{-2} and filled grains (Budhar *et al.*, (1991).

Application of Poultry manure @ 12.5 t ha^{-1} improved the yield (Budhar *et al.* 1991 and Rainay *et al.* 1992). Datta *et al.* (1992) observed that the application of Poultry manure @ 5 t ha^{-1} in combination with 21.8 kg P as Musoorie Rock Phosphate inoculation with ***Bacillus firms*** gave the highest grain yield of 4.17 t ha^{-1} and also (Sun Pal and Hsieh, 1993) application of @ 6.6 t ha^{-1} gave yield of 7.43 t ha^{-1}. Gupta *et al.* (1995) concluded that there was 55 per cent increase in yield over control and 5.22 per cent increase in yield over recommended fertilzires was observed due to Poultry manure application.

2.14. Neem cake in rice production

Neem cake serves as nitrification inhibitor and a biopesticide in controlling insect pests and diseases (Parmar and Singh, 1993).

2.14.1. Effect of Neem cake on growth, yield components and yield of rice

Bains *et al.* (1971) found that neem seed crush extract treated urea increased the number of effective tillers and influenced number of filled grains and thousand grain weight. Prameela (1996) reported that the growth and dry matter production of rice was highest with application of urea blended with neem cake (1:3 N basis).

Application of N through neem cake blended with urea increased the yield of rice in lowland reported by many workers (Bains *et al.*, 1971; Rabindra, 1981; Jadhav *et al*; 1983; Santhi, 1985 and Prameela, 1996).

Jadhav *et al.* (1983) stated that the neem cake application increased the productive tillers/hill, number of grains/panicle, total DMP. Combined application of urea and compost increased the yield when blended with neem cake (Chakravarti, 1979).

Hulagiri and Skinde (1983) observed the highest yield of rough rice with the neem extract treated urea compared to other non-edible oil cakes like mahuva, karanj treated urea.

2.15. Effect of organic manures on the soil fertility

2.15.1. Soil fertility

2.15.1.1. Effect on organic carbon

Biswas *et al.* (1976) reported that application of organic manures increased the organic carbon status of soil. Incubation studies in different

Indian soils for about 6 month have indicated that the application of FYM at the rate of 44 t ha^{-1} effectively builds up the organic matter content of different soils. Whereas in the control plot, there was a loss of 15 to 40 per cent of organic carbon Gaur ***et al.*** (1984). Increase in the organic carbon content of soil due to combined application of inorganics and organics simultaneously for a period of 10 years was observed in the long term fertilizer experiment conducted under the co-ordinated programme of the Indian Council of Agricultural Research (Nambiar and Ghosh, 1984).

According to Kanwar and Prihar (1982) continuous application of organic manures especially FYM over a period of time increased the organic carbon content of the soil. Singh ***et al.*** (1988) observed that continuous application of FYM increased organic carbon content in semi-arid region of Haryana. Sud ***et al.*** (1990) reported that application of FYM in long run increased organic carbon content by about 140 per cent. Hedge (1996) reported that FYM application improved the organic carbon content.Recently Kenchaiah (1997) summarised that FYM along with Neem cake improved the organic carbon cotnent of soil when applied over a period of long time.

Application of Press mud to sugarcane and cotton fields improved the organic matter status of the soil (Muraoka ***et al.*** 1994). Orlano ***et al.*** (1991) reported that application of moist filter cake @ of 10-25 t ha^{-1} increased the organic carbon content.

Kumar and Mishra (1991) found that organic carbon content in clay loam soil increased by pressmud application and this was confirmed by (Yadav, 1995).

Application of Poultry manure increased the organic carbon content in residual wheat in rice-wheat cropping system (Maskina ***et al.***, 1988).

Jagadeesh ***et al.*** (1994) reported that application of Biogas slurry improved total carbon and nitrogen content of soil in chilli crop. Lakhdive (1994) reported that Biogas slurry improved the organic carbon content in soil where sunflower, groundnut and soybean crops were grown.

Sesbania rostrata on continuous application improved the organic carbon content of the soil reported by Ventura **et al.** (1987). Recently Yadvinder singh ***et al.*** (1994) also found that green manuring improved organic carbon content by 20 per cent over control.

2.15.1.2. Organic 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 Hazra, 1972). Grewal ***et al.*** (1981) reported that organic manure application increased the availability of N through reduction in nitrogen loss by leaching and denitrification. Muthuvel ***et al.*** (1990) reported increased availability of nitrogen in soil after FYM application. Bharadwaj and Dev (1985), reported that incorporation of 25 t ha^{-1} of ***Sesbania rostrata*** was found to increase available N content.

Singh and Singh (1988) observed that in soil incorporation of organic manures provided substantially improvement in soil available P. Sankaran (1977) observed that application of organic manure increased available phosphorus due to production of organic acids in the soil.

Verma and Verma, 1970 reported that organics bears a positive correlation with availability of potassium. More (1994) found that addition of farm wastes and organic manures increased the availabiltiy of N, P and K. Recently Kenchaiah, (1997) reported that FYM improved the soil nutrient status by increasing the availability of N, P and K.

2.15.1.3. Effect on micronutrients

The complexing property of organic manures influences the availability and mobility of micronutrients. Continuous application of FYM over a period increased the micronutrients availability like Fe, Mn, Zn and Mg (Mann ***et al.***, 1978; Prasad and Singh, 1980; Swarup, 1987).

Continuous application of Press mud increase 'S' (Tandon, 1991; Yaduvanshi and Yadav, 1993; Dang and Verma, 1996). Biogas slurry, Poultry manure and compost increase Zn and Mn availability (Prasad and Singh, 1980; Alok Kumar ***et al.***, 1995) green manuring increased Fe availability (Takkar and Nayar, 1986; Swarup, 1987). Alok Kumar ***et al.*** (1995) concluded that application of 50 per cent recommended N through organics improved the micronutrients such as Cu, Mn, Zn and Fe.

2.15.1.4. Effect of orgnaics on soil physical properties

Application of organic manures on decomposition release acids, act as binding agents for soil aggregates (Manickam, 1993) decrease the bulk density with increase in organic matter (Suresh lal and Mathur, 1989), favours water holding capacity of soil and reduce leaching loss in coarse textured soils (Nambiar and Ghosh, 1984).

Favourable influence of FYM on soil physical characters are, improved soil aggregates, infiltration rate, total porosity and hydraulic conductivity of soil (Kanwar and Prihar, 1982; Loganathan, 1990). According to Prasad and Singh, (1980) application of slurry @ 10 t ha^{-1} increased water holding capacity and water stable aggregates.

Azolla in combination with other organics like Press mud, pig manure have a higher influence on the organomineral complextion of the soil (Singh, 1992; Sen ***et al.***, 1994; Nguyen, 1996).

2.16. Residual Effects

Organic farming experiment at IARI indicated the cumulative effect of organic on various cropping systems (Ghosh, 1981). Addition of organics in different cropping system built up not only soil fertility over a period of time and the nutreint supply was increased.

Green manuring for 3 seasons have residual effect when applied in combination with farmyard manure (Singh ***et al.***, 1996). Mikkelson (1970) reported that 8.7 per cent of N was available to third crop. Besides the

direct benefit from pressmud, residual effect through higher soil fertility also improved the yield of first ratoon of sugarcane (Yaduvanshi and Yadav, 1993). Kumar and Mishra (1991) reported that the residual fertility of application of pressmud at 10 t ha^{-1} was optimum for succeeding maize.

Intergrated application of organics and inorganics over a period, increased the yield especially in third season (Alok kumar, ***et al.***, 1995). Cassman ***et al.***, (1996) reported that the residual fertility of application of Press mud applied at 10 t ha^{-1} was optimum for succeeding crop of maize. Application of FYM for first crop improved the N and P uptake for the next crop of wheat (Brar ***et al.***, 1995).

2.17. Crop residue

Viswanathan ***et al.*** (1978) reported that significant increase in the amount of major, secondary and micronutrients. Higher quantities of available N after incorporation of crop residues have been reported by many workers (Tiwari ***et al.***, 1980; Meelu and Rekhi, 1981; Choudhary and Bathla, 1985).

Bacon (1987) reported that increasing quantities of rice stubbles on the soil surface increased the wheat yield by 37 per cent. Ramasamy (1982) observed that incorporation of rice stubbles in the summer rice has a favourable effect on the following monsoon rice in terms of better growth, nutrient uptake and yield. Marimuthu (1994) observed that application of FYM @ 5 t ha^{-1} at the time of incorporation of rice stubbles along with 150

kg N ha^{-1} increased the uptake of N, P and K in the residual blackgram crop.

2.18. Effect of organics on pest and disease management

Abdul Kareem ***et al.*** (1989) reported that reduced incident of ***Nephotetix virescences*** in paddy when seeds soaked in neem seed kernal extract. Incorporation of Neem cake followed by neem oil spray (3%) at weekly interval reduced the leaf folder incidence (Krishnaiah ***et al.***, 1990).

Application of Nimbicidin controlled the rice pest (Nagarajan, 1993). Samalo ***et al.*** (1993) showed that application of 3% neem oil at 10 days interval significantly reduced the population of gall midge ***Orseolia oryzae***. Phelan ***et al.*** (1995) noted that ***Ostrinia nubilalis***, European borer, Population was reduced by organic forming.

Application of Neem cake blended with Neem seed kernal extract controlled population of chrysomelid and acricdid (Hameed ***et al.***, 1993) and also ***Cephalocroais medinalis*** in rice field (Ambethgar, 1996).

Application of cattle manure reduce the incidence of ***Helminthosporium oryzae*** (Varughese and Pamakumar, 1993) and the application of neem cake controlled yellow mosaic disease in mungbean (Mariappan, 1994).

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

Field experiments were conducted during Rabi 1996 and Kharif 1997 at wetland research farm of Tamil Nadu Agricultural University, Coimbatore, to develop organic farming practices for wet transplanted rice. Already three field experiments (Kharif '95 and '96 and Rabi '95) were conducted and now in order to study the residual and cumulative effect of the organics, the present experiment was conducted. The details of the experiments, materials used and the procedures followed are presented in this chapter.

3.1. MATERIALS

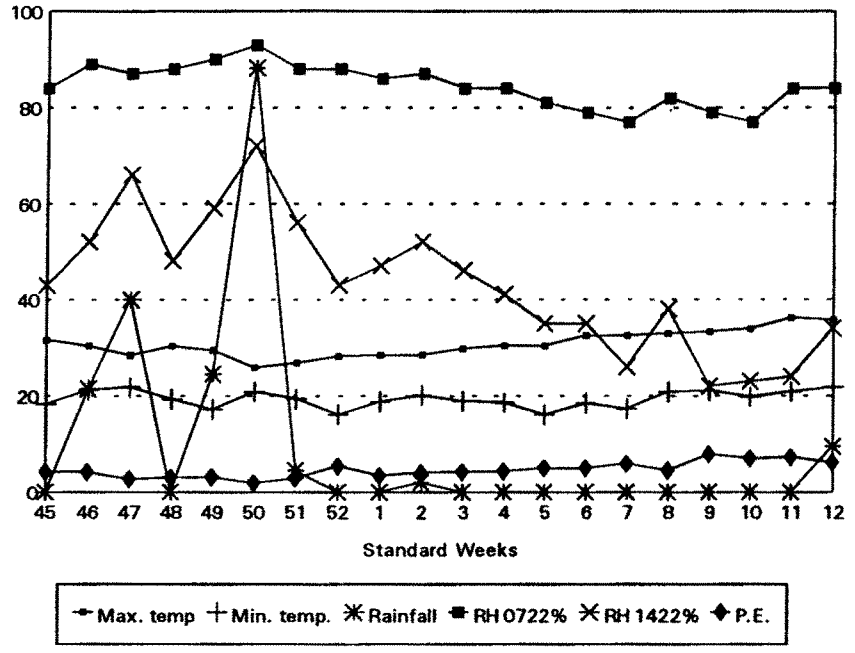
3.1.1. Field Location

Coimbatore is situated in the north western part of Tamil Nadu at 11° N, latitude and 77° E longitude at an altitude of 426.72 m above mean sea level.

3.1.2. Weather and Climate

The mean annual rainfall of Coimbatore is 657 mm (mean of 83 years) distributed over 47 rainy days. The annual mean maximum and minimum temperatures are 31.5°C and 21.0°C respectively. The weather data of the cropping periods are given in Appendix I and II illustrated in Fig. 1.

FIG.1. WEATHER PARAMETERS PREVAILED DURING CROP PERIOD RABI '96 AND KHARIF '97



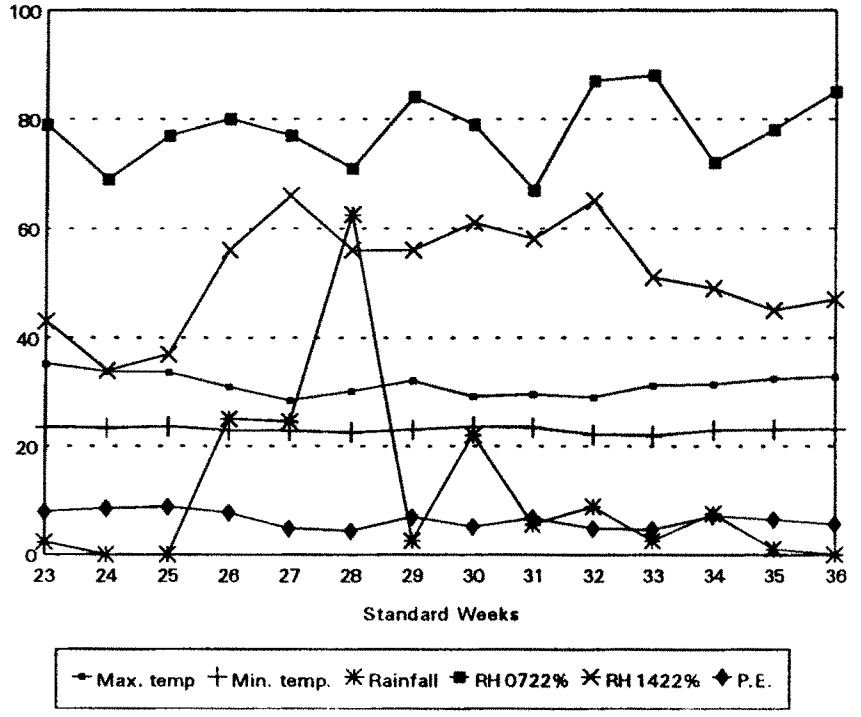


Table 1. Physico-Chemical properties of the experimental field soil.

	Particulars	D_1 block
I	**Mechanical analysis**	
	day (%)	30.7
	silt (%)	21.8
	fine sand (%)	29.7
	coarse sand (%)	17.6
II	**Chemical analysis**	
	Organic carbon (%)	0.78
	Avilable Nitrogen (Kg ha^{-1})	285.0
	Available Phosphorus (Kg ha^{-1})	15.4
	Available Potassium (Kg ha^{-1})	616.0
	pH 1 : 2 (Soil water suspension)	8.2
	EC (dSm^{-1})	0.7
	CEC (g.mol l^{-1})	5.8
III	**Physical properties**	
	Bulk density (gcc^{-1})	1.22
	Maximum WHC (%)	4.60
	Infiltration rate (cm hr^{-1})	1.50

A total rainfall of 188.1 mm was received in fourteen days during the first crop (Rabi 96) of rice (October to January), 164.1 mm in seventeen days during the second crop (Kharif '97) (June to September). The mean maximum and minimum temperature were 31.82 and 21.23, 31.85 and 21.87 during first and second crop, respectively.

3.1.3. Field and soil

The experiments were conducted in wetland 'D' block during Rabi '96 and Kharif '97 in the same site. The soil of the experimental field was deep, moderately drained, clay loam taxonomically classified under typic haplustalf, with pH of 8.2. The soil was low, medium and high in available N, P and K, respectively. Data pertaining to the mechanical, physical and chemical composition of the soil are presented in Table. 1. The experimental field was irrigated with good quality water from a bore-well nearby.

3.1.4. Seasons, Crops and varieties

Two field experiments were conducted ie., first during Rabi 1996 using rice COHR-1 maturing in 110-115 days with an yield potential of 6000 kg ha^{-1} and the next during Kharif 1997 using rice cv ADT 18 (ADT 31 x IR 50) with an yield potential of 5900 kg ha^{-1} with 105-110 days of duration.

3.2. METHODS

3.2.1. Experimental details

The present study is in continuation of previous three experiment (ie., in Kharif '95, Rabi '95, Kharif '96) which were laid out in randomized block design with three replications of previous treatments. In order to study the

residual and cumulative effect on the first crop (Rabi 96) the plot was bifurcated (2/3 and 1/3rd) then for next crop (Kharif 97) each plot was trifurcated (each having 1/3rd of plot). All the fifteen treatment combinations were alloted at random to plots within each replication and the same plot was retained for all the two seasons. The treatment combinations are given below. The layout plan is given in Fig. 2a, 2b.

3.2.2. Treatment

T_1 - 50% N as ***Sesbania rostrata*** + 25% N as Azolla + 25% N as Azospirillum

T_2 - 50% N as ***Sesbania rostrata*** + 50% N as Neem cake.

T_3 - 50% N as ***Sesbania rostrata*** + 50% N as Poultry manure.

T_4 - 50% N as FYM + 25% N as Azolla + 25% N as Azospirillum.

T_5 - 50% N as FYM + 50% N as Neem cake.

T_6 - 50% N as FYM + 50% N as Poultry manure.

T_7 - 50% N as Pressmud + 25% N as Azolla + 25% N as Azospirillum.

T_8 - 50% N as Pressmud + 50% N as Neem cake

T_9 - 50% N as Pressmud + 50% N as Poultry Manure

T_{10} - 50% N as Biogas slurry + 25% N as Azolla + 25% N as Azospirillum.

