EFFECT OF GREEN MANURE OF *Sesbania rostrata* (BREM. AND OBREM.) IN CONJUNCTION WITH NITROGEN LEVELS ON THE GROWTH, YIELD AND NITROGEN ECONOMY OF RICE

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in partial fulfilment of the requirements
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in
AGRONOMY

BANGALORE NOVEMBER 1991

Affectionately Dedicated

to my Beloved Parents

Department of Agronomy
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF GREEN MANURE OF Sesbania rostrata (BREM. AND OBREM.), IN CONJUNCTION WITH NITROGEN LEVELS ON THE GROWTH, YIELD AND NITROGEN ECONOMY OF RICE"** submitted by **Mr. Y.R.ALADAKATTI**, for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY**, of the University of Agricultural Sciences, Bangalore, is a record of research work done by him, during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or any other similar title.

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Bangalore
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CONTENTS

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

LIST OF FIGURES

LIST OF FIGURES
(Continued)

LIST OF PLATES

INTRODUCTION

I. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important food crops of the world. The area covered under rice in the world is 145.00 million hectares with a total production of 483.00 m. tonnes and average productivity of 3320 kg per ha (Anon., 1988a).

India has the largest area under rice among the rice growing countries of the world, but ranks second in total production after China. In India, rice is grown on an area of 41.0 m. ha with an annual production of 101.95 m. tonnes (Anon., 1988a). The average yield per ha in India is considerably low (2487 kg/ha) as against other countries such as Australia (7179 kg/ha), Spain (6391 kg/ha), U.S.A. (6178 kg/ha), Japan (5825 kg/ha) and China (5301 kg/ha). One of the main reasons for the low productivity of rice in India is due to low consumption of fertilizers and poor fertility status of the soil.

The total area under rice in Karnataka is 10.48 lakh ha, with an annual production of 28.14 lakh tonnes and average yield of 2827 kg per ha (Anon., 1990).

Nitrogen is a key input in increasing the rice production. Urea is the principal source of nitrogen now being used in India, but the fertilizer use efficiency is low in rice cultivation due to the losses of nitrogen from urea, which were reported to range from 60-80 per cent under poor management situations (Parr, 1967). Poor utilization of nitrogen by rice is largely due to N-losses from the soil through run off, leaching and denitrification.

The present fertilizer shortage and the universal hike in fertilizer prices have generated serious interest in the efficient use of fertilizers for rice. One of the ways to reduce fertilizer nitrogen consumption and N-losses is to substitute nitrogen through the green manure crops. Work carried out at IRRI, Philippines, in recent years has shown that the efficiency of green manure and chemical fertilizers were similar (Morris et al., 1986). Green manure which can accumulate very high amount of nutrients in a short time would act as an alternate source of fertilizers and have the potential to cover the substantial portion of nitrogen requirement by rice.

Sesbania rostrata, a tropical legume is gaining importance as green manure in rice production. It is superior to other traditional green manure species by having the ability to nodulate on both roots and stem. It is reported to putforth fast growth with high nitrogen accumulation in a short time, substituting substantial amounts of nitrogen in the rice production (Rinaudo *et al.*, 1983). Profuse stem nodulating ability provides an additional opportunity to fix nitrogen under flooded conditions (Meelu *et al.*, 1988).

In order to study the effect of *S. rostrata*, a stem nodulating green manure on transplanted rice an experiment was conducted during *kharif* 1990-91 at the Agricultural Research Station, Kathalagere, of the University of Agricultural Sciences, Bangalore, with the following specific objectives.

1. To assess the effect of *S. rostrata* green manure alone and in combination of different levels of fertilizer nitrogen on growth and yield of rice and on nitrogen economy.

2. To study the uptake of nitrogen by rice in relation to *in situ* incorporation of *S. rostrata* green manure.

3. To study the effect of *in situ* incorporation of *S. rostrata* green manure on total nitrogen status in the soil.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

In an effort to know the influence of Sesbania rostrata, a stem nodulating green manure for nitrogen economy in rice production, an attempt has been made here under to review the earlier work done on Sesbania rostrata.

2.1 Nodulation pattern of Sesbania rostrata

Most nitrogen-fixing legumes have nodules on their root system. However, S. rostrata a tropical legume forms nodules on stem as well as roots and so is characterised by good nitrogen fixing potential.

Dreyfus and Dommergues (1981) in their investigations at IRRI, Philippines, found that S. rostrata with Rhizobium inoculation produced nitrogen fixing nodules both on roots and stem and had 5-10 times more nodules than most nodulating green manure species due to its profuse stem nodulation.

In a more detailed study in Philippines, Dreyfus et al. (1985) observed that the pre-determined nodulation sites on the stem, which were arranged in vertical lines formed nitrogen fixing nodules when infected by specific strains of Rhizobium. Further, they also observed that the nodulation was regular and profuse during rainy season than in cold and dry season, which was attributed to its sensitivity to photo period, temperature and humidity.

Saint Macary et al. (1985) in Philippines, found that the nodulation on the stem of S. rostrata was not directly linked to flooding and they opined that at 43 days after sowing, the stem nodules were numerous and active, which enabled the species to reduce more acetylene than did the root nodules on S. sesban.

Work conducted at IRRI, Philippines, on S. rostrata indicated that the stem nodules formed continuously throughout the growth of the stem and remained sensitive to the Rhizobium infection. The mode of infection was unique as it involved both an intercellular invasion by Rhizobium and development of infection threads (Dreyfus et al., 1985).

In the experiment at IRRI, Philippines, it was observed that the nitrogen fixing activity (acetylene reduction activity) of stem nodules of S.rostrata was mainly due to nodules formed at third and fifth week after sowing of S. rostrata, which indicated that fifth week after sowing of S. rostrata as the most suitable time for Rhizobium inoculation (Anon., 1985a).

2.2 Rhizobium inoculation to S. rostrata

Dreyfus and Dommergues (1981) at IRRI, Philippines, isolated two types of strains, viz., stem strains, capable of nodulating both stem and root and root strains which nodulate root only. A physiological study showed that stem strain ORS-571 had the ability to grow with atmospheric nitrogen as the sole N-source.

Dreyfus et al. (1985) in Philippines, observed that the seed inoculation of S. rostrata induced complete root nodulation, but only partial stem nodulation, while the shoot inoculation of S. rostrata when plants had attained a height of 50-80 cm by Rhizobium strain ORS-571 induced the satisfactory profuse stem nodulation.

In a green house experiment at IRRI, Philippines, it was observed that the seed and stem of S. rostrata inoculated by Rhizobium strain ORS-571 produced significantly more root and stem nodules and higher nitrogenase activity compared to the uninoculated plants which produced only root nodules. The results also showed that plants grown under unflooded conditions had more nodules and nitrogenase activity than those grown under flooded conditions (Anon., 1986a).

Radhakrishna et al. (1990) in Bangalore reported that stem nodulation was occurred in five days when 30 days old plants of S. rostrata were sprayed with Azorhizobium strain SRN 3 and opined that the indigenous isolate SRN 3 was better in the efficiency due to better adoption to the ecological factors of the region. Further, they opined that compared to seed inoculation, spraying of the culture suspension to the stem produced higher number of nodules and maximum nodule dry weight.

Shivaram et al. (1991) in Bangalore, reported that seed inoculation with Azorhizobium culture produced good nodulation in roots as well as stem and the spray of the culture to S. rostrata plants at the age of 25 to 30 days induced profuse stem nodulation.

2.3 Nitrogen accumulation by *S. rostrata*

Rinaudo *et al*. (1983) in Senegal, estimated the accumulation of 267 kg N per ha by *S. rostrata* under water-logged conditions in 52 days.

Saint Macary *et al*. (1985) observed that *S. rostrata* could fix nitrogen even when the root system was submerged as it had active stem nodules and they opined that *S. rostrata* is a promising green manure for rice under flooded conditions.

In one of the field experiments at IRRI, Philippines, it was found that *S. rostrata* accumulated more than 200 kg N per ha in 58 days and 165 kg per ha in 44 days (Anon., 1985b).

Crozat and Sangchyosawat (1985) in Thailand, reported that *S. rostrata* fixed 131 kg N per ha in 55 days under water-logged conditions.

In a pot experiment at IRRI, Philippines, it was estimated that the uninoculated *S. rostrata* plants had the lowest N- fixation potential (75.6 kg N per ha) because of poor stem nodulation, while the stem + root inoculated plants had the highest N-fixation potential amounting to 254.8 kg N per ha due to profuse stem nodulation (Anon., 1987a).

In a field experiment at IRRI, Philippines, it was observed that the presence of high level of in - organic nitrogen in the soil had not inhibited the N-fixation of S. rostrata unlike other legumes as S. rostrata nodulates on the stem (Anon., 1987b).

Ndoye and Dreyfus (1988) in Senegal, in a green house experiment found that S. rostrata fixed more nitrogen (0.78-0.68 g N/plant) in 60 days, while S. sesban, a non-stem nodulating species fixed 0.06-0.05 g N per plant. Further, it was estimated that about 83-109 kg N per ha and 7-18 kg N per ha could be fixed in 60 days by S. rostrata and S. sesban, respectively.

Morris et al. (1989) in Philippines, showed that the mean nitrogen accumulation by S. rostrata under flooded conditions was 90 kg per ha in 48 days and 164 kg per ha in 60 days, whereas under unflooded conditions it was 128 kg per ha in 48 days and 198 kg per ha in 60 days.

Halepyati and Sheelavantar (1990a) in Dharwad, reported that S. rostrata with higher plant density per ha (666,000 pl/ha) had the highest N-accumulation (177.7 kg per ha) at 56 days after sowing.

Kulasooriya and Samarakoon (1990) in Sri Lanka opined that decapitating the young S. rostrata plants prior to stem inoculation with Rhizobium had produced the higher acetylene reduction activity (49.7 µmol/hr) and highest N-yield (128.5 mg/plant).

Radhakrishna et al. (1990) in Bangalore, reported that basal application of phosphorus fertilizer to S. rostrata plants and stem inoculation with Azorhizobium culture increased the biomass production (14.55 g/plant) and nitrogen uptake by S. rostrata plants (582 mg/plant) and they opined that high nitrogen fixing potential of S. rostrata was due to the increased formation of stem nodules.

Shivaram et al. (1991) in Bangalore, estimated that S. rostrata accumulated 150 to 180 kg nitrogen per ha in 45 to 50 days after emergence.

2.4 Biomass production of S. rostrata

Furoc et al. (1985) in Philippines, estimated that S. rostrata produced dry matter yield of 7.7 t per ha in 61 days with 176 kg nitrogen yield per ha, whereas the dry matter yield after 49 days was 2.6 t per ha with N-yield of 89 kg per ha. They also opined that flooding the field 25 days prior to incorporation of biomass reduced the dry matter and N-yields by about 25 per cent.

Saint Macary et al. (1985) in Philippines, showed that in flooded conditions the biomass production per plant and per unit area was higher from S. rostrata than S. sesban. They observed that the plant population reduction due to flooding was greater for S. sesban (20 per cent) than for S. rostrata.

Ireneo et al. (1987) in Philippines, in a green house experiment on S.rostrata observed that S.rostrata produced the same biomass under both flooded and unflooded conditions, and opined that its biofertilization potential could not be diminished by flooding. Further, they also noticed that the nitrogen fixation in root nodules was reduced significantly by flooding, but such reduction was not noticed in the stem nodules.

A field experiment conducted in Philippines, showed that phosphorus fertilization to S. rostrata significantly improved the growth and biomass production and the highest total dry matter yield was obtained with the application of 60 kg P_2O_5 per ha (Anon., 1987a).

In another experiment in Philippines, on S. rostrata it was found that lesser biomass of roots was produced under un-flooded than under flooded conditions. Under flooded conditions, it was noticed that the roots were more fibrous and whitish and a tuber like structure similar to that of raddish was formed from the tap root which served as a mechanism for adoptation of S. rostrata to the flooded conditions (Anon., 1987a).

Furoc *et al*. (1988) in Philippines, reported that the dry matter yield of *S. rostrata* was 5.27 t per ha. 1.08 t per ha and 0.29 t per ha at the age of 45 days, 30 days and 20 days, respectively.

Halepyati and Sheelavantar (1990a) in Dharwad, found that *S. rostrata* with higher plant density (666,000 pl/ha) produced the highest fresh biomass (23.0 t/ha) at the time of incorporation i.e. eight weeks after sowing.

Thakur (1991) in Bihar, reported that *S. rostrata* added more dry matter (4.3 t/ha) than *S. aculeata* (4.2 t/ha) and further showed that the P-application at sowing of *S. rostrata* was superior to P- applied at puddling.

2.5 Age and method of incorporation of *S. rostrata*

In a field experiment at IRRI, Philippines, it was observed that *S.rostrata* sown as inter crop when rice was transplanted, shared basal N-applied to rice, but the N- was reincorporated into the soil with green manure incorporation and increased the rice grain yield. However, it was observed that *S. rostrata* sown before rice and incorporated into the soil at 40 days of emergence increased the total dry matter yield of rice and also nitrogen accumulation (Anon., 1985a).

Soil incorporation of 43 days old S. rostrata green leaf manure produced significantly higher grain yield and higher total dry matter yield of rice than the surface application of green manure at IRRI, Philippines. The results also confirmed that in situ incorporation of S. rostrata significantly increased the total dry matter yield of rice (Anon., 1985a).

In one of the studies at IRRI, Philippines, it was found that the biomass production of S. rostrata after 65 days of sowing was double than that of 45 days old crop. The incorporation of the biomass after 65 days of sowing significantly increased the tiller number and grain yield (Anon., 1986b).

Ranvir Singh et al. (1988) in Bihar, found that 45-60 days old S. rostrata accumulated 60-90 kg N per ha and soil incorporation of the green biomass before rice transplanting increased the rice yield by 3.7 t per ha, while 60 kg inorganic nitrogen per ha increased the rice yield only by 1.7 t per ha.

Morris _et_ _al_. (1989) in Philippines, opined that regardless of flooding, herbage yields and N-accumulation in 60 days old crop of _S_. _rostrata_ was higher than that of 48 days old crop. Further, the incorporation of 60 days old _S_. _rostrata_ significantly increased the productive tillers and grain yield of rice.

Palaniappan and Budhar (1989) in Coimbatore, found that _S_. _rostrata_ incorporated 15 days prior to transplanting of rice at 12.5 t per ha significantly increased the productive tillers, panicles per m^2 and grain yield of rice.

Halepyati and Sheelavantar (1990a) in Dharwad, reported that 56 days old _S_. _rostrata_ incorporated into the soil one day prior to rice transplanting significantly increased the rice grain and straw yield with varying levels of added nitrogen.

2.6 Green manuring of *S. rostrata* and Nitrogen release

The results of a green house experiment conducted at IRRI, Philippines, revealed that the NH_4^+-N released after incorporation of *S. rostrata* was higher than the N-released by azolla. The highest concentration of NH_4^+-N was found in the top soil during the first 20 days after flooding. Further, the kinetics of NH_4^+-N in the field experiments was similar to that in pot experiment, but there was an increased release of NH_4^+-N at the end of the season (Anon., 1986c).

Higher NH_4^+-N level was observed during the first 3-weeks after rice transplanting with the *in situ* incorporation of *S.rostrata* green manure compared to the unfertilized control, at IRRI, Philippines (Anon., 1987b).

In one of the studies in Philippines, it was observed that the exchangeable NH_4^+ -N values from basally incorporated *S. rostrata* alone was highest at 21 days after transplanting of rice, which gradually decreased to a very low level after 14 days (Anon., 1988b).

Furoc *et al.* (1989) in Philippines, reported that *S.rostrata* incorporation released NH_4^+-N sharply within ten days of incorporation exceeding or equalling that from the chemical inorganic nitrogen application (20 kg N/ha) and further opined that 60 days old *S. rostrata* incorporation caused the greatest and most sustained NH_4^+ -N increase.