T_{11} - 50% N as Biogas slurry + 50% N as Neem cake

T_{12} - 50% N as Biogas slurry + 50% N as Poultry manure

Fig. 2a. Field Layout - Rabi 1996

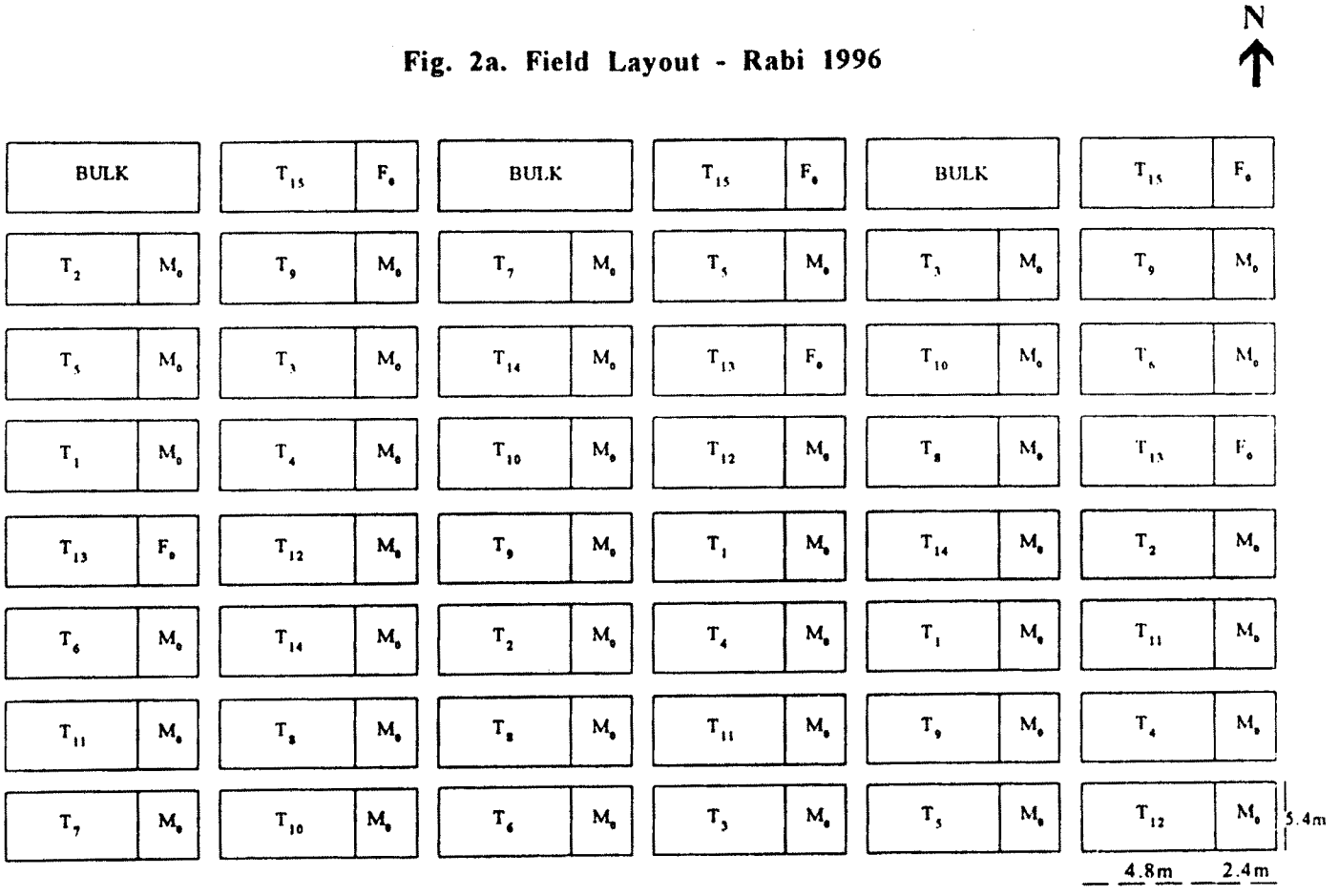
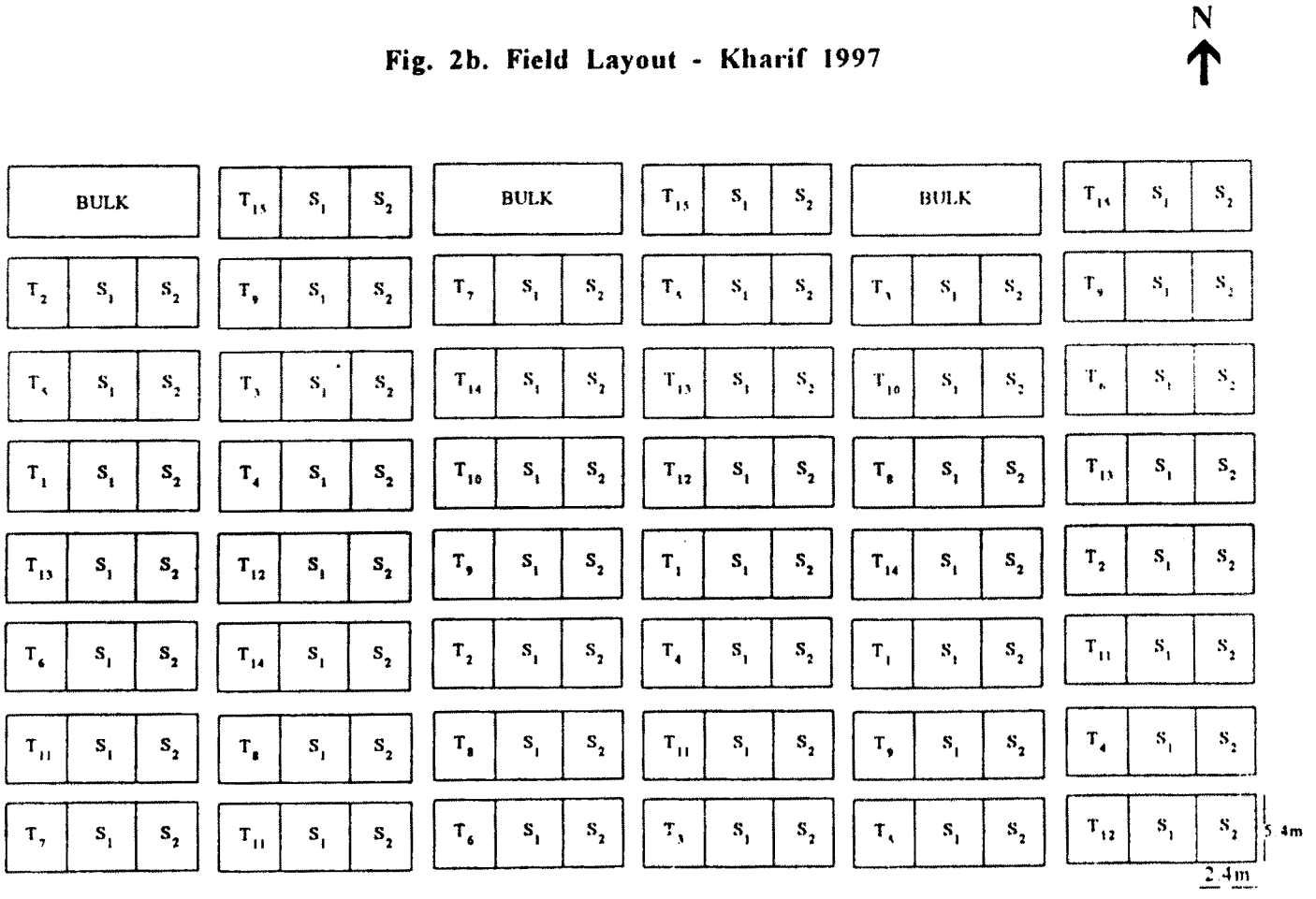


Fig. 2b. Field Layout - Kharif 1997



T_{13}	-	Recommended dose of NPK (Inorganic (120:38:38) kg N, P_2O_5 and K_2O kg ha^{-1} for Kharif and 150:50:50 kg N, P_2O_5 & K_2O kg ha^{-1} for Rabi
T_{14}	-	Absolute control (No NPK)
T_{15}	-	Recommended NPK + herbicide + plant protection by chemicals.
(T_1 - T_{14})	-	Plant protection by biocontrol agents and neem extracts.
Design	-	Randomised Block Design.
Replications	-	Three

3.2.3. Plot size, date of sowing and Harvest

Rabi 96

Particulars	Direct Crop	Residual crop
Variety	COHR-1	COHR-1
Date of planting	10.11.96	10.11.96
Date of Harvest	5.3.97	5.3.97
Spacing	20x10 cm	20x10 cm
Gross plot size	7.2m x 4.7m	7.2m x 2.35m
Net plot size	6.8m x 4.3m	6.8m x 1.95m

Kharif 97

Paritculars	Direct	1st Residual	2nd Residual
Variety	ASD 18	ASD 18	ASD 18
Date of Planting	10.6.97	10.6.97	10.6.97
Date of Harvest	19.9.97	19.9.97	19.9.97
Spacing	20x10 cm	20x10 cm	20x10 cm
Gross plot size	7.2m x 2.35m	7.2m x 2.35m	7.2m x 2.35m
Net Plot size	6.8m x 1.95m	6.8m x 1.95m	6.8m x 1.95m

3.2.4. CROP MANAGEMENT (Common to both the seasons)

3.2.4.1. Seeds and Sowing

The seeds were obtained from Central Farm, Agronomy Department. Seed rates of 8 kg and 60 kg ha^{-1} of COHR-1 and ASD-18, respectively were used for nursery. The seeds were soaked in water for 24 hours and incubated for 24 hours. The sprouted seeds were broacast and raised in nursery without adding any fertilizer.

3.2.4.2. Field preparation

The field was dry ploughed with tractor drawn disc harrow and was puddled with country plough and with tractor drawn cage wheel. The field was levelled with bullock drawn wooden levelling plank in Rabi 1996 experiment. The layout was taken providing with buffer channels all round

the plot to minimize the movement of nutrients. Final levelling was done with hand levelling board to ensure uniform stand of water.

For the next experiment, the plots were dug with spades, puddled and levelling was done by hand levelling board. The same treatment was imposed in the same plot for all the designs.

3.2.4.3. Organic manure application

Based on the nitrogen Content, required quantities of FYM, press mud, Poultry manure, Neem cake, biogas slurry, ***Sesbania rostrata*** were incorporated into the soil 10 days before transplanting of rice. Azospirillum was inoculated to seeds before sowing the nursery and applied to the soil at the time of transplanting. Different sources of organic manures were applied as per treatments. For Kharif and Rabi crops N at 120 kg N ha^{-1} and N at 150 kg ha^{-1} respectively was applied. For this purpose, N content was estimated as suggested by Yoshida ***et al*** 1972 on dry weight basis of the organic sources. The N, P and K content of the organic sources are given in Tables 2, 3, 4 and 5.

3.2.4.4. Fertilization

In treatments T13 and T_{15}, nitrogen as urea in three equal splits at basal, active tillering and panicle initiation stages and 38 kg each of P_2O_5 and K_2O ha^{-1} for Kharif, 50 kg each of P_2O_5 and K_2O ha^{-1} for Rabi was applied. No chemical fertilizer was applied to T_1 to T_{12} and N was supplied through organic sources as per the treatments. The P and K requirement

Table 2. Nutrient contents of organic manure - Rabi 1996.

S.No.	Organic Manures	Nutrient content (%)			Quantity applied on dry weight basis(t ha^{-1}) to substitute 75 kg N ha^{-1}
		N	P	K	
1.	Sesbania rostrata	2.50	0.85	1.60	3.00
2.	FYM	0.80	0.45	0.74	9.37
3.	Press mud	0.70	1.10	0.70	10.71
4.	Biogas slurry	0.75	1.00	0.80	10.00
5.	Azolla	4.60	1.45	1.65	0.815*
6.	Neem cake	3.80	0.85	1.00	1.97
7.	Poultry manure	2.50	1.30	1.40	3.00

* To substitute 37.5 kg N ha^{-1}

Table 3. Nutrient contents of organic manures - Kharif 1997.

S.No.	Organic Manures	Nutrient content (%)			Quantity applied on dry weight basis(t ha^{-1}) to substitute 60 kg N ha^{-1}
		N	P	K	
1.	Sesbania rostrata	3.00	0.85	1.60	2.00
2.	FYM	0.50	0.40	0.74	12.37
3.	Press mud	1.09	1.40	0.75	5.50
4.	Biogas slurry	1.40	1.10	0.80	4.28
5.	Azolla	4.30	1.40	1.60	0.70*
6.	Neem cake	3.80	0.70	0.75	1.58
7.	Poultry manure	3.00	2.24	1.87	2.00

* To substitute 30 kg N ha^{-1}

Table 4. **Quantity of P and K (kg ha^{-1}) added through organic sources in different treatments Rabi 1996.**

Treatments	P		K	
	Qty	Total	Qty	Total
T_1 Sesbania rostrata + Azolla	17.00+9.80	26.80	32.00+11.20	43.20
T_2 S.rostrata+Neem cake	17.00+11.06	28.06	32.00+11.85	43.85
T_3 S.rostrata+ Poultry Manure	17.00+44.80	61.80	32.00+37.40	69.40
T_4 FYM + Azolla	48.00+9.80	57.80	88.80+11.20	100.00
T_5 FYM + Neem cake	48.00+11.06	59.06	88.80+11.85	100.65
T_6 FYM+Poultry manure	48.00+44.80	92.80	88.80+37.40	126.20
T_7 Press mud+Azolla	77.00+9.80	86.80	41.25+11.20	52.45
T_8 Press mud+Neem cake	77.00+11.06	88.06	41.25+11.85	53.10
T_9 Pressmud+Poultry	77.00+44.80	121.80	41.25+37.40	78.65
T_{10} Biogas slurry + Azolla	47.08+9.80	56.88	44.00+11.20	55.20
T_{11} Biogas slurry + Neem cake	47.08+11.06	58.14	44.00+11.85	55.85
T_{12} Biogas slurry + Poultry manure	47.08+44.80	91.88	44.00+37.40	81.40

Table 5. Quantity of P and K (kg ha^{-1}) added through organic sources in different treatments Kharif 1997.

Treatments	P		K	
	Qty	Total	Qty	Total
T_1 Sesbania rostrata + Azolla	18.00+10.00	28.00	33.60+11.00	44.60
T_2 S.rostrata+Neem cake	18.00+12.18	30.18	33.60+16.87	50.47
T_3 S.rostrata+ Poultry Manure	18.00+35.82	53.82	33.60+35.82	69.42
T_4 FYM + Azolla	50.66+10.00	60.66	93.33+11.00	104.33
T_5 FYM + Neem cake	50.66+12.18	62.84	93.33+16.87	110.20
T_6 FYM+Poultry manure	50.66+35.82	86.48	93.33+35.82	129.15
T_7 Press mud+Azolla	82.19+10.00	92.19	49.31+11.00	60.31
T_8 Press mud+Neem cake	82.19+12.18	94.37	49.31+16.87	66.18
T_9 Pressmud+Poultry	82.19+35.82	118.01	49.31+35.82	85.13
T_{10} Biogas slurry + Azolla	48.27+10.00	58.27	41.37+11.00	52.37
T_{11} Biogas slurry + Neem cake	48.27+12.18	60.45	41.37+16.87	58.24
T_{12} Biogas slurry + Poultry manure	48.27+35.82	84.09	41.37+35.82	77.19

was not supplied separately and whatever contained in the organic sources are taken into account except T_{13} and T_{15}.

3.2.4.5. Water management

The plots were irrigated with one cm of water. The depth of water was increased from one cm to five cms as the crop advanced in age. Irrigation was given with five cm depth of water after the disappearance of ponded water. Irrigation was stopped 15 days before harvest.

3.2.4.6. Plant protection

The biocontrol agents ***Trichogramma japonicum*** on 30 and 37 days after transplanting (twice) and ***T. chilonis*** on 37, 44 and 51 days (thrice) were released to control stem borer and leaf folder.

Neem oil 3% and NSKE 5% were sprayed as prophylactic measure against insects. For T_{15} the chemical plant protection (Monocrotophos and Dithane M-45) were given.

3.2.4.7. Harvesting and threshing

When the crop was fully matured, two rows all around the experimental plot were harvested as border rows and the net area was harvested separately, threshed individually and weight of the grain and straw were recorded plotwise. Grain yields were recorded at 14 per cent moisture level. The straw was sun-dried and yield recorded.

3.2.5. Biometric observations

Biometric observations were recorded as per the guidelines stipulated by the All India Coordinated Rice Improvement Project (Ten Have, 1977). In each plot, five plants were selected at random and labelled for recording observations.

3.2.5.1. GROWTH CHARACTERS (Common to both seasons)

3.2.5.1.1. Plant Height

Plant height was measured from the base of the plant to the tip of the longest leaf and upto the tip of the leaf at 45 days after transplanting and at harvest respectively.

3.2.5.1.2. Leaf area index (LAI)

Five hills outside the net plot were selected at random (Yoshida ***et al.,*** 1972) and used for calculating LAI. Leaf area index was worked out using the following formula as suggested by Palaniswamy and Gomez (1974).

$$LAI = \frac{L \times W \times K \times \text{Number of leaves per hill}}{\text{Spacing adopted } (cm^2)}$$

where

L = Maximum Length of the 3rd leaf blade from the top (cm)

W = Maximum width of the leaf blade (cm)

K = Factor of 0.75 for Kharif and 0.73 for Rabi season rice

N = Number of leaves per hill

P = Land area occupied by a plant (cm^2)

3.2.5.1.3. Dry matter production (DMP)

Five hills were selected at random from each plot in the sampling area. The plants of each hill were separated into leaves, stem, roots and panicles and these samples were first air dried and then oven dried at 80°C for 72 hours. The weight of the plant parts was calculated by hill sampling and converted into hectare basis. The sum of weights of plant parts was expressed as total dry matter. Sampling was done on AT, PI flowering and harvesting stage in Kharif and Rabi season.

3.2.5.1.4. Relative Dry Matter Efficiency (RDME)

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

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

3.2.6. YIELD COMPONENTS (Common to both the seasons)

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

1. Number of panicles m^2
2. Panicle length (cm)
3. Number of mature grains per panicle
4. Thousand grains weight (g)

3.2.7. Grain and straw yield (Common to both the seasons)

Grain and straw yields were recorded at harvest from the net plot area and the grain the yield is expressed at 14 per cent moisture level. The straw was then dried and yield recorded.

3.2.7.1. Harvest Index (HI)

The harvest index was calculated using the following formula.

$$\text{Harvest Index} = \frac{\text{Grain yield}}{\text{(Grain yield + Straw yield)}} \times 100$$

3.2.7.2. Productivity Score (PS)

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

3.2.8. PLANT ANALYSIS (Common to both the season)

3.2.8.1. Plant samples

The plant samples collected for estimating DMP at different stages of crop growth were used for the analysis of plant nutrient content. The samples were powdered using a wiley mill.

3.2.8.2. Nitrogen

The leaf N content of rice at different stages was estimated by microkjeldahl method Humphries (1956). The roots were analysed for N content.

3.2.8.3. Phosphorus

The P content in plant samples at harvest and roots were estimated by calorimetric method (Jackson, 1973).

3.2.8.4. Potassium

The K content in plant samples, and roots at harvest were estimated using flame photometer (Jackson, 1973).

3.2.9. Soil analysis (Common to both the seasons)

Composite soil samples were collected before the start of the experiment. After starting of the experiment, the soil samples were collected from each plot at 0-20 cm depth from 20 days after transplanting to harvest, dried under shade, sieved through 2 mm sieve and analysed for the following.

3.2.9.1. Organic carbon

Organic carbon content was estimated by wet digestion method as suggested by Walkey and Black (1934), before start of the experiment and after harvest of the each crop and expressed in percentage.

3.2.9.2. Available nitrogen

To estimate the available nitrogen alkaline permanganate method was adopted as suggested by Subbiah and Asija (1956) and expressed in kg ha^{-1}

3.2.9.3. Available phosphorus

Available phosphorus was estimated by adopting the method suggested by Olsen ***et al.*** (1954) and expressed in kg ha^{-1}.

3.2.9.4. Available potassium

Available potassium was estimated as described by Stanford and English (1949).

3.2.9.5. Soil pH and EC

Soil pH and EC were estimated using Beckman glass electrode by pH meter and solubridge, respectively in a soil water ratio of 1:2.

3.2.10. Nitrogen use efficiency (common to all three seasons)

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

3.2.10.1. Agronomic efficiency (AE)

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

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

3.2.10.2. Apparent N recovery (ANR)

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

$$ANR\ (\%) = \frac{y^t - y^0}{N^t} \times 100$$

where

Y^t = uptake of the N in particular treatment (kg ha^{-1})

Y^0 = uptake of N in unfertilized plot (kg ha^{-1}) and

N^t = quantity of N applied for the treatment (kg ha^{-1})

3.2.11. Nitrogen balance in the cropping system

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

3.2.12. Quality characteristics

The paddy was cleaned to seperate foreign material, impurities etc., treatment wise to study the following quality characteristics.

3.2.12.1. Chemical characteristics

Preparation of the sample: Rice samples of each treatment were cleaned by removing stones and other foreign particles. Good kernels were powdered, and used for chemical analysis.

3.2.12.1.1. Moisture content

Using OSAW universal moisture meter the per cent moisture content in the material was directly read for a given temperature.

3.2.12.1.2. Crude protein (A.O.A.C., 1980)

The estimation of nitrogen was done by micro-kjeldahl method. The results were expressed as protein per cent.

3.2.12.1.3. Fat (A.O.A.C., 1980)

Fat was estimated as crude ether extract of the dry materials. Fat content per cent was calculated by the formula

$$\text{Fat content} = \frac{\text{Weight of ether extract}}{\text{Weight of the sample}} \times 100$$

3.2.12.1.4. Fibre (A.O.A.C., 1980)

Fibre per cent was calculated by the following of formula

$$\text{Fibre per cent} = 100 - \frac{\text{(moisture - fat) x weight of fibre}}{\text{Weight of the sample taken}}$$

3.2.12.1.5. Ash content (A.O.A.C., 1980)

Ash content per cent was calculated by the formula.

$$\text{Ash content \%} = \frac{\text{Weight of the ash}}{\text{Weight of the sample taken}} \times 100$$

3.2.12.1.6. Carbohydrate content (A.O.A.C., 1980)

Carbohydrate content per cent was calculated by the formula

Carbohydrate content = [100 - (moisture content crude protein (%) + Fat content (%) + Fibre content (%) + ash content (%)]

3.2.12.1.7. Amylose content

The method suggested by Sadasivam and Manickam (1996) was followed in determining amylose content.

3.2.12.2. Cooking qualities

The method suggested by Sidhu *et al.* (1975) was followed to evaluate the cooking quality of different treatments. Weighed sample (2 g) was placed in test tubes containing boiling water (20 ml) and heated in boiling water bath.

3.2.12.2.1. Cooking of rice

In all cases, the rice was cooked in pressure cooker for 3 minutes with water at a ratio of 1:2.5 as it was pre-determined by Bhattacharya *et al.* (1972) that all treatments rice absorb a known amount of water when optimally cooked.

3.2.12.2.2. Method of study

The rice samples were subjected to sensory evaluation in cooked form to a panel of judges and not more than two samples were presented at a time. Parameters evaluated by judges includes colour, grain size, texture,

taste and overall acceptability of cooked rice. A nine point Hedonic scale was used to evaluate the samples (Tai *et al.* 1994).

3.2.13. Assessment of rice pests

Observations on the infestation by stem borer, leaf roller and number of galls were recorded as followed by Krishna Dass (1978).

3.2.13.1. Stem borer and gall fly

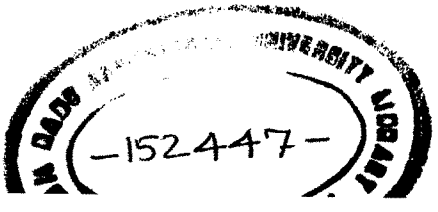
The total number of tillers and number of tillers showing dead heart, white ears caused by stem borer were observed in ten clumps selected at random per plot. In the same manner the damage by gall fly infestation was assessed based on silver shoots produced. The data were expressed as the percentage of infestation by these pests.

3.2.13.2. Leaf roller

The leaf roller damage was characteristic with leaf folding and scrapping of chlorophyll matter. The damage of the pest was observed in ten clumps on the basis of number of leaves and leaves damaged by pest and expressed as per cent damage.

3.2.13.3. Disease

No disease incidence was noticed during any of the seasons of the experimentation.



3.2.14. Economic analysis

The cost of inputs and prevailing market rates of farm produce were taken into consideration for working out the gross and net return and benefit cost ratio.

3.2.15. Statistical analysis

Statistical analysis of the data was worked out as per the methods suggested by Panse and Sukhatme (1967), wherever the result was significant, critical difference was worked out at five per cent probability level.

RESULTS

CHAPTER IV

EXPERIMENTAL RESULTS

The results from the field experiments carried out at wetlands of Tamil Nadu Agricultural University, Coimbatore from October 1996 to September 1997 in low land rice based cropping systems are presented in this Chapter.

4.1. Biometric Observations on growth

4.1.1. Plant height (Table 6)

The plant height increased with the advancement of crop growth and it was the highest at harvest. During Rabi '96 the plants were taller under Recommended NPK fertilizer application (T_{13}) at panicle initiation and at harvest stage it was it par with FYM + NC (T_5), FYM + POM (T_3) and PM + POM T_9). At panicle initiation it was on par with Conv. Fmg (T_{15}), SR + POM (T_3), FYM + NC (T_5), FYM + PDM (T_6), PM + POM (T_8) and BS + NC (T_{11}) at harvest. During Kharif '97, ***Sesbania rostrata*** + Poultry manure (T_3) produced taller plants in both panicle initiation and at harvest, however it was comparable with FYM + NC (T_5), Rec NPK (T_{13}) and PM + POM (T_9) at panicle initiation stage and it was at par with PM + POM (T_9) and FYM + NC (T_5) at harvest.

Control (T_{14}) was registered significantly lower plant height in both the seasons of study.

Table 6. Effect of different organics and fertilizers on the plant height at different growth stages (cm).

Treatment	Rabi, 1996		Kharif, 1997	
	Panicle Initiation	Harvesting	Panicle Initiation	Harvesting
T_1 SR+Az+As	40.57	63.80	50.93	74.40
T_2 SR+NC	42.12	63.02	52.79	74.47
T_3 SR+POM	45.55	69.22	57.32	77.86
T_4 FYM+Az+As	38.77	59.35	46.39	71.48
T_5 FYM+NC	46.73	68.55	57.06	76.65
T_6 FYM+POM	45.01	67.09	53.41	74.33
T_7 PM+AZ+AS	40.95	62.58	52.29	71.22
T_8 PM+NC	43.16	66.66	53.96	75.69
T_9 PM+POM	44.49	66.85	54.50	76.66
T_{10} BS+AZ+AS	39.72	58.04	50.14	70.37
T_{11} BS+NC	42.84	66.45	53.17	72.33
T_{12} BS+POM	41.95	60.09	50.15	74.55
T_{13} RecNPK	47.01	71.05	54.66	74.87
T_{14} NoNPK	37.15	54.21	44.60	61.13
T_{15} Conv.FMG	43.51	69.38	53.39	73.39
SEd	1.54	2.30	1.46	1.42
CD (P=0.05)	2.98	4.70	3.02	2.91

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

4.1.2. Leaf area Index (LAI) (Table 7)

In general with the advancement of crop growth, the LAI increased upto flowering stage.

In Rabi '96, FYM + Neem cake (T_5) registered highest LAI at flowering stage, which was comparable with Conv. Fmg (T_{15}), Rec. NPK (T_{13}) and FYM + Poultry manure (T_6). In Kharif '97 FYM + Neem cake (T_5) recorded highest LAI which was comparable with Rec. NPK (T_{13}), Conv. Fmg (T_{15}) and followed by ***Sesbania rostrata*** + Poultry manure (T_3).

(T_{14}) control, registered lowest LAI in both the seasons.

4.1.3. Dry matter production (DMP) Tables (8 and 9)

The DMP of rice was recorded at AT, PI, flowering and harvesting stages.

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

During Rabi '96, application of FYM + Neem cake (T_5) had increasead total DMP in all the crop periods. At AI stage T_5 was comparable with FYM + Poultry manure (T_6), Conv. Fmg (T_{15}), Rec. NPK (T_{13}) and Pressmud + Poultry manure (T_9). T_5 registered highest DMP, followed by T_{15}, T_{13}, T_6 and T_9 in flowering stage. T_5 showed more DMP and followed by T_{15}, T_{13}, T_9 during harvesting stage. In general the lowest DMP was recorded in no NPK (T_{14}) treatment.

Table 7. Effect of different organics and fertilizers on the leaf area index at flowering stage.

Treatment	Rabi, 1996	Kharif, 1997
T_1 SR+Az+As	3.39	4.23
T_2 SR+NC	3.59	4.14
T_3 SR+POM	4.39	5.30
T_4 FYM+Az+As	3.38	4.40
T_5 FYM+NC	5.24	7.10
T_6 FYM+POM	5.02	5.69
T_7 PM+AZ+AS	3.63	5.34
T_8 PM+NC	4.56	5.00
T_9 PM+POM	4.86	5.23
T_{10} BS+AZ+AS	3.27	3.68
T_{11} BS+NC	3.58	4.22
T_{12} BS+POM	3.87	4.20
T_{13} RecNPK	4.95	6.02
T_{14} NoNPK	2.58	2.98
T_{15} Conv.FMG	5.06	6.00
SEd	0.62	0.79
CD (P=0.05)	1.24	1.62

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 8. Effect of different organics and fertilizers on the dry matter production at different growth stages (Kg ha^{-1}) Rabi, 1996.

Treatment	Rabi, 1996			
	Active	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	1005.25	3400.21	6312.51	8730.21
T_2 SR+NC	1152.41	3614.52	6813.63	9300.40
T_3 SR+POM	1334.21	4041.27	7452.74	9940.60
T_4 FYM+Az+As	978.21	3356.47	5912.35	9230.81
T_5 FYM+NC	1474.52	4814.21	9214.22	11950.02
T_6 FYM+POM	1464.24	4382.14	8235.47	10610.42
T_7 PM+AZ+AS	1342.14	4192.12	6576.76	8960.80
T_8 PM+NC	1810.37	4174.26	7614.97	10230.69
T_9 PM+POM	1412.31	4456.55	7842.28	10370.28
T_{10} BS+AZ+AS	1234.24	3267.21	5782.40	8400.43
T_{11} BS+NC	1242.04	3842.14	6941.69	9660.60
T_{12} BS+POM	1291.21	3541.21	7361.91	9840.84
T_{13} RecNPK	1452.41	4354.21	8762.85	11080.95
T_{14} NoNPK	928.21	1242.62	2421.72	4750.16
T_{15} Conv.FMG	1451.23	4324.32	8651.84	11065.92
SEd	63.45	102.30	189.37	227.50
CD (P=0.05)	132.25	213.20	394.65	474.31

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 9. Effect of different organics and fertilizers on the dry matter production at different growth stages (Kg ha^{-1}) Kharif, 1997.

Treatment	Kharif, 1997			
	Active	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	1800	2571	6971	11070
T_2 SR+NC	1400	3513	7693	11620
T_3 SR+POM	1820	4125	8712	12050
T_4 FYM+Az+As	1510	3564	8274	11700
T_5 FYM+NC	2220	5166	9545	16150
T_6 FYM+POM	1994	4402	9027	13950
T_7 PM+AZ+AS	1441	3617	8066	11910
T_8 PM+NC	1323	3368	7608	12280
T_9 PM+POM	1782	4279	8280	12400
T_{10} BS+AZ+AS	1374	3280	7239	12400
T_{11} BS+NC	1396	3551	7031	11240
T_{12} BS+POM	1275	3161	7933	11370
T_{13} RecNPK	1937	4624	9422	11550
T_{14} NoNPK	863	1810	4671	8590
T_{15} Conv.FMG	1942	4437	9224	14470
SEd	44.89	151.29	118.83	225.61
CD (P=0.05)	91	307	379	457

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

During Kharif '97 FYM + Neem cake (T5) significiantly registered maximum total DMP in all crop periods which was followed by T_6, T_{15}, T_{13} and T_3 in AT stage. In PI stage T_5 followed by T_{13}, T_{15}, T_6 and T_9. At flowering stage T_5 was comparable with T_{13} and T_{15} and this was followed by T_6 and T_3. T_5 recorded highest DMP followed by T_6, T_{15}, T_9 and T_8. in harvest stage. Control registered lowest DMP in two season.

4.1.3.1. Relative Dry Matter Efficiency (RDME)

The mean data on RDME of Rabi, 1996 and Kharif, 1997 rice are presented in Fig.3.

In both the seasons, application of organic manures and fertilizers improved RDME. Among the different treatment tried application of FYM + Neem cake (T_5), FYM + Poultry manure (T_6), Rec. NPK (T_{13}) and Conv. Fmg (T_5), stood equally good and this was followed by T_3 and T_9. Control recorded the lowest RDME in both the seasons of experiments.

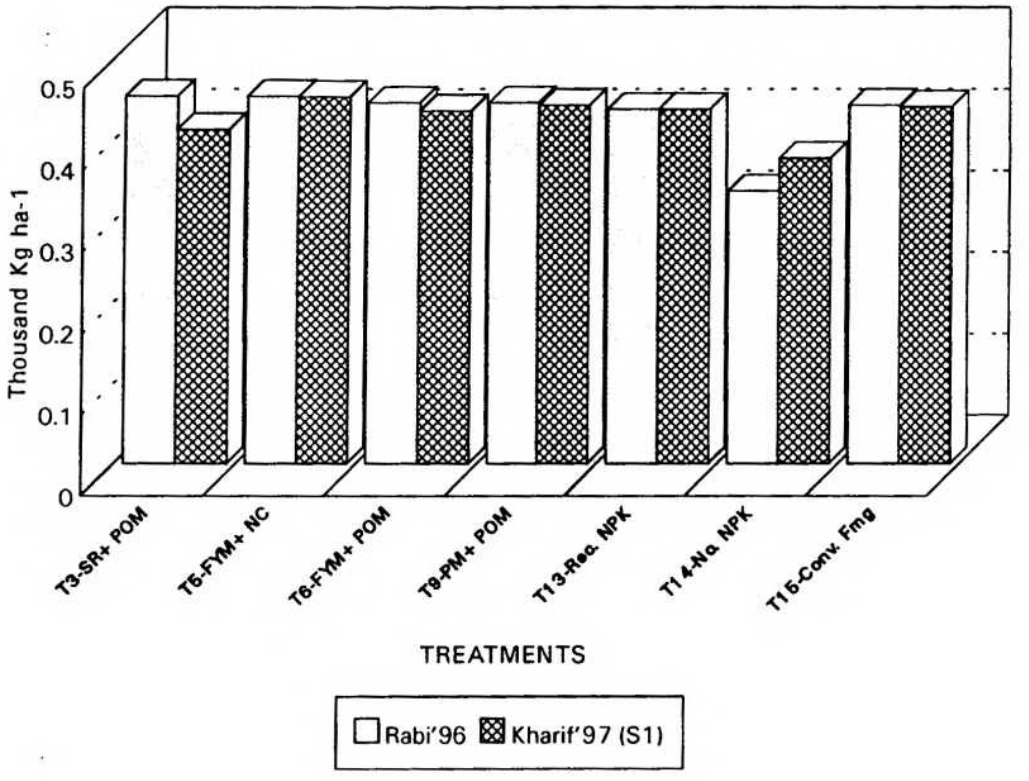
4.1.4. Yield components (Tables 10 and 11)

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

4.1.4.1. Number of Panicles m^{-2}

Application of organic manures and fertilizers had influenced this parameter significantly. In Rabi 1996, highest number of panicles were observed under FYM + Neem cake (T_6) applied treatment and which was

FIG.3. EFFECT OF OMs AND FERTILIZERS ON RELATIVE DRY MATTER EFFICIENCY FOR RABI '96 AND KHARIF '97



followed by FYM + Poultry manure (T_6), Press mud + Poultry manaure (T_9) Rec NPK (T_{13}) and Conv. Fmg (T_{15}). During Kharif 1997, FYM + Poultry manure (T_6) treatment recorded maximum number of Panicles which was at par with FYM + Neem cake (T_5), ***Sesbania rostrata*** + Poultry manure (T_3). Control exhibit lowest panicles number.

4.1.4.2. Panicle length

Organic manures and fertilizer treatments excerted significant influence on the length of panicle in both the seasons of study. During Rabi '96 Longer panicle were observed with Rec. NPK (T_{13}) treatment and it was at par with the panicle length recorded under FYM + Neem cake (T_5), FYM + Poultry manure (T_6) and Conv. Fmg (T_{15}) applied treatments. In Kharif '97 T_{13} was comparable with T_5, T_{15} and T_6.

Control (T_{14}) was registered significantly lowest length of panicle.

4.1.4.3. Percentage of filled grain

Filled grain per cent was significantly influenced by organic manure and fertilizers application studies. The lowest filled grain percentage was with control treatments, in which no manure was incorporated. During Rabi '96, FYM + Neem cake (T_5) treatment recorded the maximum filled grain percentage which was followed by Rec. NPK (T_{13}), Conv. Fmg (T_{15}) and FYM + Poultry manure (T_6). In Kharif, 1997 the same treatment T_5 was followed by T_6, T_{15}, T_{13} and T_3 applied treatments.

Table 10. Effect of different organics and fertilizers on yield attributes of Rabi, 1996.

Treatment	Rabi, 1996			
	No.of Panicles m^2	Panicle length (cm)	Filled grain (%)	1000 grain weight (g)
T_1 SR+Az+As	596.50	17.05	76.84	20.51
T_2 SR+NC	482.2	17.72	75.92	21.58
T_3 SR+POM	671.25	18.13	64.76	20.95
T_4 FYM+Az+As	596.00	17.96	72.28	21.21
T_5 FYM+NC	732.25	18.69	82.11	22.45
T_6 FYM+POM	696.75	18.43	75.28	21.43
T_7 PM+AZ+AS	604.25	17.14	67.91	21.41
T_8 PM+NC	646.85	18.03	71.01	21.59
T_9 PM+POM	676.86	18.23	75.85	21.32
T_{10} BS+AZ+AS	632.83	16.34	68.07	20.63
T_{11} BS+NC	643.50	16.71	71.88	21.38
T_{12} BS+POM	643.33	18.03	74.98	21.22
T_{13} RecNPK	671.33	19.32	79.09	21.68
T_{14} NoNPK	476.32	16.34	61.28	20.45
T_{15} Conv.FMG	666.32	18.63	76.21	21.27
SEd	16.32	0.81	0.85	0.77
CD (P=0.05)	33.33	1.64	1.73	NS

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 11. Effect of different organics and fertilizers on yield attributes of Kharif, 1997.

Treatment	Kharif, 1997			
	No.of Panicles m^2	Panicle length (cm)	Filled grain (%)	1000 grain weight (g)
T_1 SR+Az+As	590.50	17.94	71.20	20.23
T_2 SR+NC	612.5	16.74	75.21	21.58
T_3 SR+POM	712.25	19.27	77.51	20.95
T_4 FYM+Az+As	620.00	17.68	73.34	21.21
T_5 FYM+NC	724.25	19.65	84.70	22.45
T_6 FYM+POM	724.75	19.26	82.51	21.43
T_7 PM+AZ+AS	642.85	18.57	75.20	21.41
T_8 PM+NC	657.56	19.01	73.10	21.59
T_9 PM+POM	664.83	18.98	74.30	21.32
T_{10} BS+AZ+AS	530.50	16.71	68.21	20.63
T_{11} BS+NC	605.33	18.66	77.23	21.38
T_{12} BS+POM	502.33	18.77	70.51	21.22
T_{13} RecNPK	664.33	20.19	81.20	21.68
T_{14} NoNPK	440.12	16.42	67.21	20.45
T_{15} Conv.FMG	672.15	19.41	81.23	21.27
SEd	16.32	0.81	0.85	0.77
CD (P=0.05)	33.13	1.64	1.73	NS

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

4.1.4.4. Thousand grain weight

Thousand grain weight was not affected by the organic manures as well as by fertilizer in both the seasons of study.

4.1.5. Yield of Rice (Table 12 and 13) Fig.4.

4.1.5.1. Grain yield

Grain yield of rice was significantly influenced by the application of organic manures as well as by the fertilizers treatments. Among the organic manures, incorporation of Farm yard manure + Neem cake (T_5) had increased rice grain yield in both the seasons of study. During Rabi, 1996 FYM + Neem cake (T_5) treatment was followed by Conv. Fmg (T_{15}), Rec. NPK (T_{13}) applied treatments, where as in Kharif 1997 (T_5) treatment was significantly superior and this was followed by (T_{15}), (T_{13}) and (T_6). Lowest grain yield was recorded in no NPK (T_{14}).

Rice grain yield was increased with FYM + Neem cake application. Application of manures increased the grain yield to 8 and 10 per cent over Conv. Fmg (T_{15}) during Rabi, 1996 and Kharif, 1997 in respectively.

4.1.5.2. Straw yield

Straw yield was significantly increased by the organic sources and fertilizers. Among the treatments, FYM + Neem cake (T_5) incorporation registered the highest Straw yield and it was followed by Conv. Fmg (T_{15}), Rec. NPK (T_{13}) and FYM + Poultry manure (T_6) treatments during Rabi 1996, while it was followed by FYM + Poultry manure (T_6), ***Sesbania***

FIG. 4 EFFECT OF DIFFERENT ORGANICS AND FERTILIZERS ON GRAIN YIELD (Kg ha^{-1})

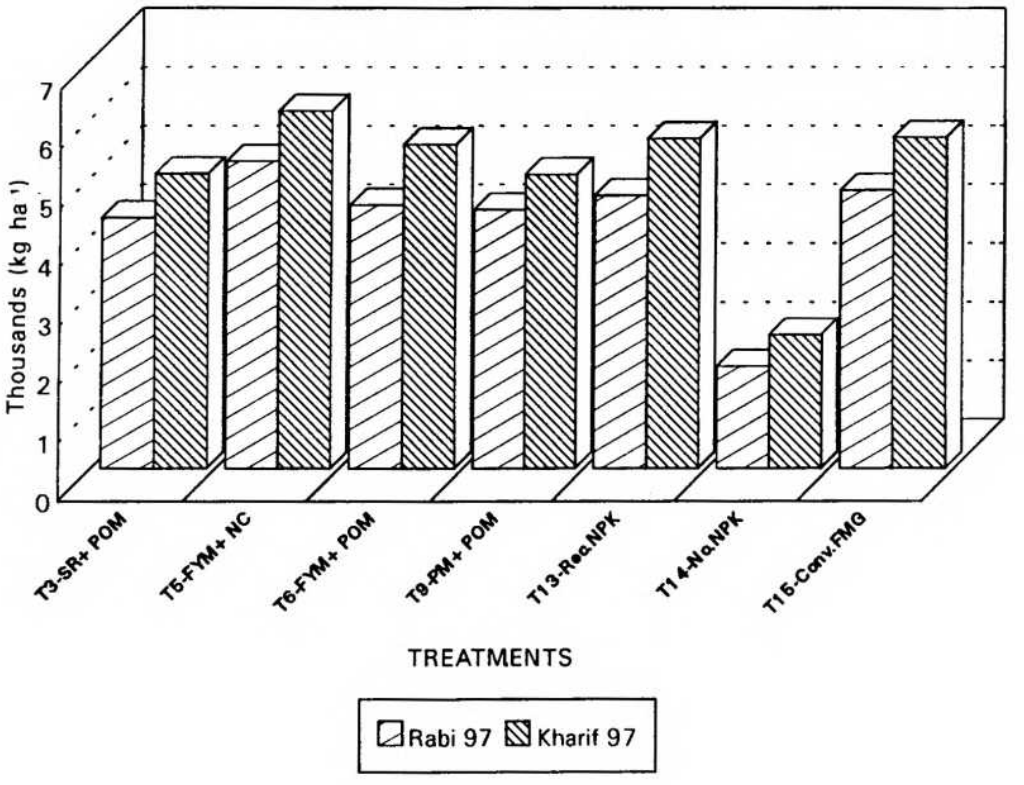


Table 12. Effect of different organics and fertilizers on grain yield, straw yield (kg ha^{-1}) and harvest index. Rabi, 1996.

Treatment	Rabi, 1996		
	Grain Yield	Straw Yield	Harvest Index
T_1 SR+Az+As	3470	4310	44.1
T_2 SR+NC	3990	4360	47.0
T_3 SR+POM	4280	4710	47.2
T_4 FYM+Az+As	3160	5120	38.9
T_5 FYM+NC	5240	5760	47.3
T_6 FYM+POM	4490	5170	46.1
T_7 PM+AZ+AS	3620	4390	45.4
T_8 PM+NC	4300	4980	46.2
T_9 PM+POM	4410	5010	46.5
T_{10} BS+AZ+AS	2950	4500	39.3
T_{11} BS+NC	4040	4670	46.6
T_{12} BS+POM	4090	4800	46.4
T_{13} RecNPK	4650	5489	45.7
T_{14} NoNPK	1750	3201	35.6
T_{15} Conv.FMG	4740	5495	46.8
SEd	56	27	0.0036
CD (P=0.05)	105	54	NS

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 13. Effect of different organics and fertilizers on grain yield, straw yield (kg ha^{-1}) and harvest index. Kharif, 1997

Treatment	Kharif, 1997		
	Grain Yield	Straw Yield	Harvest Index
T_1 SR+Az+As	4095	5281	43.2
T_2 SR+NC	4301	5904	42.3
T_3 SR+POM	5024	6582	43.2
T_4 FYM+Az+As	4483	5503	44.4
T_5 FYM+NC	6095	6745	47.5
T_6 FYM+POM	5521	6583	45.6
T_7 PM+AZ+AS	4590	5562	45.8
T_8 PM+NC	4631	5375	46.7
T_9 PM+POM	5010	5801	46.2
T_{10} BS+AZ+AS	3980	4675	46.4
T_{11} BS+NC	4090	4603	47.7
T_{12} BS+POM	4015	4842	45.2
T_{13} RecNPK	5623	5812	49.3
T_{14} NoNPK	2282	3791	37.7
T_{15} Conv.FMG	5642	5972	48.4
SEd	63.10	29	0.0037
CD (P=0.05)	140	58	NS

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

rostrata + Poultry manure (T_3) and Conv. Fmg (T_{15}) treatment during the Kharif, 1997.