In the investigations of Khind *et al.* (1987) it was observed that the incorporation of *S. rostrata* caused marked increase in water soluble Ca, Mg, P, Fe and Mn, the increase was highest at four to eight days after flooding and decreased subsequently.

Nagarajah *et al.* (1989) in Philippines, estimated that apparent NH_4^+-N release after incorporation of *S. rostrata* ranged from 44-81 per cent, but the range for Azolla was 27 to 52 per cent. They observed that soil solution and exchangeable NH_4^+ -N increased initially, but levelled off between 30 to 80 days after flooding for *S. rostrata* and 20 to 40 days after flooding for Azolla. Further, they opined that apparent recovery of added green manure -N varied from 29-67 per cent and almost all N-released from the green manure was recovered in the rice plant.

2.2 Effect of *S. rostrata* on Nitrogen substitution and rice yields

Addition of nitrogen to a legume crop is not usually necessary since the legume is capable of fixing nitrogen by itself, but an application of phosphate and potash fertilizers often stimulates the growth of the crop. The fertilizers added serve the dual purpose of increasing directly the yield of green manuring crop as well as that of succeeding crop as it is available after the incorporation into the soil.

Rinaudo *et al.* (1983) in Senegal, found that incorporation of *S. rostrata* alone resulted in a grain yield increase of 3.72 t per ha which could be equivalent to that obtained by 130 kg inorganic nitrogen per ha and also observed that soil N-status was significantly improved after the harvest of rice crop, which could benefit the subsequent rice crop.

Experiment conducted at IRRI, Philippines showed that the incorporation of *S. rostrata* green manure increased the rice grain yield by 1.3 t per ha and 0.7 t per ha over the unfertilized control and over the treatment that received 60 kg inorganic nitrogen per ha respectively (Anon., 1985b).

Dreyfus et al. (1985) in microplots trial on S. rostrata at Senegal, found that incorporation of S. rostrata resulted in a grain yield of 584 g per m^2, which is more than double the yield obtained by the control plot (212 g/m^2). Further, they observed that the effect of inorganic $(NH_4)_2SO_4$ - fertilizer was significantly less pronounced than that of S.rostrata.

Camara and Diara (1986) in Senegal, reported a saving of more than 50 per cent of recommended nitrogen fertilizers (120 kg N/ha) with S.rostrata in rice production.

In a field investigation in Philippines, Ireneo et al. (1987) found that incorporation of S. rostrata alone gave rice grain yields comparable to the yield obtained by 60 kg N per ha, and concluded that S.rostrata could supply N-requirement of transplanted rice upto 60 kg N per ha.

In a field experiment in Philippines, it was found that, the in situ incorporation of S. rostrata green manure before rice transplanting gave more rice yield(4.5 t/ha) than the prilled urea application of 60 kg N per ha (4.0 t/ha) (Anon., 1987c). In a subsequent study basal incorporation of S. rostrata before rice transplanting had given significantly higher yields (6.7 t/ha) compared to control (4.6 t/ha). Further, the yields obtained by S.rostrata incorporation alone and S. rostrata + 29 kg N per ha were comparable (Anon., 1988b). During wet season, the rice yield obtained by the incorporation of S. rostrata green manure alone (5.4 t/ha) was comparable to the rice yield obtained by 90 kg N per ha, as urea (5.1 t/ha).

Morris et al. (1989) in Philippines, reported that S. rostrata incorporation alone yielded 4.0 t per ha of rice grain, which was significantly higher than the yield obtained by the application of 60 kg N per ha (3.7 t/ha) under flooded conditions, and they opined that S.rostrata could supply N-requirement of rice upto 60 kg fertilizer N per ha. Further, they also found that S.rostrata could accumulate sufficient N between 48-60 days to increase the rice yields more than 2.0 t per ha compared to control (no -N source).

Rabindra et al.(1989) at Regional Research Station, Mandya, reported significantly higher rice grain yield(5.2 t/ha) when S. rostrata green manure with 70 kg N per ha as urea was applied, compared to the yield obtained by 100 kg N per ha as urea (4.5 t/ha). They also reported that the rice grain yield obtained by S. rostrata incorporation alone (3.4 t/ha) was comparable with that of the yield obtained by 70 kg N per ha as urea, and concluded that use of S. rostrata could substitute for fertilizer - N upto 70 kg per ha in rice production and cost involved in supplying N-through S. rostrata was less compared to the urea cost to supply the same quantity of nitrogen.

Halepyati and Sheelavantar (1990b) at Dharwad, found that the incorporation of S. rostrata green manure alone gave as much grain yield (4.63 t/ha) as did the treatment receiving 100 kg N per ha as urea (4.55 t/ha) and opined that 100 kg N per ha could be substituted by S. rostrata green manure in rice production. Further, they also reported that increasing applied nitrogen with S. rostrata has further significantly increased the rice grain yield and also raised the N-status of the soil after harvest of the rice crop.

Kalidurai and Kannaiyan (1990) in Tamil Nadu, found that S. rostrata along with 60 kg N per ha through neem coated urea gave the highest grain yield (6.2 t/ha) and straw yield (15.1 t/ha) under wet season.

Thangaraju and Kannaiyan (1990) in Coimbatore, opined that incorporation of S.rostrata green manure (2 kg per m^2) alone yielded significantly higher rice grain yield (5.6 t/ha) and straw yield (10.7 t/ha) compared to 100 kg N per ha applied as urea super granules (USG), which yielded 5.1 t per ha rice grain and 11.0 t per ha straw. Further, they observed that grain yield was significantly higher with S. rostrata + 100 kg N per ha as urea super granules (6.6 t/ha).

Thakur (1991) in Bihar, showed that the rice grain yield obtained by the incorporation of S. rostrata green manure with 40 kg N per ha as urea (3.3 t/ha) was comparable to the yield obtained by 80 kg N per ha as urea (3.3 t/ha) and concluded that S. rostrata could substitute 40 kg N requirement of transplanted rice.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

A field experiment on "Effect of green manure of Sesbania rostrata in conjunction with nitrogen levels on the growth, yield and nitrogen economy of rice" was carried out during the kharif season 1990-91. The details of the material used and methodology adopted during the course of investigations are furnished in this chapter.

3.1 Experimental site

The experiment was conducted in plot No.3 of 'N' block at the Agricultural Research Station, Kathalagere, Shimoga District in the southern transition zone of Karnataka during kharif 1990-91. This research station is located in Bhadra Command area with irrigation facility for nearly 9 to 10 months in a year. The Research Station is situated at 13°2' N latitude and 76°15' E longitude at an elevation of 561.6 metres above mean sea level.

3.2 Soil and its characteristics

Topography of the land in experimental site was fairly uniform with a gentle gradient towards the western side. The composite soil samples were collected from each replication of the experimental plot from the top 0 to 30 cm layer before sowing S. rostrata. These samples were analysed for the physical and chemical properties and the data along with the methods of their determination are furnished in Table 1.

Soil from each treatment plot was analysed for total nitrogen before imposing the treatments and also after the harvest of rice crop.

3.3 Climatic conditions

The mean weather data of ten years in respect of rainfall and the data on total rainfall, maximum and minimum temperature, relative humidity that prevailed during the period of crop growth (July to November 1990) at the Agricultural Research Station, Kathalagere are presented in Appendix-I.

The annual normal rainfall of the Agricultural Research Station, Kathalagere was 559.98 mm. The rainfall was distributed from March to November with two peaks, one during July (91.13 mm) another in September (119.46 mm).