Lowest straw yield was exhibited by the control in both the seasons of study.

4.1.5.3. Harvest Index (HI)

The mean data of HI of Rabi, 1996 and Kharif, 1997 are presented in (Tables 12 and 13). The data on harvest index indicated that treatments FYM + Neem cake (T_5) recorded higher HI, when compared to control (T_{14}). This was followed by (T_3) and (T_{15}).

4.1.5.4. Productivity Score (PS) (Tables 14 and 15)

The productivity score was greatly influenced by the application of organic manures as well as by fertilizer. Among the treatments, FYM + Neem cake (T_5) and FYM + Poultry manure (T_6), ***Sesbania rostrata*** + Poultry manure (T_3) and Pressmud + Poultry manure (T_9) was found better in increasing the productivity score. This was followed by Rec NPK (T_{13}) and Conv. Fmg (T_{15}). Control registered the lowest PS in both the season of studies.

4.1.6. Plant nutrients uptake

4.1.6.1. Nitrogen Uptake (Tables 16 and 17) Fig.5 and 6.

Organic manure and fertilizer sources had significant influence on N uptake at all the stages of crop growth in both the seasons of studies.

Table 14. Productivity Score. Rabi, 1996.

Treatment	Rabi, 1996			
	Economic yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index	Productivity Score
T_1 SR+Az+As	3.47	7.78	44.1	55.85
T_2 SR+NC	3.99	8.45	47.0	60.14
T_3 SR+POM	4.28	8.99	47.2	60.87
T_4 FYM+Az+As	3.16	8.28	38.9	49.54
T_5 FYM+NC	5.24	11.0	47.3	63.84
T_6 FYM+POM	4.49	9.66	46.1	60.55
T_7 PM+AZ+AS	3.62	8.01	45.4	56.73
T_8 PM+NC	4.30	9.28	46.2	59.88
T_9 PM+POM	4.41	9.42	46.5	60.63
T_{10} BS+AZ+AS	2.95	7.45	39.3	49.92
T_{11} BS+NC	4.04	8.71	46.6	59.05
T_{12} BS+POM	4.09	8.89	46.4	58.98
T_{13} RecNPK	4.65	10.13	45.7	60.68
T_{14} NoNPK	1.75	4.95	35.6	42.0
T_{15} Conv.FMG	4.74	10.23	46.8	61.27

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 15. Productivity Score Kharif, 1997.

Treatment	Kharif, 1997			
	Economic yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index	Productivity Score
T_1 SR+Az+As	4.09	10.18	43.2	57.87
T_2 SR+NC	4.30	10.20	42.3	56.61
T_3 SR+POM	5.02	11.78	43.2	60.10
T_4 FYM+Az+As	4.48	9.98	44.4	59.26
T_5 FYM+NC	6.09	13.64	47.5	67.13
T_6 FYM+POM	5.52	12.10	45.6	63.22
T_7 PM+AZ+AS	4.59	10.15	45.8	59.94
T_8 PM+NC	4.63	10.01	46.7	60.94
T_9 PM+POM	5.01	10.81	46.2	62.12
T_{10} BS+AZ+AS	3.98	8.65	46.4	58.63
T_{11} BS+NC	4.09	8.69	47.7	59.78
T_{12} BS+POM	4.01	8.85	45.2	58.16
T_{13} RecNPK	5.62	11.43	49.3	66.15
T_{14} NoNPK	2.28	6.07	37.7	45.85
T_{15} Conv.FMG	5.64	11.61	48.4	65.75

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

The N uptake increased with crop growth upto maturity. 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.

In Rabi, 1996 FYM + Neem cake (T_5) was at par with Conv. Fmg (T_{15}), which was followed by NPK, (T_{13}), FYM + Poultry manure (T_6), ***Sesbania rostrata*** + Poultry manure (T_3) and Pressmud + Poultry manure (T_9) combination. In Kharif '97 FYM +Neem cake (T_5) registered highest N uptake followed by T_6, T_{15}, T_{13} and T_9.

In PI stage, all the treatments showed a significant influence on N uptake over the control (T_{14}). In Rabi '96 highest N uptake was found in FYM + Neem cake (T_5) at par with Conv. Fmg (T_{15}) followed by Rec. NPK (T_{13}). In Kharif '97 T_5 followed by T_6 and T_{15}, T_{13}. During Rabi '96 the flowering stage also, N uptake was highest in (T_5) treatment. However, this was at par with T_{15}. In Kharif '97 T_5 was at par with T_6 followed by T_{15} and T_{13} at harvesting stages, all the applied treatments significantly influenced the N uptake of rice. In which T_5 registered highest N uptake which was followed by T_{15} and T_{13}. During Kharif '97 T_5 followed by T_6, T_{15}, T_{13} and T_9.

Control (T14) was registered lowest N uptake in both the seasons of study.

Table 16. Effect of different organics and fertilizer on the N uptake during Rabi, 1996 season at different growth stages (Kg ha^{-1}).

Treatment	Rabi, 1996			
	Active tillering	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	18.72	42.21	52.70	71.38
T_2 SR+NC	19.28	40.12	51.24	82.97
T_3 SR+POM	21.40	43.28	56.88	88.06
T_4 FYM+Az+As	18.62	43.15	52.62	66.62
T_5 FYM+NC	26.33	50.45	61.33	102.06
T_6 FYM+POM	21.73	43.70	57.65	93.61
T_7 PM+AZ+AS	19.01	42.14	50.24	75.09
T_8 PM+NC	21.20	42.52	50.14	87.96
T_9 PM+POM	20.90	42.21	55.23	87.04
T_{10} BS+AZ+AS	19.28	40.12	53.38	84.21
T_{11} BS+NC	19.48	41.24	49.25	85.45
T_{12} BS+POM	18.53	40.14	48.65	87.49
T_{13} RecNPK	22.15	46.70	59.83	95.88
T_{14} NoNPK	14.37	36.40	32.80	38.88
T_{15} Conv.FMG	24.33	47.78	61.32	98.73
SEd	1.10	1.17	1.97	2.86
CD (P=0.05)	2.31	3.26	4.39	5.96

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 17. Effect of different organic and fertilizer on the N uptake during Kharif, 1997 season at different growth stages (Kg ha^{-1}).

Treatment	Kharif, 1997			
	Active tillering	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	25.3	45.6	52.3	71.89
T_2 SR+NC	22.6	49.4	56.9	87.01
T_3 SR+POM	36.3	71.8	75.6	128.34
T_4 FYM+Az+As	30.5	59.5	67.6	95.02
T_5 FYM+NC	52.4	92.6	95.8	163.85
T_6 FYM+POM	48.3	89.5	93.2	141.68
T_7 PM+AZ+AS	24.8	51.8	59.0	90.92
T_8 PM+NC	30.5	58.1	65.7	109.92
T_9 PM+POM	37.3	72.9	77.5	134.9
T_{10} BS+AZ+AS	17.5	34.4	43.6	62.10
T_{11} BS+NC	27.4	52.3	58.9	78.90
T_{12} BS+POM	21.9	43.8	46.8	74.71
T_{13} RecNPK	37.6	73.2	79.4	137.48
T_{14} NoNPK	13.1	32.8	34.6	44.35
T_{15} Conv.FMG	38.2	74.8	80.5	140.45
SEd	1.23	1.90	2.2	3.19
CD (P=0.05)	2.58	3.56	4.69	6.66

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

FIG.5. EFFECT OF DIFFERENT ORGANIC AND FERTILIZER ON THE N UPTAKE DURING KHARIF 1997 SEASON AT DIFFERENT GROWTH STAGES (Kg ha^{-1})

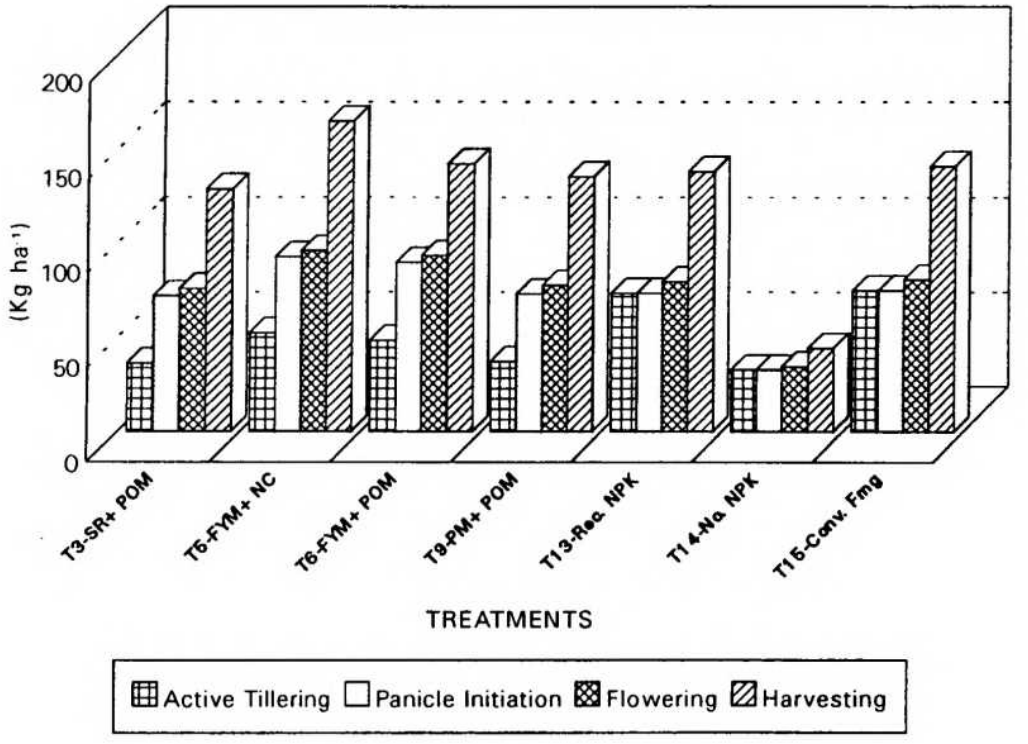
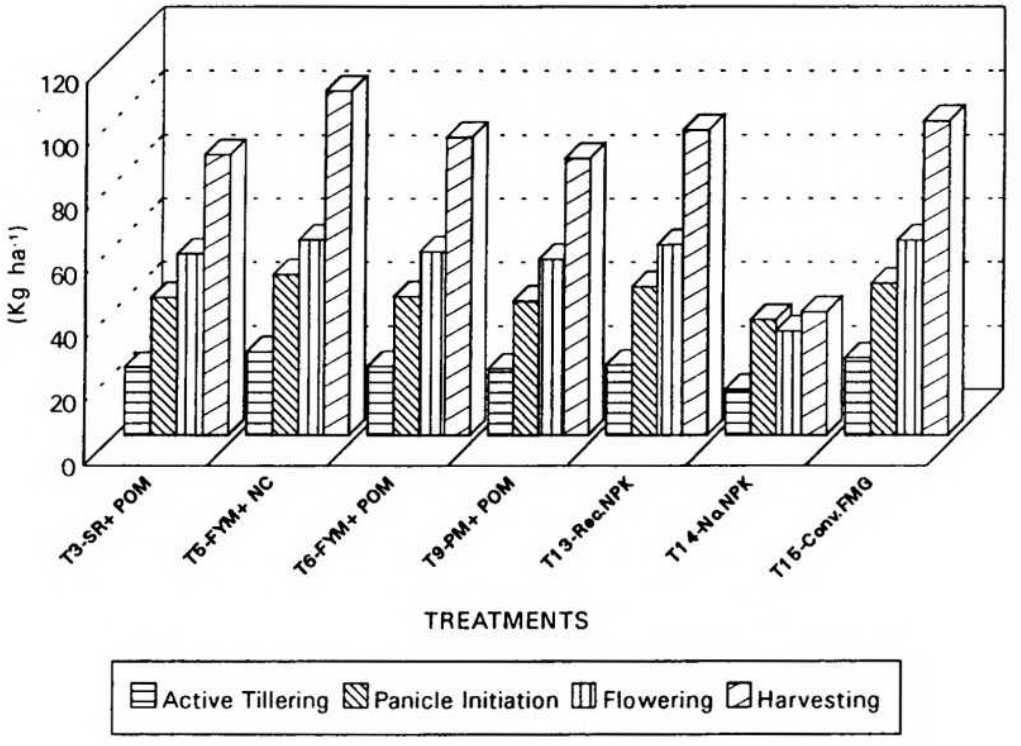


FIG.6. EFFECT OF DIFFERENT ORGANIC AND FERTILIZER ON THE N UPTAKE DURING RABI 1996 SEASON AT DIFFERENT GROWTH STAGES (Kg ha^{-1})



4.1.6.2. Phosphorous uptake Tables (18 and 19)

Organic manures and fertilizer had significant influence on p uptake at all the three stages in both the seasons. At PI stage, during Rabi '96 FYM + Neem cake (T_5) followed by Conv. Fmg (T_{15}), Rec. NPK (T_{13}), FYM + Poultry manure (T_6) and Pressmud + Poultry manure (T_9) but in Kharif '97 T_5 at par T_{13} and T_{15}.

In flowering stage T_5 followed by T_{15}, T_{13}, T_6 and T_9 in Rabi 96, T_5 was followed by T_{13}, T_{15} and T_9 in Kharif '97. At harvesting stage T_5 recorded highest P uptake at par with T_{13} and T_{15} in both the seasons. Control (T_{14}) was registered lowest P uptake in both the season.

4.1.6.3 Potassium uptake Tables (20 and 21)

Fertilizers as well as organics had significant effect on K uptake of rice at all the three stages in both the season of study.

Potassium uptake was significantly influenced by the treatments and the maximum K uptake was with FYM + Neem cake (T_5) and is comparable with T_9 and followed by T_6, T_{15} and T_{13} in both the seasons of study.

Control (T_{14}) was registered lowest uptake.

4.1.7. Use effeciencies (Table 22)

Agronomic efficiency (AE) and Apparent N Recovery (ANR) were computed for harvest stage. These data were not analysed statistically.

Table 18. Effect of different organics and fertilizer on the P uptake during Rabi, 1996 season at different growth stages (kg ha^{-1}).

Treatment	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	9.52	11.37	19.97
T_2 SR+NC	6.84	10.17	20.79
T_3 SR+POM	11.33	13.30	29.86
T_4 FYM+Az+As	9.23	12.74	27.61
T_5 FYM+NC	15.00	16.92	35.37
T_6 FYM+POM	12.93	14.79	31.64
T_7 PM+AZ+AS	6.89	10.23	21.98
T_8 PM+NC	11.36	14.05	27.63
T_9 PM+POM	12.83	14.69	30.40
T_{10} BS+AZ+AS	6.39	8.79	17.11
T_{11} BS+NC	6.38	9.52	18.56
T_{12} BS+POM	8.68	12.06	21.26
T_{13} RecNPK	13.01	14.93	32.97
T_{14} NoNPK	5.29	7.75	13.30
T_{15} Conv.FMG	13.14	14.95	33.27
SEd	0.39	0.51	1.25
CD (P=0.05)	0.87	1.14	2.79

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 19. Effect of different organics and fertilizer on the P uptake during Kharif, 1997 season at different growth stages (kg ha^{-1}).

Treatment	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	9.44	11.12	23.78
T_2 SR+NC	10.73	11.58	24.49
T_3 SR+POM	16.77	19.97	42.89
T_4 FYM+Az+As	15.89	12.19	37.63
T_5 FYM+NC	19.77	23.24	52.37
T_6 FYM+POM	18.27	10.97	42.67
T_7 PM+AZ+AS	13.67	16.96	32.78
T_8 PM+NC	12.26	20.52	38.18
T_9 PM+POM	16.23	21.78	43.03
T_{10} BS+AZ+AS	8.55	11.42	24.23
T_{11} BS+NC	11.22	13.39	25.49
T_{12} BS+POM	14.35	16.33	31.69
T_{13} RecNPK	19.37	22.51	47.94
T_{14} NoNPK	6.20	9.90	16.42
T_{15} Conv.FMG	18.34	22.42	47.27
SEd	0.68	0.72	1.16
CD (P=0.05)	1.43	1.60	2.58

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 20. Effect of different organics and fertilizer on the K uptake during Rabi, 1996 season at different growth stages (kg ha^{-1}).

Treatment	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	8.86	10.21	25.7
T_2 SR+NC	12.38	15.13	30.67
T_3 SR+POM	19.96	26.21	45.41
T_4 FYM+Az+As	17.23	23.24	41.32
T_5 FYM+NC	21.22	39.22	52.65
T_6 FYM+POM	19.13	32.31	49.85
T_7 PM+AZ+AS	15.22	17.64	33.57
T_8 PM+NC	16.13	22.21	40.54
T_9 PM+POM	20.12	38.13	51.54
T_{10} BS+AZ+AS	8.55	11.42	24.56
T_{11} BS+NC	8.52	11.39	24.02
T_{12} BS+POM	8.63	11.45	25.72
T_{13} RecNPK	21.23	39.14	53.69
T_{14} NoNPK	6.23	7.52	17.09
T_{15} Conv.FMG	22.12	38.13	52.29
SEd	0.42	0.12	1.16
CD (P=0.05)	0.94	1.60	2.50

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 21. Effect of different organics and fertilizer on the K uptake during Kharif, 1997 season at different growth stages (kg ha^{-1}).

Treatment	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	12.32	21.41	55.7
T_2 SR+NC	14.52	25.42	61.52
T_3 SR+POM	21.32	31.24	91.67
T_4 FYM+Az+As	19.27	29.15	84.83
T_5 FYM+NC	32.13	65.63	133.42
T_6 FYM+POM	29.12	51.24	124.83
T_7 PM+AZ+AS	18.52	28.13	72.44
T_8 PM+NC	22.31	33.21	94.41
T_9 PM+POM	31.23	53.26	128.83
T_{10} BS+AZ+AS	11.23	22.42	48.96
T_{11} BS+NC	13.52	23.41	58.91
T_{12} BS+POM	15.26	26.42	64.39
T_{13} RecNPK	28.12	60.21	113.08
T_{14} NoNPK	7.23	11.92	23.92
T_{15} Conv.FMG	20.16	61.31	113.86
SEd	0.51	1.25	3.23
CD (P=0.05)	1.14	2.79	6.42

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 22. Effect of different organics and fertilizer on Apparent Nitrogen Recovery (ANR), Agronomic efficiency (AE).

Treatment	ANR		AE	
	Rabi '96	Kharif '97	Kharif '97	Rabi '96
T_1 SR+Az+As	0.24	0.26	15.08	11.47
T_2 SR+NC	0.27	0.39	16.85	14.94
T_3 SR+POM	0.35	0.73	22.83	16.88
T_4 FYM+Az+As	0.23	0.46	18.28	9.38
T_5 FYM+NC	0.46	0.96	31.75	23.27
T_6 FYM+POM	0.36	0.33	26.95	18.19
T_7 PM+AZ+AS	0.27	0.42	19.21	12.51
T_8 PM+NC	0.28	0.58	19.54	17.02
T_9 PM+POM	0.34	0.79	22.74	17.72
T_{10} BS+AZ+AS	0.28	0.18	14.16	8.00
T_{11} BS+NC	0.28	0.32	15.08	19.11
T_{12} BS+POM	0.28	0.29	14.41	19.54
T_{13} RecNPK	0.30	0.81	27.78	19.32
T_{15} Conv.FMG	0.30	0.83	27.96	19.94

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

4.1.7.1. Agronomic efficiency (AE)

The AE was highly improved with the FYM + Neem cake (T_5) application in both the season. The next best was Conv. Fmg (T_{15}) in Rabi '96 and Kharif '97 seasons. Biogas slurry + Azolla + Azospirillum (T_{10}) registered the lowest AE.

4.1.7.2. Apparent N recovery

In both the seasons, the highest apparent N recovery (ANR) was seen where FYM + Neem cake (T_5) was incorporated. This was followed by FYM + Poultry manure (T_6), ***Sesbania rostrata*** + Poultry manure (T_3), Conv. Fmg (T_{15}) in Rabi '96. However, in Kharif '97, T_5 followed by T_{15} and T_{13}. Lowest ANR was registered by control (T_{14}).

4.1.8. Soil available N after Rabi 1996 and Kharif 1996 rice
Table (23 and 24) Fig.7.

Soil available N was estimated at AT, PI, flowering and harvesting stages in both the seasons. Organic manures and fertilizer N altered the soil available N to greater extent during Rabi, 1996. Organic manuring left higher soil available N when compared to non organic manure. Among the organics FYM + Neem cake (T_5) left higher soil available N. At AT stage, T_5 followed by T_6, T_9 and T_3. In PI stage T_5 followed by T_6, T_8. At flowering stage T_5 followed by T_6, T_9 and T_4 and T_6, T_9 and T_7 at harvest stage. Soil available N drastically reduced in no NPK (T_{14}) plot.

During Kharif '97, FYM + Neem cake (T_5) application influenced available soil N at AT, PI flowering and Harvest stage. At AT, T_5 was comparable with T_6 and followed by T_9, T_1. T_5 was comparable with T_6

FIG.7. POST HARVEST AVAILABLE NUTRIENT AFTER RABI '96 AND KHARIF '97 - CUMULATIVE EFFECT

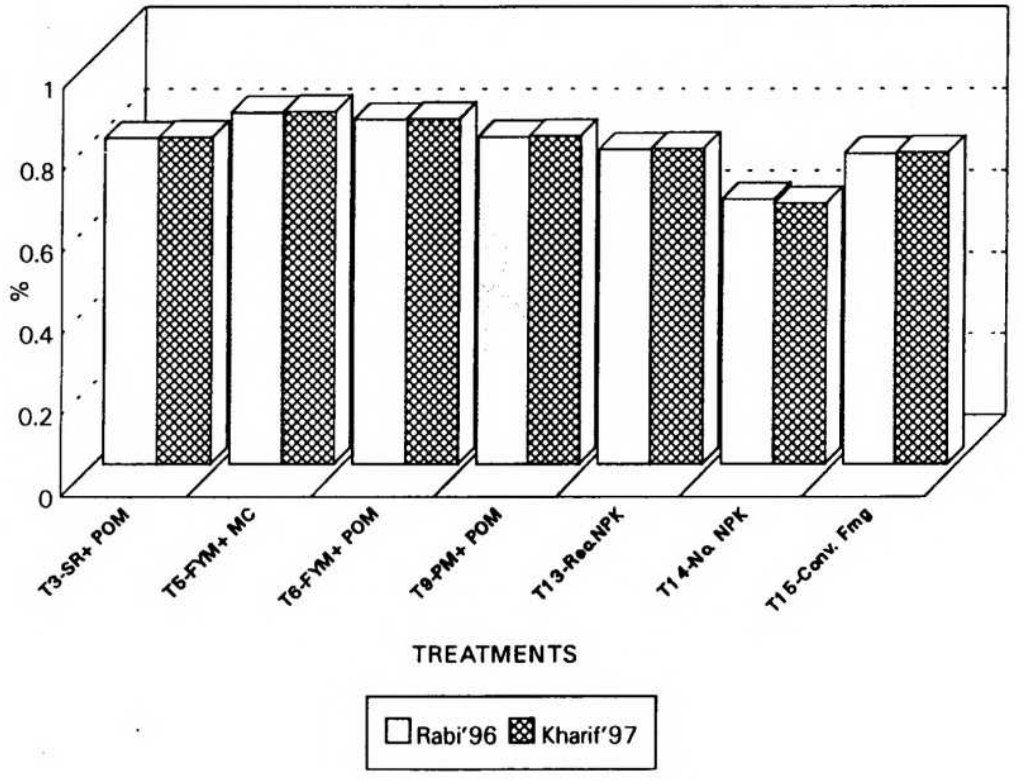


Table 23. Soil available Nitrogen (Kg ha^{-1}). Rabi, 1996.

Treatment	Rabi, 1996			
	Active tillering	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	398.6	386.4	369.4	387.3
T_2 SR+NC	396.8	386.2	379.9	378.3
T_3 SR+POM	404.9	396.6	394.5	380.2
T_4 FYM+Az+As	381.8	373.4	367.1	365.3
T_5 FYM+NC	451.1	444.8	419.4	422.7
T_6 FYM+POM	438.7	426.2	407.4	406.6
T_7 PM+AZ+AS	383.9	381.8	401.2	381.3
T_8 PM+NC	409.1	415.4	402.3	380.3
T_9 PM+POM	412.8	406.5	405.2	404.1
T_{10} BS+AZ+AS	379.8	399.9	381.2	365.3
T_{11} BS+NC	384.1	388.2	381.2	370.1
T_{12} BS+POM	375.4	371.2	362.5	349.3
T_{13} RecNPK	354.8	350.6	361.2	336.2
T_{14} NoNPK	92.7	88.5	76.2	35.5
T_{15} Conv.FMG	358.8	360.8	351.2	312.3
SEd	7.5	6.6	6.2	5.9
CD (P=0.05)	14.8	13.6	12.7	12.1

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 24. Soil available Nitrogen (Kg ha^{-1}). Kharif, 1997.

Treatment	Kharif, 1996			
	Active tillering	Panicle Initiation	Flowering	Harvesting
T_1 SR+Az+As	429.2	425.1	421.2	419.4
T_2 SR+NC	428.9	423.1	413.2	411.7
T_3 SR+POM	410.8	402.3	401.2	398.6
T_4 FYM+Az+As	396.8	394.3	392.3	394.3
T_5 FYM+NC	454.2	452.5	451.2	453.9
T_6 FYM+POM	449.4	449.5	448.1	448.3
T_7 PM+AZ+AS	400.1	402.1	401.3	405.1
T_8 PM+NC	426.2	422.2	421.2	419.6
T_9 PM+POM	431.5	430.2	428.7	427.8
T_{10} BS+AZ+AS	375.7	372.7	373.8	396.4
T_{11} BS+NC	409.9	407.2	400.2	401.6
T_{12} BS+POM	376.4	362.1	360.3	359.9
T_{13} RecNPK	411.3	402.3	360.7	358.6
T_{14} NoNPK	25.2	22.3	18.5	14.5
T_{15} Conv.FMG	388.3	381.2	361.2	360.5
SEd	12.3	6.4	8.4	9.2
CD (P=0.05)	24.69	12.44	16.79	18.62

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake, POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

and followed by T_9, T_1, T_2 at flowering stage. At harvest stage T_5 comparable with T_6 and followed by T_9. Low available N was registered by no NPK (T_{14}) treatment.

Residual crop

This experiment was conducted during the same year of main crop Rabi, 1996 and Kharif, 1997. Here during Rabi 1996 to reveals the residual effect of Kharif '96 crop each plot divided into two parts, first one to study the direct effect and another to study residual effect. In Kharif, 1997 two residual crops are grown (S_1 & S_2) along the main crop. S_1 is the residual effect Rabi '96 (main crop), and S_2 is the residual effect Rabi '96 (Residual crop).

4.2. Residual effect of organic manures and fertilizer on Rabi '96 and Kharif '97 rice

4.2.1. Growth attributes of rice at flowering

4.2.1.1. Plant height (Table 25)

The carry over effect of organic manures applied during Kharif '96 was seen on the plant height of rice, sown during the seasons Rabi '96 and Kharif '97. In that Residual effect of plant was higher in plots applied with FYM + Neem cake (T_5) which was comparable with FYM + Poultry manure (T_6). This was followed by ***Sesbanica rostrata*** + Poultry manure (T_3) and Pressmud + Poultry manure (T_9).

Recommended level of N applied (T_{13} and T_{15}) to Kharif '96 crop had not influenced the plant height during Rabi, 1996 and during Kharif 1997. Residual effect of Rabi '96 rice T_9 was at par with T_3 and T_5 and in

Table 25. Growth attributes of rice at flowering

Treatments	Rabi 1996		Kharif 1997			
			S_1		S_2	
	Plant height (cm)	LAI	Plant height (cm)	LAI	Plant height (cm)	LAI
T_1 SR+Az+As	40.31	3.01	51.01	3.04	31.75	2.59
T_2 SR+NC	43.02	3.03	51.02	3.05	31.72	2.58
T_3 SR+POM	43.21	3.10	55.99	4.12	34.21	2.64
T_4 FYM+Az+As	42.71	3.05	50.65	3.61	31.64	2.56
T_5 FYM+NC	50.32	3.75	54.91	5.04	36.42	2.81
T_6 FYM+POM	45.51	3.16	51.01	4.14	34.51	2.66
T_7 PM+AZ+AS	42.61	2.95	50.81	3.32	31.25	2.54
T_8 PM+NC	42.72	3.07	52.07	3.07	32.01	2.62
T_9 PM+POM	43.19	3.12	55.52	4.10	34.04	2.63
T_{10} BS+AZ+AS	41.32	3.01	50.72	3.02	31.92	2.52
T_{11} BS+NC	40.21	3.08	50.91	3.12	30.42	2.51
T_{12} BS+POM	41.51	2.62	52.10	3.181	32.24	2.61
T_{13} RecNPK	40.01	2.91	50.13	3.00	30.24	2.37
T_{14} NoNPK	35.21	2.03	49.23	0.01	28.20	2.22
T_{15} Conv.FMG	40.02	2.63	50.12	2.91	30.12	2.36
SEd	2.41	0.29	1.42	0.18	0.91	0.07
CD (P=0.05)	4.82	NS	2.82	NS	1.82	NS

(S_2) T_5 registered higher plant height followed by T_6, T_9 and T_3 control (T_{14}) recorded lowest plant height.

4.2.1.2. Leaf area Index

Leaf area Index at flowering was not influenced significantly by all the organic manures applied during Kharif '96 season. Recommend levels of fertilizer N applied to Kharif 1996 crop did not influence the LAI of Rabi 1996 rice crop.

Similar results were observed in Kharif 1997 residual crops also.

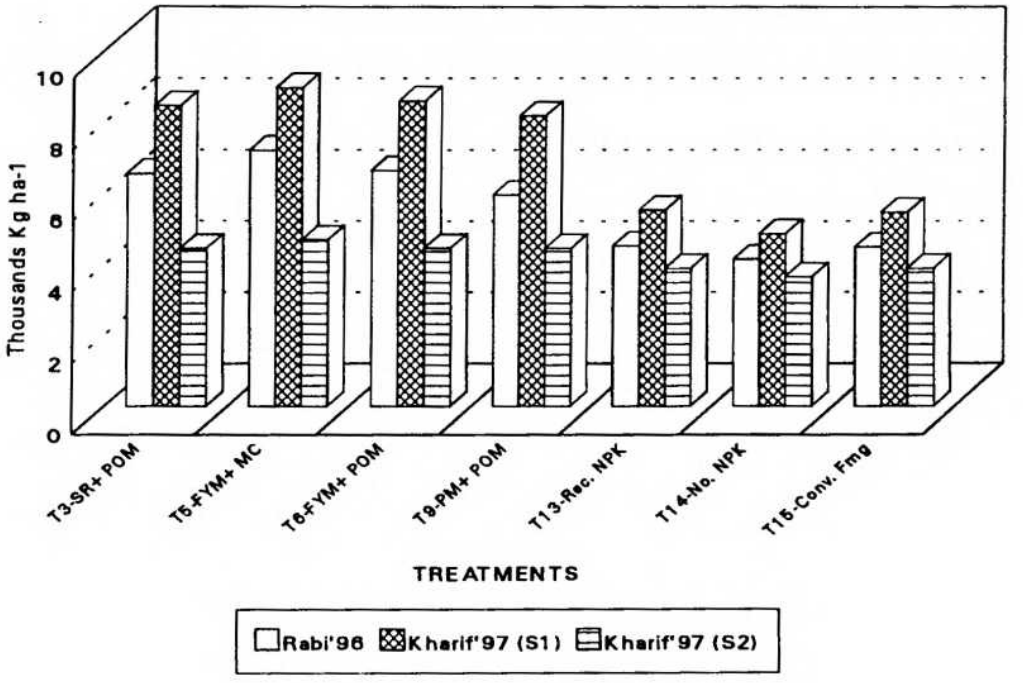
4.2.1.3. Dry matter production (Fig. 8)

Organic manuring applied to Kharif, 1996 rice crop had excerted a significant influence on DMP at the harvest stages of Rabi, 1996 rice. Residual effect of FYM + Neem cake (T_5), FYM + Poultry manure (T_6), ***Sesbania rostrata*** + Poultry manure (T_3) and the effect of these organic manures on DMP was comparable. Even though Biogas slurry + Azolla + Azospirillum (T_{10}) produced significantly higher DMP than control, its effect was significantly lower than other organic manures studied.

Recommended fertilizer from T_{13} and T_{15} applied to Kharif, 1996 crop did not influence the DMP of Rabi, 1996 rice crop. In Kharif '97 also T_5 registered highest DMP followed by T_6 and T_9. T_{13} and T_{15} registered lower DMP.

Control (T_{14}) recorded lowest DMP in both the seasons of studies.

FIG.8. EFFECT OF OMs AND FERTILIZERS ON DMP OF RESIDUAL RABI '96 AND KHARIF '97 RICE CROP (kg ha^{-1})



4.2.2. Yield attributes (Table 26, 27, 28)

4.2.2.1. Productive tillers

In Rabi '96 crop application of FYM + Neem cake (T_5) to Kharif '96 rice produced maximum number of tillers per m^2 followed by FYM + Poultry manure (T_6) which was at par with Press mud + Poultry manure (T_9). During Kharif, 1997 (T_5) produced maximum number of productive tillers. This was followed by T_3, T_6, T_9 and control (T_{14}). Produced lower productive tillers in both the seasons.

4.2.2.2. Panicle length

Panicle length was highly influenced by the organic manures. Application of FYM + Poultry manure (T_6) registered highest panicle length followed by FYM + Neem cake (T_5) and ***Sesbania rostrata*** + Poultry manure (T_3) during Rabi '96 rice. In Kharif '97 T_5 followed by T_9 and T_6. In both the seasons, control plot (T_{14}) recorded the shorter panicles.

Application of recommended level of N (T_{13} and T_{15}) to Kharif '96 crop had not influenced much to panicle length when compared to organic N in both the seasons of Rabi '96 and Kharif '97.

4.2.2.3. Filled grain percentage

Maximum filled grain percentage was recorded in FYM + Neem cake (T_5) applied plot and was followed by FYM + Poultry manure (T_6) and Pressmud + Poultry manure (T_9) in Rabi '96. During Kharif '97, T_5 followed by T_9 and T_6.

Table 26. Yield attributes of rice. Rabi, 1996.

Treatment	Rabi, 1996			
	Productive tillers (m^{-2})	Panicle length (cm)	Filled grain (%)	1000 grains weight (g)
T_1 SR+Az+As	416	10.52	61.84	18.03
T_2 SR+NC	410	10.43	61.92	18.95
T_3 SR+POM	452	12.00	53.76	18.25
T_4 FYM+Az+As	432	10.23	63.28	18.03
T_5 FYM+NC	512	12.14	72.11	17.71
T_6 FYM+POM	490	11.50	65.28	17.30
T_7 PM+AZ+AS	390	10.38	47.91	17.02
T_8 PM+NC	448	10.68	65.01	18.00
T_9 PM+POM	464	10.93	69.85	18.23
T_{10} BS+AZ+AS	380	10.12	48.07	17.85
T_{11} BS+NC	376	10.01	61.88	17.00
T_{12} BS+POM	448	10.82	54.98	17.12
T_{13} RecNPK	352	9.45	63.09	16.55
T_{14} NoNPK	323	8.29	43.11	16.21
T_{15} Conv.FMG	350	9.43	66.21	16.54
SEd	4.54	0.45	0.89	0.24
CD (P=0.05)	10.12	1.01	1.65	NS

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 27. Yield attributes of rice. Kharif, 1997 (S_1).

Treatment	Kharif, 1997			
	Productive tillers (m^{-2})	Panicle length (cm)	Filled grain (%)	1000 grains weight (g)
T_1 SR+Az+As	421	11.07	63.94	18.23
T_2 SR+NC	412	11.01	63.99	18.97
T_3 SR+POM	485	12.05	55.76	18.45
T_4 FYM+Az+As	430	11.12	65.29	18.23
T_5 FYM+NC	509	13.75	74.12	17.81
T_6 FYM+POM	507	13.74	66.29	17.42
T_7 PM+AZ+AS	452	10.95	49.91	17.12
T_8 PM+NC	451	11.23	67.01	18.03
T_9 PM+POM	482	12.14	69.85	18.42
T_{10} BS+AZ+AS	479	11.54	49.07	17.86
T_{11} BS+NC	412	10.83	62.88	17.01
T_{12} BS+POM	461	12.01	55.99	17.13
T_{13} RecNPK	410	10.21	62.09	16.21
T_{14} NoNPK	387	9.07	44.11	16.04
T_{15} Conv.FMG	409	10.23	62.21	16.53
SEd	10.2	0.45	0.74	0.49
CD (P=0.05)	20.4	10.12	1.56	0.97

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 28. Yield attributes of rice. Kharif, 1997 (S_2)

Treatment	Kharif, 1997			
	Productive tillers (m^{-2})	Panicle length (cm)	Filled grain (%)	1000 grains weight (g)
T_1 SR+Az+As	308	7.45	47.07	16.40
T_2 SR+NC	306	7.46	46.02	16.27
T_3 SR+POM	313	7.81	47.24	16.61
T_4 FYM+Az+As	304	7.51	47.06	16.07
T_5 FYM+NC	332	8.24	45.75	17.29
T_6 FYM+POM	315	7.82	48.69	16.67
T_7 PM+AZ+AS	310	7.43	47.25	16.01
T_8 PM+NC	303	7.76	46.04	16.20
T_9 PM+POM	312	7.78	47.20	16.72
T_{10} BS+AZ+AS	302	7.53	45.62	16.29
T_{11} BS+NC	300	7.41	45.53	15.49
T_{12} BS+POM	309	7.73	47.14	16.50
T_{13} RecNPK	283	7.00	44.01	15.19
T_{14} NoNPK	267	6.52	42.40	13.74
T_{15} Conv.FMG	282	6.97	43.94	14.20
SEd	8.2	0.21	0.71	0.15
CD (P=0.05)	16.3	0.42	NS	NS

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

T_{13} and T_{15} which produced the lower filled grain per cent and Control (T_{14}) had lowest filled grain percentage in both the seasons of study.

4.2.2.4. Thousand grain weight

Thousand grain weight was unaltered due to organic manures as well as by fertilizer supplied to Kharif rice. However T_5 produced maximum weightage than other treatments. Inorganics fertilizer treatment of T_{13} and T_{15} produced lowest grains weight comparable with the control in both the seasons of studies.

4.2.3. Nutrient uptake of residual crop at harvest (Table 29)

The carry over effect of different organic manures and fertilizer applied to the previous rice crop altered the uptakes of N, P and K of Rabi, 1996 and Kharif, 1997 rice crop. The variation due to the residual effect were large enough to measure statistically.

4.2.3.1. Nitrogen uptake

Application of organic manures to Kharif 1996 and Rabi 1996 crop significantly increased the N uptake to succeeding crop. The highest uptake of N was recorded in FYM + Neem cake (T_5) followed by FYM + Poultry manure (T_6) applied plot and this was comparable with ***Sesbania rostrata*** + Poultry manure (T_3) and Pressmud + Poultry manure (T_9) during Rabi '96. In Kharif '97 T_5 followed by T_6, T_3, T_9 and T_8 control recorded the lowest uptake.

In both the seasons, application of recommended level of N through fertilizer T_{13} and T_{15} to Kharif 1996 crop had not significantly influenced higher N uptake when compared to organic manures.

4.2.3.2. Phosphorus uptake

Different organic manures and fertilizer applied to Kharif 1996 rice crop significantly influenced the P uptake in both the seasons. The highest P uptake was observed in FYM + Neem cake (T_5) applied plot which was at par with FYM + Poultry manure (T_6) and ***Sesbania rostrata*** + Poultry manure (T_3) applied plots in Rabi, 1996. During Kharif 1997 T_5 followed by T_6, T_9 and T_3.

Application of Recommened N (T_{13} & T_{15}) by fertilizers recorded lower P uptake in both the seasons of study. Control (T_{14}) exhibit lowest P uptake.

4.2.3.3. Potassium uptake

Among the organic manures FYM + Neem cake (T_5), FYM + Poultry manure (T_6), ***Sesbania rostrata*** + Poultry manure (T_3) and Pressmud + Poultry manure (T_4) applied plots recorded significant higher K uptake values. This was followed by Rec. NPK (T_{13}) and Conv. Fmg (T_{15}). Control T_{14} registered lower P uptake.

Table 29. Nutrient uptake of rice at harvest (kg ha^{-1}) Rabi, 1996 and Kharif, 1997 Crop.