Table 1. Physical and chemical properties of the soil of the experimental site at Agricultural Research Station, Kathalagere

Soil properties	Value	Remarks	Method of determination
A. Physical properties			
1. Coarse sand (%)	28.88	-	International Pipette method (Piper, 1966)
2. Fine sand (%)	22.10	-	
3. Silt (%)	16.66	-	
4. Clay (%)	30.64	-	
5. Textural class		Clay-loam	
6. Field capacity (%)	17.40		Field method (Piper, 1966)
7. Bulk density (g/cc)	1.57	-	Core Sampler method (Piper, 1966)
B. Chemical Properties			
1. Soil pH	6.50	Normal	pH meter(Jackson, 1967)
2. Organic carbon(%)	0.52	Medium	Walkley and Black's method(Jackson, 1967)
3. Total nitrogen(kg/ha)	689.00	Medium	Modified Kjeldhal's method (Jackson,1967)
4. Available P_2O_5 (kg/ha)	11.00	Low	Bray's extractant method (Jackson,1973)
5. Available K_2O (kg/ha)	216.00	Medium	Flame photometer method(Jackson, 1973)

The crop growth period was from July 1990 to November 1990. The rainfall received during the crop growth period was less than the normal in June (68.8 mm), July (51.10 mm), September (18.5 mm) and October (45.4 mm), while it was more than the normal in May (108.0 mm), August (124.5 mm) and November (84.9 mm). The total rainfall received during the year 1990 was 501.20 mm and it was less by 58.78 mm as compared to the normal rainfall.

3.4 Cropping history of the experimental site

Generally paddy monoculture was practiced in the experimental site at the Agricultural Research Station, Kathalagere. Previous crop on the experimental site (during *kharif* 1989) was paddy and the site was kept fallow during summer, 1990.

3.5 Experimental details

The experimental details are as follows.

3.5.1 Treatments

There were seven treatments as detailed below.

T_1 - No Sesbania rostrata + no nitrogen (control)

T_2 - S. rostrata green manure only

T_3 - S. rostrata + 25 kg nitrogen per hectare

T_4 - S. rostrata + 50 kg nitrogen per hectare

T_5 - S. rostrata + 75 kg nitrogen per hectare

T_6 - S. rostrata + 100 kg nitrogen per hectare

T_7 - Normal practice (100 kg N per hectare)

A common dose of 50 kg P_2O_5 per ha and 50 kg K_2O per ha was applied to all the treatments. *S. rostrata* green manure biomass was incorporated *in situ* as per the treatments at the age of 55 days. Same quantity of biomass i.e. 25 kg per plot (18.5 t/ha) was incorporated into the soil of each plot except in the plot receiving T_1 and T_7 treatments.

3.5.2 Design and layout

The experiment was laid out in Completely Randomized Block Design (CRBD) with three replications. The layout plan adopted for the experiment is given in Fig.1.

3.5.3 Plot size

Gross plot size : 4.5 m x 3.0 m

Net plot size : 4.0 m x 2.4 m

LEGEND

T_1 – No *Sesbania rostrata* + No nitrogen (Control)
T_2 – *S. rostrata* green manure only
T_3 – *S. rostrata* + 25 Kg N per ha
T_4 – *S. rostrata* + 50 Kg N per ha
T_5 – *S. rostrata* + 75 Kg N per ha
T_6 – *S. rostrata* + 100 Kg N per ha
T_7 – Normal practice (100 Kg N per ha)

N ← S

* A common dose of 50 kg P_2O_5 and 50 Kg K_2O/ha applied to all treatments

** Equal quantity of *S. rostrata* green manure biomass (18.5 t/ha) incorporated *in situ* in all the treatment plots except in plots receiving T_1 & T_7 treatments.

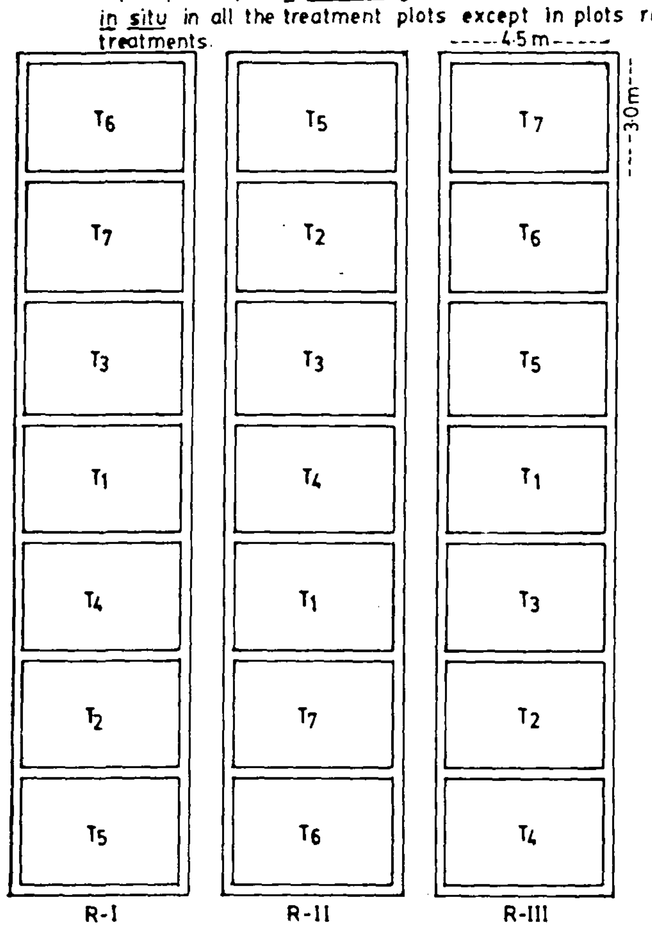

FIG. 1. LAYOUT PLAN OF THE EXPERIMENT

3.5.4 Spacing

Sesbania rostrata	:	30 cm x 10 cm
Paddy	:	20 cm x 10 cm

3.5.5 Variety

'Jaya' variety of paddy was used for the experiment. It is a coarse grain variety having moderately good tillering habit with plant height of about 83 cm and matures in 135 days. It responds well to the added nitrogen having high yield potential.

3.5.6 Land preparation

The land was ploughed twice and the clods were crushed to prepare fine seed bed. Plots were laid out as per the plan and strong small bunds of sufficient height were put around each plot and replication to prevent surface flow of water between the plots. Smoothening and slight levelling was done within the plots manually for maintaining uniform depth of water.

3.6 Growing of *Sesbania rostrata* green manure crop

3.6.1 Seed treatment

The seeds of *S. rostrata* were soaked in boiling water for 3 to 4 minutes and then treated with specific Rhizobium culture after the pretreatment of fungicide Emissan.

To treat the seeds with Rhizobium culture, sugar solution was sprinkled over the seeds uniformly. Later, Rhizobium culture was mixed properly with seeds wetted with sugar solution. It was ensured that the seed coat was smeared uniformly with rhizobium culture.

3.6.2 Sowing of S. rostrata green manure crop

The treated seeds of S. rostrata were dibbled in rows with an interrow spacing of 30 cm and intrarow spacing of 10 cm in each plot as per the treatment on 27.5.1990. To ensure uniform crop stand in each plot, gap filling was done wherever necessary after ten days through direct seeding.

3.6.3 Shoot inoculation of S. rostrata

A liquid culture of specific Rhizobium strain (CRS-571) obtained from the Department of Microbiology, UAS, Bangalore was sprayed on the shoots of S.rostrata in all the treatment plots after 30 days of sowing to initiate the stem nodulation.

3.6.4 Incorporation of S. rostrata green biomass

The plots were drained when S. rostrata crop was 55 days old. The plants in the treatment plots were cut to the ground level and further chopped into 10-20 cm long segments and incorporated into the soil on 22.7.90. The green biomass incorporated in each plot was 25 kg (18.5 t/ha) and the corresponding dry matter was 3.55 t per ha.

3.6.5 Plant analysis of S. rostrata

The plant sample along with stem and leaves collected at the time of incorporation, was oven dried at 60°C to a constant dry weight and then ground in willey mill and analysed for nitrogen content. Nitrogen estimation was done by micro-Kjeldhal's method (Black, 1965a).

3.6.6 Nitrogen accumulation

Nitrogen accumulation in S. rostrata green manure crop at the time of incorporation was calculated by the following formula.

$$\text{Nitrogen accumulation (kg/ha)} = \frac{\text{N-per cent in plant sample} \times \text{Dry biomass (kg/ha)}}{100}$$

3.7 Growing of paddy

3.7.1 Raising paddy nursery

The land selected for raising nursery was ploughed twice followed by clod crushing and harrowings to bring the soil to fine tilth. The field was levelled perfectly and raised seed beds of 7.5 m long, 1.2 m wide and 0.1 m height were prepared. Fertilizer at the rate of 450 g of ammonium sulphate, 280 g super phosphate, 75 g muriate of potash and 25 kg compost was applied by opening rows on the seed beds. Paddy seeds were sown in the small rows opened by the side of the fertilizer lines. The seed beds were irrigated immediately after sowing and maintained at the saturation level till the germination was complete. When the seedlings were one inch high, the seed beds were submerged in a shallow layer of water. One week before transplanting, each nursery bed was top dressed with 150 g of urea. Twenty-five days old seedlings were used for planting.