Treatments	Nitrogen			Phosphorus			Potassium		
	Rabi'96	Kharif'97 (S_1)	Kharif'97 (S_2)	Rabi'96	Kharif'97 (S_1)	Kharif'97 (S_2)	Rabi'96	Kharif'97 (S_1)	Kharif'97 (S_2)
T_1 SR+Az+As	47.3	59.73	27.21	13.12	20.42	9.43	15.14	35.14	12.12
T_2 SR+NC	47.5	63.72	28.38	13.24	20.43	9.41	20.27	30.27	16.24
T_3 SR+POM	51.2	65.23	29.43	15.20	22.72	9.53	22.40	32.40	16.24
T_4 FYM+Az+As	46.2	64.03	25.31	13.00	21.03	9.37	19.31	49.31	16.12
T_5 FYM+NC	58.6	69.60	31.42	15.61	24.39	10.14	39.05	69.05	30.05
T_6 FYM+POM	52.4	66.73	28.43	15.42	23.84	9.63	36.25	66.25	22.62
T_7 PM+AZ+AS	47.1	61.23	26.43	13.04	21.24	9.34	19.97	39.97	17.72
T_8 PM+NC	49.1	64.21	26.42	14.90	22.4	9.27	26.94	36.94	20.62
T_9 PM+POM	50.4	67.00	25.14	15.15	23.12	9.47	26.94	66.94	20.63
T_{10} BS+AZ+AS	48.1	59.63	27.13	14.12	20.94	9.17	37.94	30.94	20.94
T_{11} BS+NC	48.3	60.13	27.32	14.50	21.03	9.08	10.96	30.96	9.62
T_{12} BS+POM	48.7	60.23	21.42	14.81	19.45	9.45	10.42	50.42	9.42
T_{13} RecNPK	46.2	56.90	22.41	12.52	18.90	8.58	21.69	42.31	14.23
T_{14} NoNPK	21.2	42.75	19.31	8.01	10.30	6.07	9.92	10.62	6.72
T_{15} Conv.FMG	46.1	56.73	18.41	12.42	18.86	8.57	21.69	41.24	13.23
SEd	0.87	1.60	0.87	0.21	0.27	0.23	1.07	1.32	1.21
CD (P=0.05)	1.72	3.21	1.74	0.42	0.54	0.42	2.14	2.75	2.52

4.2.4. Yield of rice (Table 30) Fig.9.

4.2.4.1. Grain yield

The effect of different organic manures and fertilizer applied to the Kharif, 1996 crop had significant influence on the grain yield of Rabi 1996 and Kharif 1997 rice. Application of organic to Kharif 1996 rice had increased the Rabi '96 rice grain yield. Among the organic manures, FYM + Neem cake (T_5) applied plot recorded maximum grain yield. However, it was followed by the yield obtained under FYM + Poultry manure (T_6), ***Sesbania rostrata*** + Poultry manure (T_3) applied plot. T_{13} and T_{15} registered comparatively lower grain yield than the organics.

Similar results was recorded for the residual crop Kharif 1997. Absolute control (T_{14}), produced the lowest grain yield. During Kharif, 1997 the grain yield was very low in fertilizer Rec. NPK (T_{13}) & T_{15} Conv. Fmg applied plots.

4.2.4.2. Straw yield

Straw yield of Rabi, 1996 was influenced by the organic as well as by the fertilizer applied to Kharif, 1996 crop. In Rabi, 1996 FYM + Neem cake (T_5) registered higher straw yield followed by Press mud + Neem cake (T_8), Press mud + Poultry manure (T_{10}) and FYM + Poultry manure applied treatment.

T_{13} and T_{15} applied to Kharif, 1996 and did not show any effect on succeeding Rabi, 1996 crop on straw yield, control (T_{14}) exhibit lowest yield. In Kharif '97 T_5 followed by T_6, T_3 and T_9 in both the residual crops.

FIG.9. GRAIN YIELD OF RABI '96 AND KHARIF '97 RESIDUAL RICE CROP

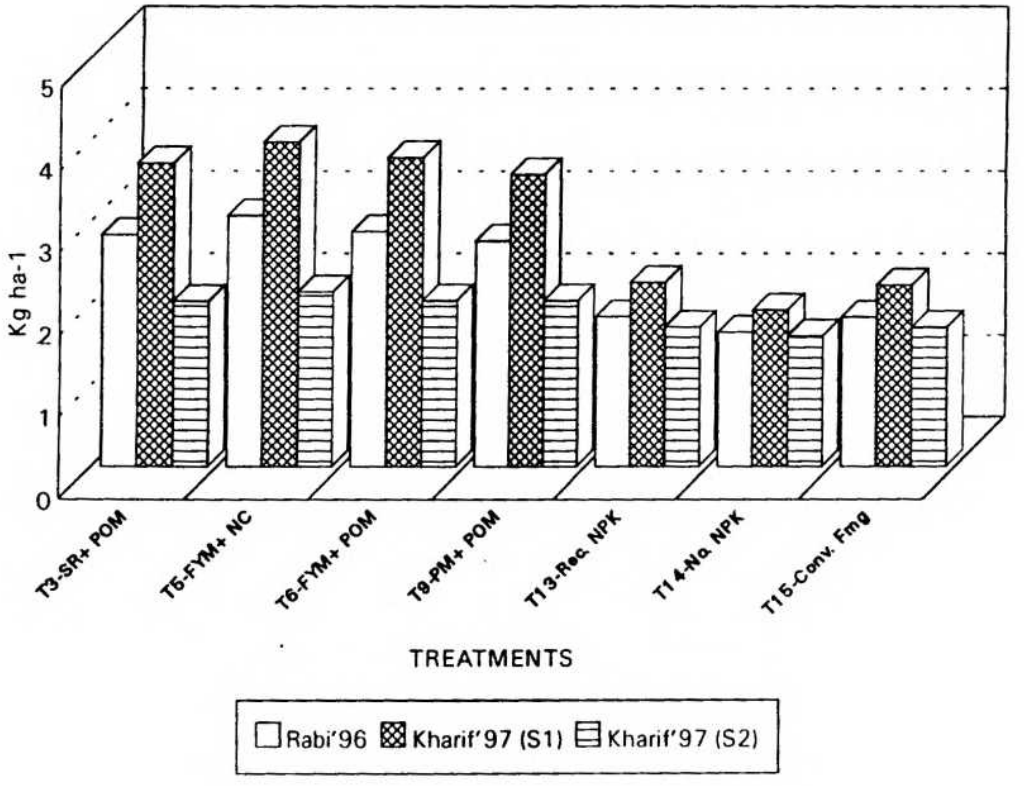


Table 30. Grain and Straw yield of Rabi, 1996 and Kharif, 1997 Season (kg ha^{-1})

	Grain Yield			Straw Yield		
	Rabi '96	Kharif '97 (S_1)	Kharif '97 (S_2)	Rabi '96	Kharif '97 (S_1)	Kharif '97 (S_2)
T_1 SR+Az+As	2532	2950	1970	2688	3952	2724
T_2 SR+NC	2220	3150	1812	3080	4152	2720
T_3 SR+POM	2815	3695	2009	3270	4697	2764
T_4 FYM+Az+As	2414	3305	2001	3146	4307	2642
T_5 FYM+NC	3053	3950	2125	3687	4952	2921
T_6 FYM+POM	2863	3765	2019	3312	4767	2775
T_7 PM+AZ+AS	2524	3360	1825	3136	4366	2735
T_8 PM+NC	1950	3365	1997	3580	4367	2603
T_9 PM+POM	2750	3557	2017	3190	4559	2741
T_{10} BS+AZ+AS	2015	2775	1990	3385	3777	2575
T_{11} BS+NC	2315	2820	1802	2745	3822	2562
T_{12} BS+POM	2698	2420	2004	2812	3428	2752
T_{13} RecNPK	1825	2241	1698	2625	3243	2416
T_{14} NoNPK	1638	1907	1590	2462	2909	2251
T_{15} Conv.FMG	1820	2210	1696	2620	3212	2407
SEd	112.39	91.5	53.2	115.2	102.4	73.7
CD (P=0.05)	250.40	185.6	106.0	238.2	207.6	146.1

Similar result followed in Residual Kharif 1997.

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

4.2.6.1. Soil available N (Table 31) Fig.10.

Soil available N status was significantly influenced by the different organic manures and fertilizer N application done to Kharif, 1996 rice. Among the different organic manures, application of FYM + Poultry manure (T_6) and FYM + Neem cake (T_5) significantly showed higher level of post harvest soil available N. This was followed by Press mud + Poultry manure (T_9) and ***Sesbania rostrata*** + Poultry manure (T_3). Control (T_{14}) registered the lowest soil available.

Recommend NPK through fertilizer (T_{13}) and Conv. Fmg (T_{15}) had not influenced the soil available N, in Rabi '96 and Kharif '97. In Kharif '97 T_5 was followed by T_6, T_9, T_3 for both the residual crops. T_{13} and T_{15} registered comparatively lower soil available N compared to the other organic treatments.

4.2.6.2. Organic carbon

Tabulation of organic carbon is given for both cumulative and residual crop for both the season in Table 31.

Organic carbon content in the soil was significantly influenced by the application of organic manures in both the years. With regard to the cumulative effect, OC build up was noticed, which was more in T_5 and was

FIG.10. POST HARVEST AVAILABLE NUTRIENT AFTER RABI 96 AND KHARIF 97 RESIDUAL CROP

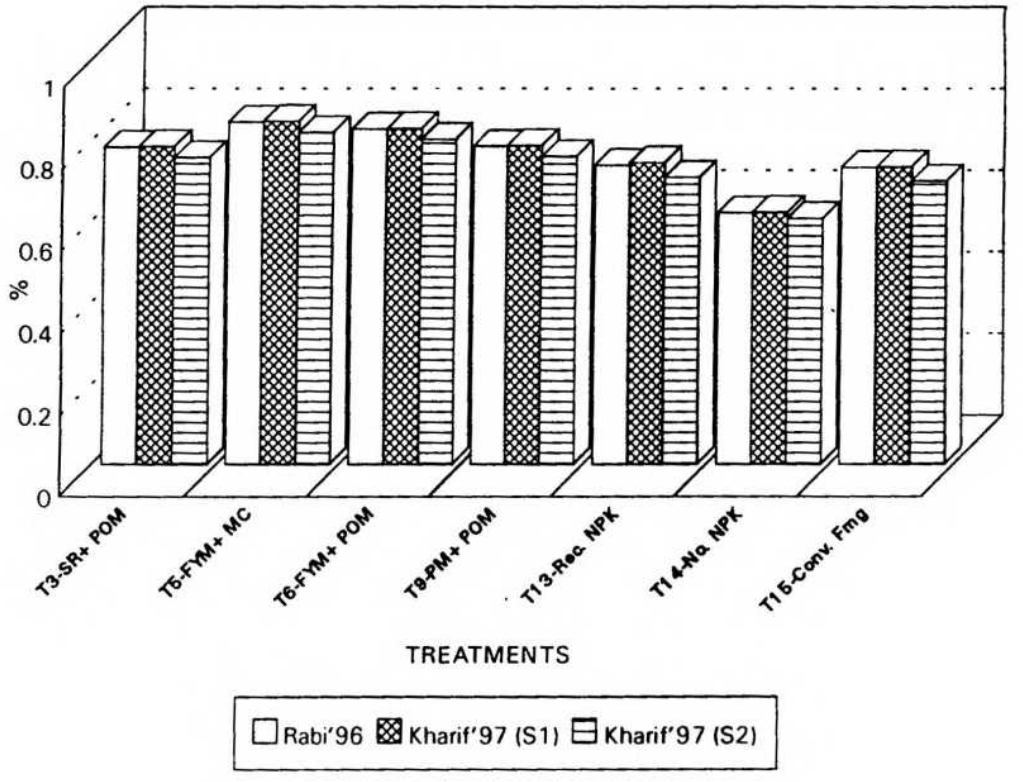


Table 31. Post harvest available nutrient after Rabi, 1996 and Kharif, 1997 Cumulative and Residual Crop.

Treatment	Nitrogen			Organic Carbon				
				Cumulative Effect		Residual Effect		
	Rabi'96	Kharif'97 (S_1)	Kharif'97 (S_2)	Rabi '96	Kharif'97	Rabi'96	Kharif'97 (S_1)	Kharif'97 (S_2)
T_1 SR+Az+As	270.2	247.9	224.1	0.790	0.792	0.765	0.767	0.740
T_2 SR+NC	266.1	243.8	220.6	0.794	0.796	0.769	0.771	0.744
T_3 SR+POM	291.3	269.1	245.8	0.800	0.802	0.775	0.777	0.750
T_4 FYM+Az+As	271.8	249.5	226.3	0.798	0.800	0.773	0.775	0.748
T_5 FYM+NC	319.8	297.6	274.4	0.862	0.864	0.837	0.839	0.812
T_6 FYM+POM	308.6	286.3	263.1	0.845	0.847	0.820	0.821	0.795
T_7 PM+AZ+AS	276.1	253.7	230.5	0.796	0.798	0.771	0.773	0.746
T_8 PM+NC	267.4	244.8	221.4	0.797	0.801	0.774	0.776	0.749
T_9 PM+POM	294.2	271.7	248.5	0.803	0.805	0.778	0.780	0.753
T_{10} BS+AZ+AS	268.8	246.5	223.4	0.792	0.794	0.767	0.769	0.742
T_{11} BS+NC	266.2	243.9	220.7	0.794	0.796	0.769	0.771	0.744
T_{12} BS+POM	244.7	222.4	199.2	0.793	0.795	0.737	0.770	0.743
T_{13} RecNPK	210.	188.3	165.9	0.772	0.774	0.732	0.738	0.702
T_{14} NoNPK	19.4	10.5	12.4	0.650	0.640	0.615	0.616	0.601
T_{15} Conv.FMG	207.5	185.6	138.8	0.762	0.764	0.727	0.728	0.693
SEd	4.25	8.91	5.61	0.0051	0.0081	0.0091	0.007	0.009
CD (P=0.05)	8.59	17.82	11.5	0.0100	0.0162	0.019	0.014	0.020

comparable to T_6, T_8, T_9 followed by others. In both the seasons of studies.

In residual crops, the OC reduced mildly due to non application of organic manures. However, T_5 registered highest OC than any other treatments in both seasons.

Control (T_{14}) recorded lowest OC. Recommended N by fertilizer (T_{13} and T_{15}) had not influenced the O.C content in residual crop when compared to other organic manure treatments.

4.2.7. Available N balance after rice-rice cropping system tables (Table 32a & 32b)

Datas in the table gives the details about soil N balance for previous 4 years (Kharif 95, Rabi 95, Kharif 96, Rabi 96 and Kharif 97). In order to study the soil N balance the present soil N level was compared to the previous soil N level.

During Rabi, 1996 and Kharif, 1997 N applied @ 150 kg ha^{-1} both by means of organic manures and by fertilizer sources. Total N uptake for Rabi '96 ranged from 42.04 (absolute control) to 161.54 kg ha^{-1} FYM + Neem cake (T_5). In Kharif '97, it was 44.38 and 163.85 kg ha^{-1}.

The actual N balanced showed on increase trend of soil available N with OMs and fertilizer addition to the rice. T_5 registered highest N accumulation in both the season.

Table 32a. Available Soil N balance after rice - rice cropping system 1995-97

Treatments	Initial Soil N status Kharif'95 Kg ha^{-1}	N applied to Kharif'95 Crop Kg ha^{-1}	N applied to Rabi'95 crop Kg ha^{-1}	N applied to Kharif'96 crop Kg ha^{-1}	N applied to Rabi'96 crop Kg ha^{-1}	N applied to Kharif'97 crop Kg ha^{-1}	Total int of N applied	N uptake by Kharif'95	N uptake by Rabi'95	N uptake by Kharif'96	N uptake by Rabi'96
T_1 SR+Az+As	285	150	150	150	150	150	750	53.97	68.85	71.38	69.58
T_2 SR+NC	285	150	150	150	150	150	750	73.75	80.44	82.97	84.70
T_3 SR+POM	285	150	150	150	150	150	750	103.94	85.53	88.06	126.03
T_4 FYM+Az+As	285	150	150	150	150	150	750	84.13	64.09	66.62	92.71
T_5 FYM+NC	285	150	150	150	150	150	750	137.37	105.53	108.06	161.54
T_6 FYM+POM	285	150	150	150	150	150	750	121.82	91.08	93.61	139.37
T- PM+AZ+AS	285	150	150	150	150	150	750	69.83	72.86	75.09	88.61
T_8 PM+NC	285	150	150	150	150	150	750	101.02	85.43	87.96	107.61
T_9 PM+POM	285	150	150	150	150	150	750	127.46	84.51	87.04	132.59
T_{10} BS+AZ+AS	285	150	150	150	150	150	750	49.53	81.71	84.21	60.07
T_{11} BS+NC	285	150	150	150	150	150	750	60.45	82.92	85.45	76.59
T_{12} BS+POM	285	150	150	150	150	150	750	61.20	84.46	87.47	72.40
T_{13} RecNPK	285	150	150	150	150	150	750	108.30	92.62	95.88	135.17
T_{14} NoNPK	285	150	150	150	150	150	750	30.46	41.41	38.88	42.04
T_{15} Conv.FMG	285	150	150	150	150	150	750	108.77	96.20	98.73	138.14

Table 32b. Available Soil N balance after rice - rice cropping system 1995-97

Treatments	N uptake by Kharif 1997	Total N uptake	Actual balance Rabi'96 (direct effect)	Net gainer loss after Rabi'96	Actual Balance Kharif'97 (direct effect)	Net gainor loss	Actual balance after residual Rabi'96	Net gain or loss	Actual balance after Kharif'97 (residual) (S_1)	Net gain or loss	Actual balance Kharif'97 residual) (S_2)	Net gain or loss
T_1	71.89	335.27	387.3	102.8	419.4	134.4	270.2	-14.8	247.9	-37.1	224.1	-60.9
T_2	87.01	408.88	378.3	93.8	411.7	126.7	266.1	-18.9	243.8	-41.2	220.6	-64.4
T_3	128.34	535.07	380.2	95.6	398.6	113.6	291.3	+6.3	269.1	-15.9	245.8	-39.2
T_4	95.02	401.64	365.3	80.4	394.3	109.3	271.3	-13.7	249.5	-35.5	226.3	-58.7
T_5	163.85	676.35	422.7	137.6	448.3	163.3	319.8	+34.8	297.6	+12.5	274.4	-10.6
T_6	141.68	587.56	406.6	121.9	453.9	168.9	308.6	+23.6	286.3	+1.3	263.1	-21.9
T_7	90.92	397.01	381.3	96.1	405.1	120.1	276.1	-8.9	253.7	-31.3	230.5	-54.5
T_8	109.92	491.94	380.3	95.7	419.6	134.6	267.4	-17.6	244.8	-40.2	221.4	-63.6
T_9	134.91	566.51	404.1	119.2	427.8	142.8	294.2	9.2	271.7	-13.3	248.5	-36.5
T_{10}	62.10	337.62	365.3	80.1	396.4	111.4	268.8	-16.2	246.5	-38.5	223.4	-61.6
T_{11}	78.90	384.31	370.1	85.0	401.6	116.6	266.2	-18.8	243.9	-41.1	220.7	-64.3
T_{12}	74.71	380.24	349.3	64.4	359.9	74.9	244.7	-40.3	222.4	-62.6	199.2	-85.8
T_{13}	137.48	569.42	336.2	51.1	358.6	73.6	210.6	-74.4	188.3	-96.5	165.9	-119.1
T_{14}	44.38	188.29	35.5	-240.9	145	-270.5	19.4	-265.6	10.5	-274.5	12.4	-272.6
T_{15}	140.35	343.11	312.3	27.8	360.5	75.5	207.5	-77.5	185.6	-99.4	138.8	-146.2

With regarding to its residual effect, the actual balance showed a depletion of soil available N due to non application of OMs and fertilizer to the rice, especially depletion was more in fertilizer plots T_{13} and T_{15} than organic manure plots.

After examining the N balance at both the years, it was observed that FYM + Neem cake (T_5) application improved the soil available N status. No application of OMs and fertilizer to Rabi '96 and Kharif '97 rice resulted in a sharp decrease.

4.3. Quality : Quality characteristics were analysed for Rabi '96 (COHR-1)

4.3.1. Chemical composition of rice

4.3.1.1. Moisture content (Table 33)

During the Rabi '96 both the organics and inorganics application had no significant influence on moisture content.

4.3.1.2. Protein content

Significant influence on protein content was observed due to the addition of organic manures, but not in inorganic.

Application of FYM + Neem cake (T_5) recorded highest protein content which was comparable with FYM + Poultry manure (T_6) and Pressmud + Poultry manure (T_9). Lesser protein content was recorded with control (T_{14}).

4.3.1.3. Fat content

During Rabi, 1996 fat content significantly increased due to the application of different organic manures.

Application of ***Sesbania rostrata*** + Poultry manure (T_3) registered highest fat content which was comparable with all other treatment. Lowest value recorded in (T_{14}) control.

4.3.1.4. Fibre content

Significant response for fibre content has observed to the application of FYM + Poultry manure (T_6) which was comparable with Pressmud + Poultry manure (T_9) and FYM + Neem cake (T_5). Application of Biogas slurry + Poultry manure (T_{12}) had produced significantly lower fibre content during the period of experiment.

4.3.1.5. Carbohydrate content

Even though organic manure application was significantly influenced the carbohydrate content. The control (T_{14}), had registered higher carbohydrate content that other treatments. Lower carbohydrate content observed under T_5 and T_6.

4.3.1.6. Amylase content

Use of different organic manures and biofertilizers significantly influenced the Amylase content. Addition of FYM + Neem cake (T_5) significantly enhanced the Amylase content and it was on par with ***Sesbania rostrata*** + Poultry manure (T_3), Pressmud + Poultry manure (T_9) and conv.

Table 33. Chemical Composition of rice (cv COHR-1) Rabi'96

Treatments	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Total ash (%)	Carbohydrate (%)	Amylase content (%)
T_1 SR+Az+As	12.01	7.18	0.53	0.19	0.738	79.66	23.05
T_2 SR+NC	12.04	7.15	0.52	0.213	0.702	79.60	22.95
T_3 SR+POM	12.01	7.37	0.53	0.195	0.775	79.56	24.68
T_4 FYM+Az+As	12.03	7.34	0.50	0.198	0.712	79.46	22.56
T_5 FYM+NC	12.03	7.18	0.53	0.218	0.888	78.56	24.69
T_6 FYM+POM	12.11	7.79	0.53	0.288	0.815	78.74	24.02
T_7 PM+AZ+AS	12.04	7.34	0.51	0.231	0.715	79.41	22.98
T_8 PM+NC	11.94	7.56	0.53	0.211	0.782	79.26	20.98
T_9 PM+POM	12.04	7.88	0.54	0.188	0.715	78.93	23.95
T_{10} BS+AZ+AS	12.01	7.10	0.52	0.198	0.645	79.77	22.95
T_{11} BS+NC	12.01	7.23	0.52	0.185	0.855	79.43	22.95
T_{12} BS+POM	12.03	7.35	0.53	0.161	0.765	79.42	22.95
T_{13} RecNPK	12.02	7.65	0.53	0.178	0.745	79.12	23.67
T_{14} NoNPK	11.99	6.65	0.50	0.208	0.652	80.21	22.91
T_{15} Conv.FMG	12.01	7.81	0.53	0.178	0.748	78.96	23.95
SEd	0.18	0.08	0.016	0.005	0.025	0.182	0.418
CD (P=0.05)	NS	0.16	0.03	0.054	0.053	0.364	0.82

farming (T_{15}). Addition of Pressmud + Neem cake (T_5) registered lower value which was on par with control (T_{14}) and Biogas slurry + Neem cake (T_{11}). T_5 registered highest value no comparable with T_{15}.

4.3.2. Cooking character of milled rice

4.3.2.1. Rice length (cm) (Table 34)

A significant influence on rice length was observed due to application of organics and inorganics.

Among the organic manures, FYM + Neem cake (T_5) produced significantly lengthier cooked rice of 8.90 mm and it was comparable with FYM + Poultry manure (T_6), which produced 8.72mm and conv. farming, produced 8.70mm.

4.3.2.2. Breadth (mm)

Application of FYM + Poultry manure (T_6) registered higher breadth which was comparable with FYM + Neem cake (T_5) and Pressmud + Poultry manure (T_9). Lesser Breadth value observed with T_8 and it was on par with control (T_{14}).

4.3.2.3. L/B ratio

L/B ratio was markedly influenced by FYM + Poultry manure (T_6) which was comparable with Pressmud + Poultry manure (T_9). Lower value recorded in ***Sesbania rostrata*** + Azolla + Azospirillum (T_1).

Table 34. Cooking characteristics of milled rise (COHR-1) Rabi, 96.

Treatment	Length (cm)	Breadth (cm)	L/B ratio
T_1 SR+Az+As	0.75	0.28	0.26
T_2 SR+NC	0.74	0.24	0.30
T_3 SR+POM	0.81	0.29	0.27
T_4 FYM+Az+As	0.71	0.24	0.29
T_5 FYM+NC	0.89	0.28	0.31
T_6 FYM+POM	0.89	0.30	0.29
T_7 PM+AZ+AS	0.76	0.27	0.28
T_8 PM+NC	0.78	0.23	0.33
T_9 PM+POM	0.82	0.23	0.35
T_{10} BS+AZ+AS	0.79	0.26	0.30
T_{11} BS+NC	0.76	0.26	0.29
T_{12} BS+POM	0.81	0.29	0.27
T_{13} RecNPK	0.79	0.27	0.29
T_{14} NoNPK	0.72	0.23	0.30
T_{15} Conv.FMG	0.86	0.27	0.31
SEd	0.015	0.008	0.008
CD (P=0.05)	0.04	0.02	0.02

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

4.3.3. Sensory Characteristics of cooked rice (Table 35)

4.3.3.1. Colour

Pressmud + Poultry manure (T_9) had influenced the colour of cooked rice and it was similar to FYM + Neem cake (T_5) and Biogas slurry + Azolla + Azospirillum (T_{10}) treatments. Pressmud + Azolla + Azospirillum (T_7) recorded lower mean score 5.2.

4.3.3.2. Texture

Pressmud + Poultry manure (T_9) has influenced the texture of cooked rice and it was followed by Biogas slurry + Neem cake (T_{11}) and FYM + Neem cake (T_5). The lowest mean score was noted for No NPK (T_{14}) treatment.

4.3.3.3. Taste

Pressmud + Poultry manure (T_9) has acceptable taste and it was followed by Biogas slurry + Neem cake (T_{11}). Both were superior when compared to other treatments. Lower mean score was recorded for T_{15}, T_{14}, T_{13}, T_{12}, T_4, T_2 and T_1 treatments.

4.3.3.4. Overall acceptability

Pressmud + Poultry manure (T_9) had higher mean score (7.2) than other treatments. It was followed by Biogas slurry + Neem cake (T_{11}) treatment (7.0). The lower score was noted for T_{14}, T_{12}, T_7, T_4, T_2 and T_1 treatment (5.1).

Table 35. Sensory characteristics of cooked rice

Treatment	Colour	Texture	Taste	Overall acceptability
T_1 SR+Az+As	7.1	5.2	5.2	5.2
T_2 SR+NC	7.1	5.3	5.3	5.2
T_3 SR+POM	7.1	5.4	5.2	5.3
T_4 FYM+Az+As	7.2	5.3	5.3	5.1
T_5 FYM+NC	7.4	5.5	5.5	5.3
T_6 FYM+POM	7.2	5.4	5.4	5.3
T_7 PM+AZ+AS	5.3	5.3	5.2	5.2
T_8 PM+NC	7.2	5.3	5.3	5.4
T_9 PM+POM	7.4	7.2	7.2	7.2
T_{10} BS+AZ+AS	7.4	5.3	5.4	5.2
T_{11} BS+NC	7.2	7.0	7.1	7.1
T_{12} BS+POM	7.2	5.2	5.2	5.2
T_{13} RecNPK	7.3	5.4	5.2	5.3
T_{14} NoNPK	7.2	5.3	5.2	5.2
T_{15} Conv.FMG	7.2	5.3	5.2	5.3

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

4.4. Stubble management in Rice (Table 36 and 37)

4.4.1. Addition of stubbles of rice and their added nutrients recycled after harvest

Significant influence on nutrient addition was observed due to the addition of organic manures.

In both the season of experiments the beneficial effect of organic manures towards nutrient addition was more pronounced. During Rabi '96 the crop applied with FYM + Neem cake (T_5) showed higher root stubbles (1248 kg ha^{-1}) which was comparable with FYM + Poultry manure (T_6) (1160 kg ha^{-1}). The control (T_{14}) registered significantly lowest root biomass. The added nutrients was to the tune of 12.30 kg N, 5.23 kg P, 6.54 kg K ha^{-1} for T_5 and which was comparable with T_6 (11.93 kg N, 5.07 kg P and 6.01 kg K ha^{-1}). In Conv. Fmg T_{15} (12.14 kg N, 5.14 kg P, 6.41 kg K) were added through stubbles. Lowest level of 6.24 kg N, 2.97 kg P, and 3.92 kg K ha^{-1} was registered for control (T_{14}).

During Kharif '97 FYM + Neem cake (T_5) added markedly higher (2358 kg ha^{-1}) rice stubbles and the computed nutrient level was 25.47 kg N, 11.53 kg P and 15.42 kg K ha^{-1}. Lowest root stubbles of 7.53 kg N, 1.25 kg P and 2.45 kg K ha^{-1}.

4.5. Rice Pests (Table 38 and 39)

The observation recorded on 30, 45, 75 DAT in Rabi '96 for leaf folder and stem borer damage.

Table 36. Addition of Nutrient through stubbles Rabi, 1996 (kg ha^{-1})

Treatments	Weight of Stubble	NPK added		
		N	P	K
T_1 SR+Az+As	972	7.03	3.29	4.51
T_2 SR+NC	1018	8.23	4.52	4.24
T_3 SR+POM	956	11.52	4.74	5.20
T_4 FYM+Az+As	1146	6.47	3.14	4.12
T_5 FYM+NC	1248	12.30	5.23	6.54
T_6 FYM+POM	1160	11.93	5.07	6.01
T_7 PM+AZ+AS	1010	7.14	4.62	6.25
T_8 PM+NC	1154	11.73	4.94	5.73
T_9 PM+POM	1150	11.63	4.84	5.42
T_{10} BS+AZ+AS	920	6.52	3.12	4.92
T_{11} BS+NC	1026	9.42	4.64	5.07
T_{12} BS+POM	1098	10.23	4.72	5.14
T_{13} RecNPK	1180	12.14	5.14	6.41
T_{14} NoNPK	750	6.24	2.97	3.92
T_{15} Conv.FMG	1192	12.05	5.11	6.47
SEd	142	Not analysed	Not analysed	Not analysed
CD (P=0.05)	304.2			

Table 37. Addition of nutrients through Stubbles Kharif, 1997 (kg ha^{-1}).

Treatments	Weight of Stubble	NPK added		
		N	P	K
T_1 SR+Az+As	1439	9.52	8.65	8.42
T_2 SR+NC	1544	10.42	8.64	9.20
T_3 SR+POM	1888	18.24	10.67	14.21
T_4 FYM+Az+As	1723	16.24	8.76	12.42
T_5 FYM+NC	2358	25.47	11.53	15.42
T_6 FYM+POM	2030	22.14	10.97	14.31
T_7 PM+AZ+AS	1692	9.43	9.42	11.52
T_8 PM+NC	1587	13.41	9.07	10.65
T_9 PM+POM	1950	21.04	10.52	13.24
T_{10} BS+AZ+AS	1764	15.52	9.35	8.52
T_{11} BS+NC	1752	9.27	9.15	9.52
T_{12} BS+POM	16.32	14.27	9.23	8.67
T_{13} RecNPK	2243	23.21	11.23	14.24
T_{14} NoNPK	11.31	7.53	1.24	2.45
T_{15} Conv.FMG	2046	23.14	11.17	2.45
SEd	61	Not analysed	Not analysed	Not analysed
CD (P=0.05)	147.2			

Table 38. Pest Incidence, Rabi, 1996

Treatments	Leaf Folder Damage (%)			Stem Borer Damage (%)		
	30	45	75	30	45	75
T_1 SR+Az+As	6.72	3.46	2.36	9.87	6.97	4.22
T_2 SR+NC	6.02	4.76	1.66	8.12	4.62	2.92
T_3 SR+POM	5.64	2.21	1.33	9.42	6.62	4.14
T_4 FYM+Az+As	4.93	2.04	0.57	8.01	4.01	2.97
T_5 FYM+NC	6.02	4.76	1.46	7.24	3.62	2.41
T_6 FYM+POM	3.92	2.66	2.44	7.32	3.93	2.52
T_7 PM+AZ+AS	6.21	4.95	1.85	9.02	6.35	3.97
T_8 PM+NC	3.62	2.36	0.74	7.54	4.31	2.72
T_9 PM+POM	3.72	2.46	0.64	7.52	6.01	3.82
T_{10} BS+AZ+AS	6.21	4.95	1.85	8.94	4.04	2.64
T_{11} BS+NC	3.80	2.54	0.56	7.31	5.72	3.63
T_{12} BS+POM	8.71	7.45	4.35	8.82	5.42	3.24
T_{13} RecNPK	7.42	6.16	3.06	8.62	5.31	3.22
T_{14} NoNPK	7.56	6.30	3.21	8.23	4.73	3.02
T_{15} Conv.FMG	3.87	2.61	2.49	8.41	5.13	3.42
SEd	1.31	1.19	1.28	2.42	1.92	1.84
CD (P=0.05)	NS	2.85	2.74	5.84	4.63	4.42

Table 39. Pest Incidence, Kharif 1997

Treatments	Stemborer damage (%)				Leaf folder damage (%)			
	30 DAT	40 DAT	60 DAT	80 DAT	30 DAT	40 DAT	60 DAT	80 DAT
T_1 SR+Az+As	8.23	7.23	6.21	3.03	8.24	2.13	0.82	0.07
T_2 SR+NC	7.54	6.49	5.53	2.56	7.80	1.88	0.61	0.05
T_3 SR+POM	8.21	7.14	6.17	2.93	7.47	1.87	0.59	0.03
T_4 FYM+Az+As	7.52	6.46	5.52	2.53	7.47	1.87	0.59	0.03
T_5 FYM+NC	7.42	6.40	5.23	2.03	7.62	1.83	0.52	0 04
T_6 FYM+POM	7.47	6.43	5.41	2.49	7.42	1.84	0.54	0 05
T_7 PM+AZ+AS	8.14	7.03	6.03	2.87	8.03	2.01	0.79	0.06
T_8 PM+NC	7.57	6.51	5.65	2.57	7.53	1.89	0.58	0.05
T_9 PM+POM	8.03	7.01	6.01	2.84	8.01	1.97	0.78	0.06
T_{10} BS+AZ+AS	8.01	6.93	5.93	2.82	7.92	1.96	0.76	0.05
T_{11} BS+NC	7.60	6.52	5.86	2.61	7.67	1.91	0.64	0.06
T_{12} BS+POM	7.92	6.91	5.87	2.79	7.87	1.98	0.74	0.06
T_{13} RecNPK	7.89	6.89	5.82	2.76	7.84	1.94	0.72	0.05
T_{14} NoNPK	7.62	6.70	5.72	2.62	7.77	1.92	0.68	0.04
T_{15} Conv.FMG	7.75	6.71	5.73	2.67	7.82	1.93	0.69	0.05
SEd	1.24	0.95	0.42	0 3421	0.3162	0.1762	0.1042	0 0085
CD (P 0.05)	NS	1.82	0 85	NS	0.67	0 42	0.25	NS

In Rabi '96 leaf folder damage was not significant at 30 DAT. At 45 DAT, Biogas slurry + Poultry manure (T_{12}) had higher per cent leaf folder damage which was comparable with T_4, T_{13}, T_{14}, T_7 and T_5. At 75 DAT, the same above trend followed. The lowest incidence noticed in T_5 with was comparable with all treatments except T_{15}, T_5 and T_3.

In Rabi '96 dead hearts (stem borer) were higher in ***Sesbania rostrata*** Azolla + Azospirillum (T_1) at 30 DAT, which was on par with T_{12}, T_{14}, T_8, T_6, T_7. The least incidence recorded in Conv. Fmg (T_{15}). Similar result was also observed in 45 and 75 DAT.

In Kharif '97 stem borer damage noticed on 30, 40 and 60 and 80 DAT and also for leaf folder damage. The data revealed that the per cent stem borer damage on 30 DAT was not significant among treatments. At 40 DAT (T_1) recorded higher damage which was comparable with T_7, T_{10}, T_{12}, T_{13} and T_{15}. The lowest damage in T_5. At 80 DAT the data's are not significant.

With regard to leaf folder damage, in all the days (T_1) recorded highest damage per cent and (T_5) recorded the lowest per cent damage.

4.6. Economics (Table 40 and 41)

4.6.1. Gross income (Rs. ha^{-1})

Application of organic manures influenced the Gross income. Among organic manures application of FYM + Neem cake (T_5), registered highest Gross income ie., Rs.25,884/- and Rs.30101/- for Rabi '96 and Kharif '97

Table 40. Economics of rice cultivation Rabi, 96

Treatment	Rabi, 1996			
	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BC ratio
T_1 SR+Az+As	8027	17339	9312	2.16
T_2 SR+NC	15634	19699	4065	1.26
T_3 SR+POM	8959	21144	12185	2.36
T_4 FYM+Az+As	9403	16268	6865	1.73
T_5 FYM+NC	15136	25884	10748	1.71
T_6 FYM+POM	11143	22509	11366	2.02
T_7 PM+AZ+AS	12619	18046	5427	1.43
T_8 PM+NC	14924	21342	6418	1.43
T_9 PM+POM	9458	21849	12391	2.31
T_{10} BS+AZ+AS	10541	15075	4534	1.43
T_{11} BS+NC	18061	20048	1987	1.11
T_{12} BS+POM	12609	20041	7432	1.59
T_{13} RecNPK	9713	23117	13404	2.38
T_{14} NoNPK	7152	9155	2003	1.28
T_{15} Conv.FMG	8811	23526	14715	2.69

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

Table 41. Economics of rice cultivation Kharif '97

Treatment	Kharif '97			
	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BC ratio
T_1 SR+Az+As	7654	20517	12863	2.67
T_2 SR+NC	13568	21710	8142	1.60
T_3 SR+POM	8162	25222	17060	3.09
T_4 FYM+Az+As	10210	22360	12150	2.19
T_5 FYM+NC	16096	30101	14005	1.87
T_6 FYM+POM	10672	27536	16864	2.58
T_7 PM+AZ+AS	8689	23287	14598	2.68
T_8 PM+NC	14454	22983	8529	1.59
T_9 PM+POM	8979	24693	15714	2.75
T_{10} BS+AZ+AS	8869	19778	10909	2.23
T_{11} BS+NC	14777	20245	5468	1.37
T_{12} BS+POM	9165	19981	10816	2.18
T_{13} RecNPK	8766	27614	18848	3.15
T_{14} NoNPK	6846	11776	4930	1.72
T_{15} Conv.FMG	7844	27768	19924	3.54

SR - Sesbania rostrata, AZ - Azolla, AS - Azospirillum, NC - Neem Cake,
POM - Poultry manure, FYM - Farm yard manure, PM - Pressmud, BS - Biogas slurry

respectively. The next best was Conv. Fmg Rs.23,526/- which was followed by Rec. NPK (Rs.23117) and FYM + Poultry manure (Rs.22,509) in Rabi '96. During Kharif '97 the T_5 was followed by conventional farming Rs.27,768, recommend NPK (Rs.27,614). Lowest gross return was recorded in control plot (Rs.9155 in Rabi '96 and Rs.11776) in Kharif '97.

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

Conventional farming registered the highest net returns Rs.14715 and Rs.19924 during Rabi '96 and Kharif '97 respectively. This was followed by Rec. NPK (Rs.13404) in Rabi '96 and (Rs.18848) in Kharif '97. The next best was (T_6) FYM + Poultry manure (Rs.11366) in Rabi '96 and (Rs.16864) in Kharif '97. The lowest net returns (Rs.2003 in Rabi '96 and Rs.4930 in Kharif '97) was obtained with no NPK plots.

4.6.3. B:C ratio

Conventional farming (T_{15}) recorded high BC ratio (2.67 and 3.54) in Rabi '96 and Kharif '97 respectively. This was followed by Rec. NPK (2.38 and 3.15 in Rabi '96 and Kharif '97) and ***Sesbania rostrata*** + Poultry manure (2.36 in Rabi '96 and 3.09 Kharif '97). Lowest B:C ratio was recorded in (T_{11}) Biogas slurry + Neem cake (1.11) and 1.37 in Rabi 96 and Kharif '97 respectively.

DISCUSSION

CHAPTER V

DISCUSSION

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore from October, 1996 to September 1997 with the objectives of evaluating the cumulative and their residual effect of applied organic manures and N fertilizers for low land rice. The experimental results presented in chapter IV are discussed in this chapter.

5.1. Effect of OMs and fertilizer on growth attributes of rice

Application of either OMs or fertilizer led to a noticeable increase in plant height when compared to unfertilized treatments (Table 6). This observation lends evidence to the fact that, application of N played a pivotal role in changing the growth rate of crop. Taller plants were obtained with fertilizer, Rec. NPK (T_{13}), only at PI stage. This might be due to better N release from the fertilizer in early stages of growth.

Sesbania rostrata + Poultry manure (T_3) did improve plant height in the latter stages of growth. However the improved plant height obtained from these two treatments (T_{13} and T_3) in general was similar to the effect obtained from application of FYM + Neem cake, FYM + Poultry manure. Due to early mineralisation and accumulation of available nutrients, the plant height was improved by the treatments T_3. Chakraborthy ***et al.*** (1988) reported that quick mineralisation and release of nutrients occurred with the application of inorganic source of nutrients while due to slow mineralization of organic source (Gaur ***et al.***, 1984), the effect of nutrients was felt at later stages with time advancement. Geethalakshmi (1996) found that in ***Sesbania aculeata*** nutrients released after two weeks of

incorporation. Since Poultry manure was cured and applied, it was quite possible to get immediate release of nutrients, as it was reported that microbial activity got influenced with the application of Poultry manure (Yin-Po Wang and Chen Chang Chao, 1995).

Fertilizers and OMs had significant influence on LAI compared to control (Table 7). Application of FYM + Neem cake (T_5) produced highest LAI. FYM + Neem cake would have resulted in gradual mineralisation leading to supply of required N to the crop is the plausible reason for increasing LAI. Application of higher levels of N either through inorganic or organic sources increased the leaf length as well as breadth. (Sri Ramachandrasekaran, 1994). In the present study also, better utilization of N resulted in higher leaf surface area and there by higher LAI. At higher LAI, plants become photosynthetically more active (Sharma and Mittra, 1989). 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 (Table 8 and 9). Application of OMs and fertilizer had a significant increase in DMP at all crop growth stages over their respective control DMP tended to increase progressively with incorporation of FYM + Neem cake (T_5). The root biomass is a healthier index for vigorous rice plant since it supports the above ground plant parts. So, for the treatment FYM + Neem cake there is every possibility of improvement in soil physical condition and this might have provided a better soil environment for higher root development. It was also proved with evidence in the past that the root

biomass had a closer positive correlation with shoot biomass. Increase root and shoot biomass would have influenced panicle biomass. As a result of these components the treatment T_5 resulted in higher DMP besides damage due to pest controlled by the neem cake would have enhanced the dry matter production of rice grain. Incorporation of FYM would have enhanced the level of N availability in the rice rhizosphere of the soil at the initial stage of the crop (Brar ***et al.***, 1995), and under submerged stage soil physical conditions were improved by the application of FYM in addition to nutrient supply. (Subramanian, 1986). Fertilizer treatment T_{13} and T_{15} had similar effect with DMP, this might be due to the presence of adequate N and larger surface of the source, the dry matter accumulation increased at a rapid rate (Sharma and Das, 1994).