3.7.2 Fertilizer application

A common dose of 50 kg P_2O_5 and 50 kg K_2O per hectare was applied to all the plots at the time of transplanting of paddy and nitrogen was applied as per the treatments. Nitrogen was applied in two equal split doses, half at planting and the other half at panicle initiation stage.

3.7.3 Transplanting of paddy seedlings

Twenty five days old, healthy seedlings were uprooted from the nursery beds and transplanted in each treatment plot by providing an inter row spacing of 20 cm and intra row spacing of 10 cm. Two to three seedlings were planted per hill. Transplanting was done on 30.7.1990. Gap filling was done wherever necessary after a week through direct transplanting of paddy seedling.

Transplanting of paddy seedlings was undertaken one week after the *in situ* incorporation of *S. rostrata* green biomass in the plots.

Plate 1. Green manure crop stand of *Sesbania rostata* before *in situ* incorporation in the treatment plots.


Sesbania rostrata

3.7.4 After care

Butachlor (machete) herbicide was applied to the soil in each treatment plot by mixing with sand and broadcasting uniformly on fifth day after transplanting paddy seedlings. Rotary weeder was passed to remove the weeds and the plots were kept weed free throughout the growth period.

3.7.5 Irrigation

A thin sheet of water was maintained in the plots during first ten days after planting. From eleventh day onwards, water level in the plots was raised to 5 cm. In general, a water level of 3 to 5 cm was maintained upto ten days before harvesting of the crop.

3.7.6 Plant protection measures

Carbofuran granules at the rate of 18.5 kg per ha was applied to the plots on 25th day after trans - planting and spraying of Endosulfan was done on 50th and 70th day after transplanting.

3.7.7 Harvesting

Crop was harvested on 23.11.1990 with a total crop period of 140 days. First, all the border rows were harvested by cutting at the base, and threshed separately. Afterwards, the crop in the net plots was harvested and threshed. The grains were cleaned by winnowing and dried in the sunlight.

3.8 Collection of experimental data

Five plants were randomly selected in the net plot area of each treatment and tagged for the observations on growth parameters, at various growth stages and yield parameters at harvesting stage. Observations were recorded at a regular interval of 30 days after transplanting paddy and at harvesting stage.

Five plants at random were uprooted from the gross plot area and used for the recording of dry matter accumulation at different growth stages and also at harvesting stage. Crop from the net plot area was harvested, weighed and used for recording yield.

3.8.1 Growth parameters of paddy

3.8.1.1 Plant height

Plant height was measured from ground level to the tip of the top most leaf and after panicle emergence, the height was measured upto the tip of the tallest panicle. The mean plant height of five plants was expressed in centimetres (cm).

3.8.1.2 Total tiller number

The total number of tillers was recorded in tagged five plants by counting the number of tillers per hill at various growth stages. Mean of five plants was expressed as the number of tillers per hill.

3.8.1.3 Leaf area per plant (cm^2)

Leaves from the five plants, which were selected for the record of dry matter accumulation were separated and leaf area was recorded by directly feeding the leaves into the LI-3100 leaf area meter (from LI-COR, Inc/LI-COR Ltd., Nebraska, U.S.A.). The mean leaf area of five plants was computed.

3.8.1.4 Leaf area index (LAI)

Leaf area index is a measure of the extent of crop canopy covering the land. It was computed by using the formula suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area per plant}}{\text{Land area occupied by the plant}}$$

3.8.1.5 Leaf area duration (LAD)

Leaf area duration is the integral of LAI over the growth period and was worked out as outlined by Power *et al*. (1967). The formula reads,

$$LAD = \frac{LAI_1 + LAI_2}{2} \times (t_2 - t_1)$$

where,

LAI_1 and LAI_2 = periodical observation on leaf area index at an interval between time t_1 and t_2.

LAD thus calculated was expressed in days.

3.8.1.6 Dry matter production and accumulation

Five randomly selected plants at different growth stages were separated into leaf, stem and panicles, and were dried at 60°C to constant weight. Dry weight of leaves, stem and panicles was recorded separately. The mean dry weight of five plants was computed and expressed in g per plant.

3.8.2 Yield parameters

Five plants tagged in net plot area on which the observations on growth parameters were recorded, were also used for recording the observations on yield parameters.

3.8.2.1 Number of panicles per hill

The number of fully exerted and grain bearing panicles per hill was counted at maturity on all the five tagged plants. The mean of five plants was expressed as the number of panicles per hill.

3.8.2.2 Panicle length (cm)

Twenty panicles were randomly selected from the net plot. Length of each panicle was measured from the base of the panicle to the tip. The mean length per panicle was then calculated.

3.8.2.3 Single panicle weight (g)

Twenty randomly selected panicles from net plot area were weighed and the mean was calculated, expressed as g per panicle.

3.8.2.4 Number of grains per panicle

The number of fully developed grains per panicle were counted from all the panicles of each hill and average was worked out and expressed as the number of grains per panicle.

3.8.2.5 Thousand grain weight (g)

One thousand grains were counted and separated from the sample obtained from the net plot grain yield, weighed and then expressed in g.

3.8.2.6 Sterility percentage of spikelets

The totally undeveloped or poorly developed grains per panicle and total number of grains per panicle were counted. The spikelet sterility was calculated by the formula.

$$\text{Spikelet sterility}(\%) = \frac{\text{Total number of undeveloped grains per panicle}}{\text{Total number of grains per panicle}} \times 100$$

3.8.2.7 Grain yield

The crop in the net plot area was harvested discarding the border rows. The grains were threshed, winnowed, cleaned and dried under sunlight. The dried grain weight of each plot was recorded and it was expressed as grain yield in quintals per ha.

3.8.2.8 Straw yield

After threshing, the straw from the net plot area was sundried for a week and weight was recorded. The straw weight was then expressed as quintals per ha.

3.8.2.9 Harvest index

Harvest index was calculated by using the formula as outlined by Donald (1962).

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.8.3 Plant analysis

Plant samples collected to record the dry matter production and its accumulation at various growth stages were used for chemical analysis. The plant samples were oven dried at 60°C and ground in willey mill and analysed for nitrogen content.

3.8.3.1 Nitrogen content (%)

Nitrogen in the plant was determined by micro-Kjeldhal's method as outlined by Black (1965a). At harvesting stage nitrogen content in the rice straw and grain was determined separately.

3.8.3.2 Nitrogen uptake (kg/ha)

Based on the nitrogen per cent and dry matter of the plant part, the nitrogen uptake (kg/ha) in different parts was calculated, and from which the total uptake (kg/ha) by the crop at different growth stages was computed.

$$\text{Nitrogen uptake by straw or grains (kg/ha)} = \frac{\text{N \% in straw or grain}}{100} \times \text{Dry weight of straw or grain (kg/ha)}$$

3.8.4 Soil analysis for nitrogen

Composite soil samples from 0 to 30cm depth were collected before sowing of S. rostrata and after the harvest of rice crop from each treatment plot. The soil samples were dried in shade and finely powdered with wooden pestle and mortar to pass through 2 mm sieve. This soil sample was used for estimating total nitrogen content following the modified micro-Kjeldhal's method as outlined by Jackson (1967).

3.8.5 Statistical analysis of the experimental data

The experimental data were subjected to statistical test as per Fisher's method of Analysis of variance for completely Randomised Block Design as outlined by Sundararaj *et al*. (1972).

The level of significance used in 'F' and 't' tests was 5 per cent.

Critical difference values were calculated wherever the 'F' test was significant and in other cases, values of standard error of means have been furnished.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the experiment conducted during *kharif* 1990-91 at the Agricultural Research Station, Kathalagere, to study the effect of *Sesbania rostrata* on growth and yield of rice and on nitrogen economy are presented in this chapter.