5.1.2. Effect of OMs and fertilizer 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 OMs and fertilizer (Table 10 and 11). 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 FYM + Neem cake increased the productive tillers, higher number of panicles per unit area. Availability of adequate N promoted the supply of assimilates to sink, thus increasing the length of panicles. Steady supply of N due to gradual mineralisation of FYM + Neem cake enabled the rice plant to maintain the optimum N content for various physiological processes. Matsushima (1980) stated that early emergence of tillers after transplanting, was a factor which

contribute more towards the yield. Proliferation of tillers soon after transplanting is important for increasing the yield (Budhar, 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 it was observed that nutrient uptake through cumulative effect of FYM + Neem cake which resulted in more number of panicles per unit area.

Thousand grain weight was not significantly influenced by OMs and fertilizer applied as the weight of individual grain is mainly influenced by the genetic make up of the plant as compared to other environmental factors (Bharadwaj and Dev 1985; Narayanasamy, 1994).

Adequate N supply through FYM + Neem, promoted the supply assimilates from the source to sink which resulted in improving the yield attributes. Continuous and steady supply of N into the soil solution to match the required absorption pattern of rice plant, enables to meet the required nutrients for physiological processes, which in turn improved the yield (Srinivasulu Reddy, 1988). In the present study also it was evident that combined application of FYM + Neem cake improved the absorption of N from the soil, which inturn increased the nutrients uptake, there by increasing the yield attributes and yield (Table 12 and 13).

Nitrogen absorbed by the rice plants from tillering to PI, helped to increase its number of tillers and panicles. Nitrogen absorbtion during PI to flowering increased the number of filled spikelets per panicle. De Datta

(1981). Matsushima (1980), stated that increasing the level of N through OMs increased the grain filling percentage. Similar results were expressed by Dhal and Misra (1993). In the present investigation also, it was found that number of filled grain were high with FYM + Neem cake (T_5) application. It has been documented that nitrogen from OMs is least subjected to losses, so it was a more rational method of N supply to rice (Westcott and Mikkelson, 1988). The enormous yield is due to continuous application of cattle manure improved the yield also reported by Anilkumar *et al.* (1993).

As the yield attributes have positive correlation with grain yield of rice the treatment T_5 had higher grain yield of rice. In the present investigation best treatment FYM + Neem cake T_5 and is next followed by conv. FMg (T_{15}).

5.1.3. Effect of OMs and fertilizer 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.

Though nitrogen appears to be the crucial element, Indian soils are generally deficient in N and addition of OMs, particularly affect the available N status in the soil. The results indicated that OMs, in general resulted in

significantly higher values of N uptake, irrespective of the stage (Table 16 and 17). In grain yield too, the same trend was noticed, FYM + Neem cake (T_5) again proved superior in this regard. FYM + Neem cake 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. Brar ***et al.***, (1995) reported that higher N uptake due to FYM alone as compared to other organic sources.

In respect to P, a similar trend was noticed. FYM + Neem cake in general, recorded significantly higher P uptake over control (Tables 18 and 19). Increased availability of P in soil could have been brought by not only the decomposition of FYM (Yadvinder singh ***et al.,*** 1994), but also by synergistic effect existing between N and P. Alexander (1977), reported that release of P was most rapid under conditions favouring ammonification. In the present study also it was evident, application of FYM + Neem cake favourably influenced the P uptake of rice crop.

More or less a similar trend as pH P uptake was noted with respect to the nutrient K uptake (Tables 20 and 21). Increased K uptake in rice due to FYM was early reported by Brar ***et al.***, (1995). The increase in K availability could be due to priming effect on K besides the direct contribution of K by OMs.

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

5.1.4. Effect of OMs and fertilizers on the use efficiency of N

The various parameters of use efficiency of N were influenced by OMs as well as fertilizers.

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 FYM was combined with Neem cake. This not only showed that FYM + Neem cake, apart from contributing organic N, improved the efficiency of fertilizer N also, this was supported by (Crasswell and Godwin, 1984).

Apparent N recovery (ANR), which indicates the efficiency of absorption of applied N. FYM + Neem cake tended to increase the ANR (Table 22) and this could be explained as follows. The ANR was computed based on difference between uptake of specific treatment and control. With FYM combination with Neem cake (T_5), the uptake of N by rice was fairly high. FYM might have contributed considerable quantity of N upon mineralisation making more N available to plants. Naturally ANR becomes higher with increased N availability.

5.1.5. Post harvest soil available N

Incorporation of OMs and fertilizer excerted considerable influence post harvest soil available N status (Table 23 and 24), whenever OMs was applied, there was an improvement in soil available N content, when compared to control. This is attributable to release of N from the OMs

incorporated, due to steady and slow mineralisation process. Among OMs FYM + Neem cake, left significantly higher soil available N. The FYM 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 (Hedge, 1996). The second fraction of FYM might have contributed to the improvement in the post harvest soil available N status in case of FYM + Neem cake.

Residual study

5.2. Residual effect of applied OMs and fertilizers on Kharif and Rabi crop

5.2.1. Growth attributes

The residual effect of OMs applied to previous rice on growth attributes was well pronounced in terms of plant height and LAI (Table 25) during flowering and DMP at harvest stages (Fig.4) of rice. This might be due to higher post harvest soil available N after Rabi and Kharif in the case of OMs applied plots. Among the different OMs, the effect was more in FYM + Neem cake, FYM + Poultry manure and ***Sesbania rostrata*** + Poultry manure applied treatments.

In fertilizer applied plots Rec. NPK (T_{13}) and Conv. Fmg (T_{15}) did not show any marked effect on growth parameters on succeeding crop, indicating that there is no residual effect for fertilizer applied on the subsequent crop.

5.2.2. Yield attributes and yield

The residual effect of OMs in 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 the location (Singh *et al.*, 1991). In the present study, application of OMs to rice showed a favourable residual effect on yield attribute (Table 26, 27 and 28) and yield (Table 30) of subsequent season rice. The increase in yield was 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.

The reports of previous workers on the residual effect of Farm yard manure are often contradictory. However 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 FYM + Neem cake 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 and this was substanciated by (Bouldin, 1988).

5.2.3. Nutrient uptake

The residual effect of applied OMs on the uptakes of N, P and K by subsequent crops was noticed (Table 29). Among OMs FYM + Neem cake (T_5) FYM + Poultry manure (T_6) and ***Sesbania rostrata*** + Poultry manure (T_3) increased the N, P and K uptake. Application of above organic manures, not only resulted in higher available N, P and K status in the soil but also produced significantly highest dry matter as well as grain yield due to higher nutrient uptake.

Application of fertilizer to previous rice crop had not influenced the nutrient uptake and this might be due to loss of available N. In present investigation nutrient uptake was more in organic manuring plot, due to slower release of nutrients (Bouldin, 1988).

5.2.4. Soil fertility after rice-rice cropping system (Fig.11)

Incorporation of OMs as well as application of fertilizer excerted considerable influence on the soil fertility status (Table 32a and 32b).

Organic manuring improved the soil available carbon content. FYM + Neem cake (T_5), FYM + Poultry manure (T_6), recorded significant improvement in organic carbon content. This might be due to addition of root biomass, which might have left larger volume of root organic material into the soil besides the left out decomposition portion of organic manures. In general, roots accumulate considerable amount of plant nutrient and under intensive cropping systems, if the stubbles were turned back to the soil considerable quantities of nutrients would be rotated and become available to subsequent crops (Meelu and Rekhi, 1981; Srinivasulu reddy, 1988). Several workers have reported increased organic matter status of the soil by the incorporation of crop stubbles, green manures and pulse residues in rice based cropping system (Jayanti Chinnusamy, 1995).

In respect of N balance study, the balance was positive and greater for the treatment T_5 with the advancement in seasons. Since the

treatments T_5 has FYM as one among the nutreint source it might have reduced different losses of N, which are possible under submerged condition. This has been proved by different research work in the past (Jayanthi Chinnasamy 1995 and Geethalakshmi, 1996).

Inversely the treatments T_{13} and T_{15} have shown decreased N balance due to several losses, but T_5 showed minimum loss and this was confirmed by Kenchaiah (1997) it his simulation studies.

Soil available N balance after residual crop indicated that, (Table 32a and 32b), in residual study due to non application of manures, fertilizer there was a decrease in soil available N status. This shows that for the subsequent crop the soil N balance was not sufficient to meet its crop N requirement which resulted in depletion of soil N status.

In general, incorporation of organic manures would cause increase and rapid production of CO_2 which in turn enhanced the solubility of calcium in the soil. Calcium ions replace sodium ions on the exchange complex resulting in pH favourable to rice culture (Shirkant and Rajkumar, 1992). Hence by organic manuring, 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 organic manures act as a slow release fertilizer and conserve nutrients for longer period.

5.3. Effect of OMs and fertilizer on quality characters

5.3.1. Milled rice

5.3.1.1. Chemical composition

Application of OMs profusely altered the chemical composition of milled rice. Among the organics FYM + Neem cake (T_5) registered highest protein and total ash per cent. This might be due to increased seed N content and higher minerals content of the rice.

Seed moisture had not influenced significantly with the sources of nutrient.

Press mud + Poultry manure (T_9), the fat per cent was increased. This might be due to the nutrients present in Poultry manure. As observed with the application of PM + Poultry manure there was increase in over all quality. In respect of fibre percentage also these manure had such positive role in this study.

5.3.1.2. Cooking characteristics of milled rice

Organic manuring had a significant influence on length and breadth of rice. FYM + Neem cake (T_5) and FYM + Poultry manure (T_6) registered highest length and breadth of rice, while (Pressmud + Neem cake) T_8 and Pressmud + Poultry manure (T_9) recorded highest L:B ratio which might be due to lowest length and breadth.

5.3.1.3. Sensory characteristics

In respect of colour, texture, taste and overall acceptability, application of Press mud + Poultry manure (T_9) had highest record as compared to other treatments evaluated. It was found earlier that the quality treatments of rice was improved (Hsieh, 1995) with the application of Poultry manure.

5.4. Effect of OMs and fertilizer on insects

Organic manures especially Neem cake application controlled the leaf folder and stem borer. Among the organics lowest pest incidence observed in FYM + Neem cake and Press mud + Neem cake. The Neem cake might have helped to reduce the incidence of pests from the beginning. Similar results were reported by Krishnaiah ***et al.*** (1990).

5.5. Economics

Organic manuring and fertilizer influenced the economics of rice-rice cropping system comprehensively. BC ratio increased with the inorganic fertilizer. Among this Rec. NPK (T_{13}) and con. Fmg (T_{15}) registered highest B:C ratio. This increased BC ratio was due to lesser cost towards inorganic sources.

Among organics ***Sesbania rostrata*** + Poultry manure registered highest B:C ratio due to lesser cost of organic sources like ***Sesbania rostrata***, Poultry manure than FYM, Neem cake, pressmud Biogas slurry and Azolla. It may be inferred from the study that organic manures have their own advantages in favouring crop growth and yield besides, no harmful effect of

chemical residues in the consumable part of the plants. This is the way to maintain the sustainability of the crop production without causing deterioration effect on the system, especially to the soil. In the present study though the economics worked out was not higher with the organic manuring to obtain the sustained yield but this method of farming gives an assurance on the production of the sustained production rice crop besides providing.

Pollution free environment on the other hand, the inorganic sources though resulted higher return and B:C ratio are not obviously taking care of the system esp the soil and their positive effect can be Press mud only for a short period. Hence considering the large interest and welfare of human being this method of farming is going to be trend in the next century.

SUMMARY

CHAPTER VI

SUMMARY AND CONCLUSION

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore from October, 1996 to September, 1997 with the objectives of evaluating the cumulative and residual effects of organic farming during Kharif '95 Rabi '96 and Kharif '96. The experiment was laid out in Randomized block design, replicated thrice during Rabi '96 to study the direct effect of applied organic manure and fertilizers. In the same season the plot was divided into two, other part to study the residual effect of previous seasons and in Kharif the plot was divided into three, first part to study the direct effect of applied manures and the second part to study the residual effect of previous Rabi '96 crop and the third part to study the residual effect of previous Rabi '96 residual crop. The experiment consisted of fifteen treatments comprising of which twelve treatments are of combination of organic manures, remaining two treatments were inorganic fertilizer treatments and a No NPK (control). The recommended dose of NPK was 120:38:38 kg ha^{-1} for Kharif and 150:50:50 kg ha^{-1} for Rabi rice. The recommended dose of N was substituted through combination of two organics with 50 per cent recommended N each. The P and K was not applied. The conventional farming treatment (T_{15}) received full dose of recommended NPK, weed control through herbicide and plant protection by chemicals. The recommened NPK, treatment received full dose of

NPK but weed control through manual weeding and plant protection by neem products. The plant protection was done through neem products for treatment from T_1 to T_{14}. Neem oil 3% and NSKE 5% were used for plant protection. ***Trichogramma japanicum*** and ***chilonis*** were used as biological control for stem borer and leaf folder respectively. To study the residual effect No fertilizers and organic manures was applied but all the plant protection measures were done like weed control, pest and disease management as above.

The conclusion drawn from the study are summarised here under.

Application of organic manures, Rec. NPK, FYM + Neem cake, ***Sesbania rostrata*** + Poultry manure application improved rice plant height to a greater extent.

Use of FYM + Neem cake resulted in larger LAI, DMP and the Relative Dry matter efficiency.

FYM + Neem cake 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 in both organic manures and fertilizer sources.

In FYM + Neem cake the percentage of increase in yield was 20 and 37.0 during Rabi '96 and Kharif '97 over the conventional farming and also higher in straw yield and HI.

Productivity Score increased with FYM + Neem cake followed by FYM + Poultry manure, ***Sesbania rostrata*** + Poultry manure and Rec. NPK (T_{13}).

Higher N uptake was seen where FYM + Poultry manure and FYM + Neem cake was incorporated.

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

AE/AF

Application of FYM + Neem cake improvement the apparent N recovery (ANR) and Agronomic Efficiency (AE) to a greater level. This was followed by FYM + Poultry manure and Rec. NPK. Lowest ANR, AE was registered by control (No NPK).

Among the treatments, FYM + Neem cake, left significantly higher available N. The increase was 23.52 per cent during Rabi '96 and 42.41 per cent during Kharif '97, respectively over inorganics. In general, soil available N increased due to organics.

The carry over effect of different organic manures and fertilizer was studied and presented below.

Residual effect on Rabi '96 rice, observed was that the plant height and LAI was higher in FYM + Poultry manure and FYM + Neem cake applied to Kharif '96 rice. Carry over effect of applied fertilizer were not as much as that of organics. The same trend was registered in the Kharif '97 rice crop.

Organic manuring done to Kharif '96 rice had excerted a significant influence on DMP of Rabi '96 rice at harvest stage. Residual effect of FYM + Neem cake, ***Sesbania rostrata*** + Poultry manure, was observed through out the growth period of Rabi '96 rice and the effect of these organic manures on DMP was comparable. Fertilizer application to Kharif '96 rice showed no positive influence on DMP of Rabi '96 rice. The same, trend was observed in the Kharif '97 rice.

Application of FYM + Neem cake, FYM + Poultry manure and applied to Kharif '96 crop increased the productive tillers per unit area, panicle length and filled grain percentage of Rabi '96 crop. Fertilizer tretments on Kharif '96 crop did not have any influence on the yield parameters like productive tillers per unit area, panicle length and field grain per cent.

Thousand grain weight was unaltered in Rabi '96 rice due to organic manure as well as by fertilizers to Kharif '95 rice crop. The same above trend was followed in Kharif '97 residual crops.

N, P and K uptakes in Rabi '96 rice crop was higher in FYM + Neem cake and FYM + Poultry manure applied plots. Fertilizer treatment showed little influence on N, P and K uptakes in both the seasons of studies.

Application of organic manures to Kharif '96 crop increased the Rabi '96 rice grain yield from 12.6 to 52.5 per cent over control. Application of FYM + Neem cake, increased the grain yield of Rabi '96 to greater extent. Fertilizer applied for Kharif '96 rice did not exert any significant influence on the grain yield of Rabi '96 rice. And the same trend was observed in Kharif '97.

Straw yield exposed similar trend as that of grain yield in both season of studies.

Organic manuring applied to Kharif '96 rice, in general, improved the soil fertility status after the harvest of Rabi '96 rice. Incorporation of organic manures increased the organic carbon content also. Fertilizer application done to Kharif '96 rice did not exhibit any influence on the organic carbon content of soil after the harvest of the Rabi rice. The same trend observed in Kharif '97 rice.

Application of organic manures to Kharif '95, Rabi '96 and Kharif '96 increased the soil available N, P and K after rice-rice cropping system. FYM + Neem cake, left more soil N. Application of fertilizer decreased N, P and K content.

Regarding quality aspect

Application of FYM + Neem cake increased protein and ash content. Seed moisture not affected by treatments. Pressmud + Poultry manure and FYM + Poultry manure increased the fat and fibre per cent respectively.

FYM + Poultry manure application, increased length and breadth of cooked rice. FYM + Neem cake application had equal performance like FYM + Poultry manure combination. Press mud + Neem cake and Press mud + Poultry manure had given higher L:B ratio.

Pressmud + Poultry manure application improved the colour, texture, taste and overall acceptability of rice.

Combined application of FYM + Neem cake had higher root stubbles of 1248 kg ha^{-1} in Rabi '96 and 2358 kg ha^{-1} Kharif '97. In turn, it has supplied 12.30 kg N, 5.23 kg P_2O_5 and 6.54 kg K_2O in Rabi '96 and 25.47 kg N, 11.53 kg P_2O_5 and 15.42 kg K_2O.

Neem oil 3% and NSKE 5% and release of ***Trichogramma japonicum*** and ***T. chilonis*** effectivley controlled leaf folder, stem borers and gall midge in rice.

Conventional farming recorded highest pest incidence.

It could be concluded from the above results that the combination of FYM + Neem cake was superior in recording higher grain yield, increase in soil fertility, increase in qualtiy aspects like protein and mineral content of rice and also to some extent resistant to insects damage. This treatment followed by conventional farming, Rec. NPK, FYM + Poultry manure, Press mud + Poultry manure and ***S. rostrata*** + Poultry manure.

With regard to net returns and B:C ratio Conv. Fmg was found to be the best and was followed by Rec. NPK. Even though the application of FYM + Neem cake improved the yield, quality of paddy but in B:C ratio it stood third, to compensate this the organic sources like FYM and Neem cake should be available at cheaper rate to practice organic farming with application of FYM + Neem cake with no chemical plant production will be more beneficial, economical and ecofriendly farming.

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1. Entire view of experimental field Rabi '96

2. Farm yard manure + Neem cake treated plot

3. Farm yard manure + Poultry manure treated plot

4. Recommended NPK organic spray

5. Recommended NPK inorganic spray

APPENDICES

APPENDIX - I

Weather parameters prevailed during crop season Rabi 1996.

Std wks	Rainfall mm.	Max. temp. (°C)	Min. temp. (°C)	RH (0722 %)	RH 1422 (%)	P.E. mm day^{-1}
45	-	31.6	18.3	84	43	4.2
46	21.4	30.3	21.2	89	82	4.1
47	40.0	28.4	21.8	87	66	2.7
48	-	30.3	19.3	88	48	3.0
49	24.5	29.4	17.2	90	59	3.1
50	88.2	25.9	20.9	93	72	1.9
51	4.5	26.8	19.4	88	56	2.8
52	-	28.2	16.1	88	43	5.4
1	-	28.5	18.8	86	47	3.4
2	2.0	28.5	20.1	87	52	4.0
3	-	29.8	18.9	84	46	4.2
4	-	30.4	18.6	84	41	4.3
5	-	30.4	16.1	81	35	5.0
6	-	32.5	18.5	79	35	5.0
7	-	32.3	17.3	77	26	5.9
8	-	32.9	20.8	82	38	4.5
9	-	33.3	21.1	79	22	7.9
10	-	33.9	19.8	77	23	7.0
11	-	36.2	20.9	84	24	7.3
12	9.5	35.7	21.8	84	34	6.1

APPENDIX II

Weather parameters prevailed during crop season Kharif 1997.

Std wks	Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	RH (0722 %)	RH 1422 (%)	P.E. mm day^{-1}
23	2-3	35.3	23.5	79	43	7.9
24	-	33.8	23.3	69	34	8.5
25	-	33.7	23.6	77	37	8.8
26	25.0	31.0	22.9	80	56	7.7
27	24.5	28.4	22.8	77	66	4.8
28	62.5	30.2	22.5	71	56	4.3
29	2.5	32.2	23.0	84	56	6.9
30	22.0	29.2	23.6	79	61	5.1
31	5.5	29.6	23.4	67	58	6.7
32	8.8	29.0	22.1	87	65	4.8
33	2.5	31.3	21.9	88	51	4.6
34	7.5	31.5	22.9	72	49	7.1
35	1.0	32.5	23.0	78	45	6.4
36	-	32.9	23.1	85	47	5.6

Weather parameters Kharif '97