4.1 Nitrogen content (per cent) in *S. rostrata*

Nitrogen content in the *S. rostrata* plant sample at the time of incorporation into the soil was 4.2 per cent on dry weight basis.

4.2 Nitrogen accumulation(kg/ha) by *S. rostrata*

Nitrogen accumulated by the *S. rostrata* green biomass at the time of incorporation was 149.1 kg per ha on dry weight basis.

4.3 Growth parameters of rice

4.3.1 Plant height of rice (cm)

The data on the plant height as influenced by the *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels at various growth stages are furnished in Table 2.

Table 2. Plant height (cm) of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different nitrogen levels at various growth stages

Treatments	30 DAP	60 DAP	90 DAP	At harvest
T_1 : No *S. rostrata* + no nitrogen(control)	32.47	41.37	55.36	60.27
T_2 : *S. rostrata* only	37.93	48.60	62.97	67.46
T_3 : *S. rostrata* + 25 kg N	38.63	53.40	67.53	72.63
T_4 : *S. rostrata* + 50 kg N	45.93	61.27	74.90	79.03
T_5 : *S. rostrata* + 75 kg N	49.70	65.67	79.23	85.23
T_6 : *S. rostrata* + 100 kg N	52.70	66.36	84.67	87.27
T_7 : Normal practice (100 kg N/ha)	44.90	59.70	74.03	77.97
Mean	43.18	56.62	71.24	75.69
S.Em.±	1.67	1.79	1.19	1.35
C.D. at 5%	5.15	5.53	3.68	4.18

Incorporation of *S. rostrata* green manure along with different nitrogen levels had significant effect on plant height of rice at all growth stages.

At harvest, maximum plant height was recorded with the treatment receiving *S. rostrata* + 100 kg N per ha (87.27 cm) followed by *S. rostrata* + 75 kg N per ha (85.23 cm) and both were significantly higher than the plant height recorded in all other treatments. The plant height recorded in the treatment *S. rostrata*+ 50 kg N per ha (79.03 cm), was on par with that of normal practice receiving 100 kg N per ha (77.97 cm). Lowest plant height was observed in the control which received no *S. rostrata* and no nitrogen (60.27 cm) and was significantly different from all other treatments.

At all other growth stages, the treatment receiving *S. rostrata* + 100 kg N per ha recorded the maximum plant height followed by the treatment receiving *S. rostrata* + 75 kg N per ha which were significantly higher over the control, which received no *S.rostrata* and no nitrogen. However, at 30 DAP and 60 DAP the plant height recorded in the treatments receiving *S. rostrata* alone and *S. rostrata* + 25 kg N per ha, *S.*

rostrata + 50 kg N per ha and S. rostrata + 75 kg N per ha, were on par with each other.

4.3.2 Number of tillers per hill

The data on the number of tillers per hill as influenced by in situ incorporation of S. rostrata green manure along with different nitrogen levels at various growth stages are furnished in Table 3 and the number of tillers per hill recorded at harvest is depicted in Fig.2.

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on number of tillers per hill at all growth stages.

At harvest, the treatment receiving S. rostrata + 100 kg N per ha recorded the highest number of tillers per hill (13.73) closely followed by S. rostrata + 75 kg N per ha (13.27), which were significantly superior to all other treatments. The number of tillers per hill with the treatment receiving S. rostrata + 50 kg N per ha (11.93) and that in the normal practice receiving 100 kg N per ha (11.73) were on par with each other. Significantly, lower number of tillers per hill was recorded in control plot (6.27) as against all other treatments.

Table 3. Number of tillers per hill of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different N-levels at various growth stages

Treatments	30 DAP	60 DAP	90 DAP	At harvest
T_1 : No *S. rostrata* + no nitrogen (control)	1.87	8.53	8.07	6.27
T_2 : *S. rostrata* only	2.40	11.20	9.93	8.20
T_3 : *S. rostrata* + 25 kg N	2.73	12.73	11.47	10.13
T_4 : *S. rostrata* + 50 kg N	3.40	15.33	13.27	11.93
T_5 : *S. rostrata* + 75 kg N	3.87	16.47	15.00	13.27
T_6 : *S. rostrata* + 100 kg N	3.93	16.87	15.40	13.73
T_7 : Normal practice (100 kg N/ha)	3.60	15.13	13.00	11.73
Mean	3.12	13.75	12.31	10.75
S.Em.±	0.12	0.37	0.48	0.40
C.D. at 5%	0.36	1.13	1.47	1.24

LEGEND

T_1 = No *Sesbania rostrata* + No nitrogen (CONTROL)
T_2 = *Sesbania rostrata* Green manure only
T_3 = *Sesbania rostrata* + 25kg N per ha
T_4 = *Sesbania rostrata* + 50kg N per ha
T_5 = *Sesbania rostrata* + 75kg N per ha
T_6 = *Sesbania rostrata* + 100 kg N per ha
T_7 = Normal practice (100kg N per ha)

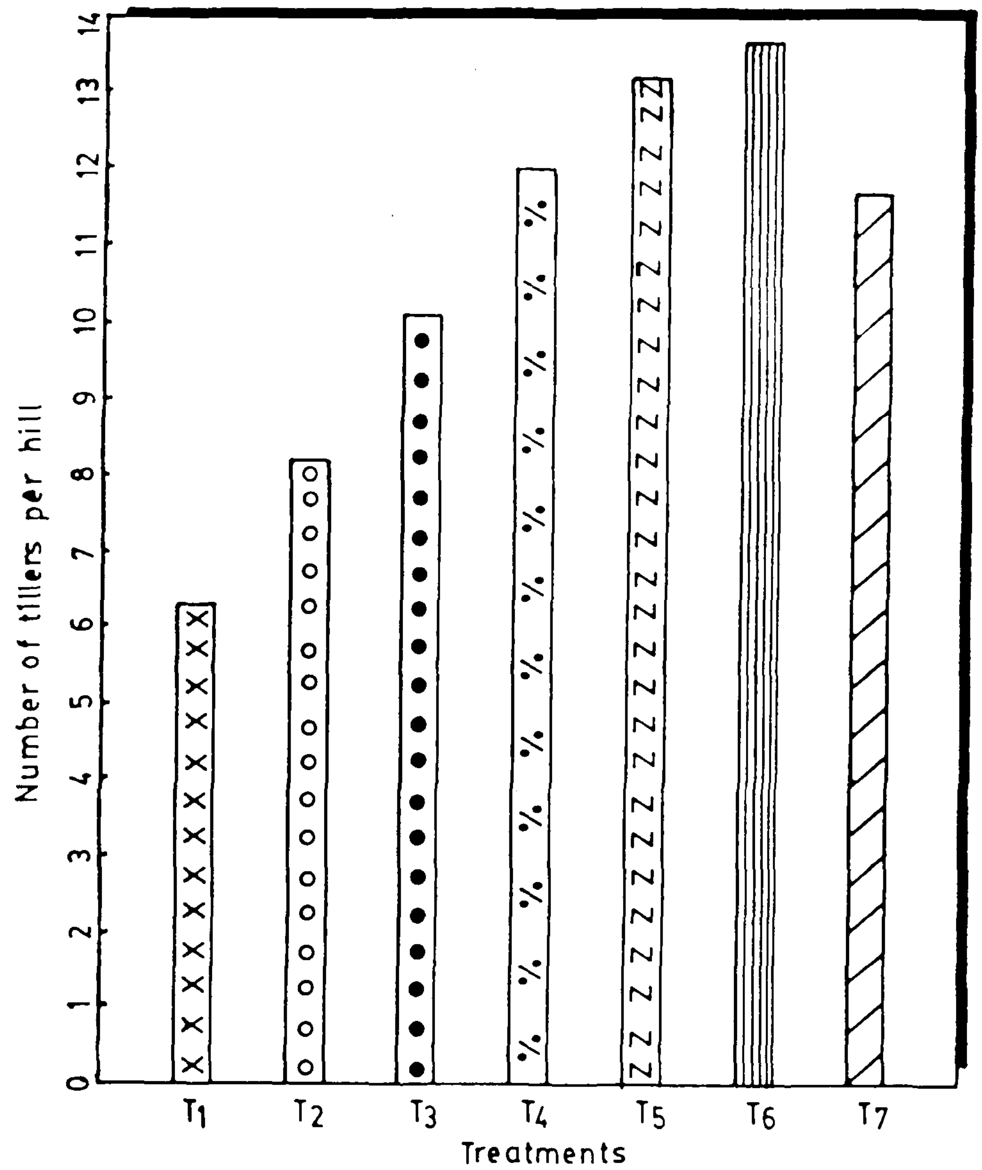

FIG.2. NUMBER OF TILLERS PER HILL OF RICE AS INFLUENCED BY *IN SITU* INCORPORATION OF *S. rostrata* GREEN MANURE ALONG WITH DIFFERENT NITROGEN LEVELS AT HARVEST.

At all other growth stages, the treatment receiving *S. rostrata* + 100 kg N per ha recorded the maximum number of tillers followed by *S. rostrata* + 75 kg N per ha and both were significantly superior to all other treatments. However, at 30 DAP the number of tillers per hill with the treatment receiving *S. rostrata* alone(2.40) was on par with that of *S. rostrata* + 25 kg N per ha(2.73).

4.3.3 Leaf area index (LAI) of rice

The data on the leaf area index (LAI) as influenced by *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels at various growth stages are presented in Table 4.

Incorporation of *S. rostrata* green manure along with different nitrogen levels had significant effect on LAI at all growth stages. Maximum LAI was observed at 90 DAP in all treatments, the treatment receiving *S. rostrata* + 100 kg N per ha (5.68) and *S. rostrata* + 75 kg N per ha (5.46), being significantly superior to all other treatments. LAI in *S. rostrata* + 50 kg N per ha (5.11) was on par with that recorded with normal practice receiving 100 kg N per ha (5.11). Lowest LAI was recorded with the control plot (3.85), which was significantly different as compared to the treatment receiving *S. rostrata* green manure alone (4.37).

Table 4. Leaf area index(LAI) of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different N-levels at various growth stages

Treatments	30 DAT	60 DAT	90 DAT	At harvest
T_1 : No *S. rostrata* + no nitrogen(control)	0.86	2.67	3.85	1.54
T_2 : *S. rostrata* only	1.05	3.38	4.37	2.16
T_3 : *S. rostrata* + 25 kg N	1.17	3.85	4.76	2.32
T_4 : *S. rostrata* + 50 kg N	1.28	4.31	5.11	2.88
T_5 : *S. rostrata* + 75 kg N	1.49	4.61	5.46	3.17
T_6 : *S. rostrata* + 100 kg N	1.56	4.71	5.68	3.45
T_7 : Normal practice (100 kg N/ha)	1.28	4.27	5.11	2.82
Mean	1.24	3.97	4.91	2.62
S.Em.±	0.05	0.10	0.11	0.13
C.D. at 5%	0.16	0.30	0.34	0.41

At 30 DAP and 60 DAP, maximum LAI was recorded with the treatment receiving S. rostrata + 100 kg N per ha followed by S. rostrata + 75 kg N per ha, which were significantly superior to control.

However, at harvest the LAI decreased considerably and the maximum LAI was observed in the treatment S. rostrata + 100 kg N per ha (3.45) followed by S. rostrata + 75 kg N per ha (3.17), which were significantly superior to all other treatments.

4.3.4 Total dry matter production (g/hill)

The data on total dry matter production as influenced by in situ incorporation of S. rostrata green manure along with different nitrogen levels at various growth stages are furnished in Table 5. Total dry matter production recorded at harvest is depicted in Fig. 3.

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on total dry matter production at all growth stages.

At harvest, maximum dry matter production was recorded with the treatment receiving S. rostrata + 100 kg N per ha (19.76 g) closely followed by S. rostrata

Table 5. Dry matter production (g/hill) of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different N-levels at various growth stages

Treatments	30 DAP	60 DAP	90 DAP	At harvest
T_1 : No *S. rostrata* + no nitrogen (control)	0.45	3.49	7.47	12.58
T_2 : *S. rostrata* only	0.88	4.59	9.15	15.11
T_3 : *S. rostrata* + 25 kg N	1.21	5.46	10.41	16.28
T_4 : *S. rostrata* + 50 kg N	1.63	6.18	10.99	17.93
T_5 : *S. rostrata* + 75 kg N	1.75	6.90	12.15	19.39
T_6 : *S. rostrata* + 100 kg N	1.81	7.07	12.51	19.76
T_7 : Normal practice (100 kg N/ha)	1.58	6.09	10.83	17.43
Mean	1.33	5.73	10.49	16.93
S.Em.±	0.05	0.23	0.24	0.29
C.D. at 5%	0.16	0.70	0.73	0.87

LEGEND

T_1 = No *Sesbania rostrata* + No nitrogen (CONTROL)
T_2 = *Sesbania rostrata* Green manure only
T_3 = *Sesbania rostrata* + 25kg N per ha
T_4 = *Sesbania rostrata* + 50kg N per ha
T_5 = *Sesbania rostrata* + 75kg N per ha
T_6 = *Sesbania rostrata* + 100 kg N per ha
T_7 = Normal practice (100kg N per ha)

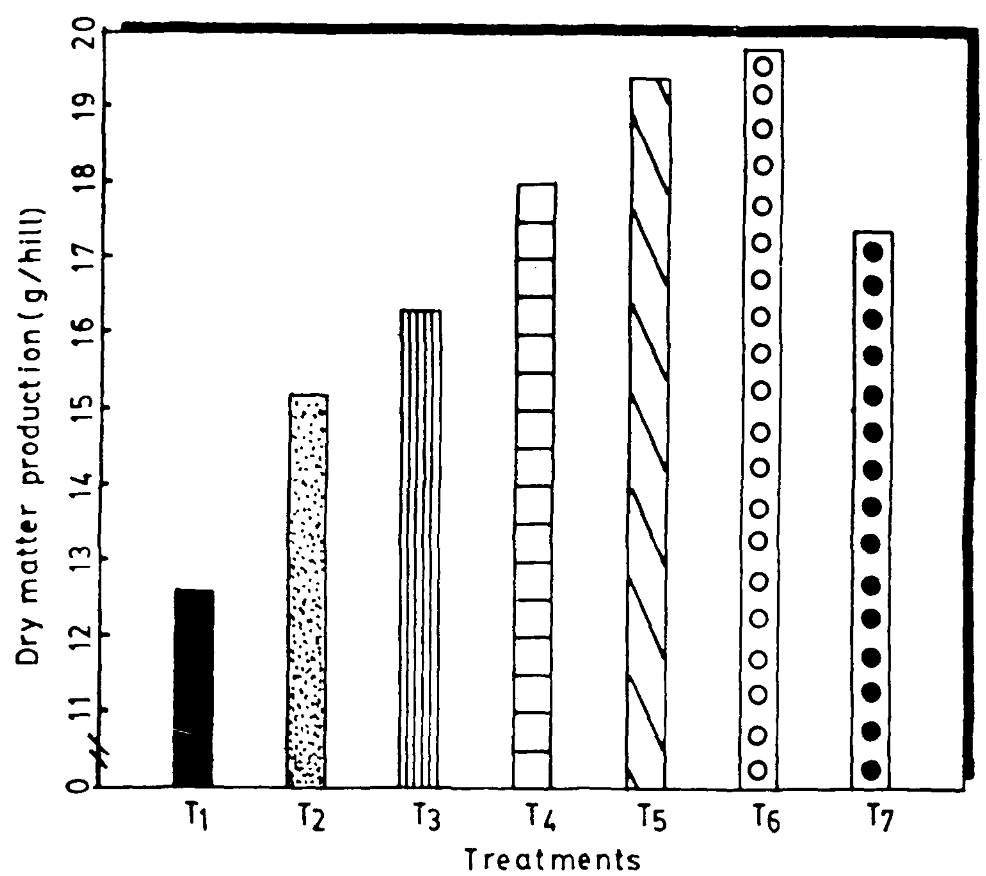

FIG.3. DRY MATTER PRODUCTION (g/hill) OF RICE AS INFLUENCED BY *IN SITU* INCORPORATION OF *S. rostrata* GREEN MANURE ALONG WITH DIFFERENT NITROGEN LEVELS AT HARVEST.

+ 75 kg N per ha (19.39 g), which were superior to all other treatments. The dry matter production with the treatment receiving S. rostrata + 50 kg N per ha (17.93g) and that recorded with the normal practice receiving 100 kg N per ha (17.43 g) were on par but superior to the control (12.58 g). Lowest dry matter production was recorded with the control plot (12.58 g) which was significantly different as compared to all other treatments.

At other growth stages, the maximum dry matter production was observed with the treatment receiving S. rostrata + 100 kg N per ha followed by S. rostrata + 75 kg N per ha and both were superior to all other treatments. However, at 30 DAP the dry matter production recorded with the treatment receiving S. rostrata + 50kg N per ha (1.63 g) was on par with that of S. rostrata + 75 kg N per ha (1.75 g). At 90 DAP, the dry matter production observed with S. rostrata + 25 kg N per ha(10.41g) and with S. rostrata + 50 kg N per ha (10.99 g) were on par with each other.

4.3.5 Dry matter accumulation in leaf (g/hill)

The data on the dry matter accumulation in leaf as influenced by incorporation of S.rostrata green manure along with different nitrogen levels at various growth stages are presented in Table 6.

Table 6. Dry matter accumulation in leaf (g/hill) of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different N-levels at various growth stages

Treatments	30 DAP	60 DAP	90 DAP	At harvest
T_1 : No *S. rostrata* + no nitrogen (control)	0.26	1.30	2.12	2.01
T_2 : *S. rostrata* only	0.51	1.82	2.80	2.50
T_3 : *S. rostrata* + 25 kg N	0.67	2.03	2.91	2.50
T_4 : *S. rostrata* + 50 kg N	0.89	2.64	2.93	2.61
T_5 : *S. rostrata* + 75 kg N	0.90	2.99	3.02	2.97
T_6 : *S. rostrata* + 100 kg N	0.93	3.11	3.17	3.15
T_7 : Normal practice (100 kg N/ha)	0.85	2.60	2.89	2.55
Mean	0.72	2.36	2.83	2.61
S.Em. ±	0.04	0.14	0.08	0.10
C.D. at 5%	0.11	0.42	0.23	0.32

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on dry matter accumulation in leaf of rice at all growth stages.

Maximum dry matter accumulation in leaf was recorded at 90 DAP in all the treatments. The treatment receiving S. rostrata + 100 kg N per ha (3.17 g) followed by S.rostrata + 75 kg N per ha (3.02 g) recorded significantly higher dry matter as compared to all other treatments. The dry matter accumulation in leaf recorded with the treatment receiving S. rostrata + 50 kg N per ha (2.93 g) was on par with that recorded with the normal practice receiving 100 kg N per ha (2.89 g). Significantly lowest dry matter accumulation in leaf was recorded with the control (2.12 g) as against all other treatments.

At harvest, the maximum dry matter accumulation was observed with the treatment receiving S. rostrata + 100 kg N per ha (3.15 g) followed by S. rostrata + 75 kg N per ha (2.97 g) which were significantly superior over all other treatments. However, the dry matter recorded with the treatment receiving S. rostrata + 50 kg N per ha (2.61 g) was on par with that recorded with normal practice receiving 100 kg N per ha (2.55 g). Similar trend in dry matter accumulation in leaf was noticed at 30 DAP and at 60 DAP in these treatments.

4.3.6 Dry matter accumulation in stem (g/hill)

The data on dry matter accumulation in stem as influenced by *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels at various growth stages are furnished in Table 7.

Incorporation of *S. rostrata* green manure along with different nitrogen levels had significant effect on the dry matter accumulation in stem at all growth stages.

Maximum dry matter accumulation in stem was recorded at 90 DAT in all the treatments. The treatments receiving *S. rostrata* + 100 kg N per ha (7.59 g) closely followed by *S. rostrata* + 75 kg N per ha (7.53 g) were significantly superior to all others. At harvest, the treatment receiving *S. rostrata* + 50 kg N per ha recorded the dry matter accumulation (5.96 g) which was on par with that of normal practice receiving 100 kg N per ha (5.91 g). The maximum dry matter in stem was recorded with *S. rostrata* + 100 kg N per ha (6.42 g) followed by *S. rostrata* + 75 kg N per ha (6.38 g) and both were significantly superior to all other treatments. Significantly, lowest dry matter was recorded with the control(4.56g) as compared to all other treatments at harvest.

Table 7. Dry matter accumulation in stem (g/hill) of rice as influenced by incorporation of *Sesbania rostrata* green manure along with different N-levels, at various growth stages

Treatments	30 DAP	60 DAP	90 DAP	At harvest
T_1 : No *S. rostrata* + no nitrogen (control)	0.19	2.19	4.83	4.56
T_2 : *S. rostrata* only	0.37	2.77	5.46	5.44
T_3 : *S. rostrata* + 25 kg N	0.54	3.43	6.29	5.63
T_4 : *S. rostrata* + 50 kg N	0.74	3.54	6.61	5.96
T_5 : *S. rostrata* + 75 kg N	0.85	3.91	7.53	6.38
T_6 : *S. rostrata* + 100 kg N	0.88	3.96	7.59	6.42
T_7 : Normal practice (100 kg N/ha)	0.73	3.49	6.58	5.91
Mean	0.61	3.33	6.41	5.76
S.Em.±	0.03	0.16	0.24	0.20
C.D. at 5%	0.11	0.49	0.75	0.61

At all other growth stages, the maximum dry matter accumulation in stem was recorded with the treatment receiving S. rostrata + 100 kg N per ha closely followed by the treatment S. rostrata + 75 kg N per ha, which were significantly superior to others. S. rostrata + 50 kg N per ha recorded the dry matter accumulation, which was on par with that recorded with the normal practice receiving 100 kg N per ha.

4.3.7 Dry matter accumulation in panicle (g/hill)

The data on dry matter accumulation in panicles as influenced by in situ incorporation of S. rostrata green manure along with different nitrogen levels at 90 DAP and at harvest are furnished in Table 8.

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on dry matter accumulation in panicles both at 90 DAP and at harvest.

At harvest, maximum dry matter accumulation in panicles was recorded with the treatment receiving S. rostrata + 100 kg N per ha (10.19 g), closely followed

Table 8. Dry matter accumulation in panicle (g/hill) of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different N-levels at various growth stages

Treatment	90 DAP	At harvest
T_1 : No *S. rostrata* + no nitrogen (control)	0.52	6.01
T_2 : *S. rostrata* only	0.89	7.17
T_3 : *S. rostrata* + 25 kg N	1.21	8.15
T_4 : *S. rostrata* + 50 kg N	1.45	9.36
T_5 : *S. rostrata* + 75 kg N	1.60	10.04
T_6 : *S. rostrata* + 100 kg N	1.75	10.19
T_7 : Normal practice (100 kg N/ha)	1.36	8.97
Mean	1.25	8.55
S.Em.±	0.07	0.15
C.D. at 5%	0.21	0.46

by S. rostrata + 75 kg N per ha (10.04 g) which were significantly superior to all other treatments. The dry matter accumulation with the treatment S. rostrata + 50 kg N per ha (9.36 g) was on par with that recorded with the normal practice receiving 100 kg N per ha (8.97g). Significantly lowest dry matter accumulation was recorded with the control (6.01 g), which received no S. rostrata and no nitrogen as against the treatment, which received S. rostrata alone (7.17 g) and all other treatments.

At 90 DAP, the dry matter accumulation recorded with the treatment receiving S. rostrata + 50 kg N per ha (1.45 g) was on par with that of S. rostrata + 75 kg N per ha (1.60 g) and the normal practice receiving 100 kg N per ha (1.36 g). Maximum dry matter was recorded with S. rostrata + 100 kg N per ha (1.75 g) followed by S. rostrata + 75 kg N per ha (1.60), which were significantly superior to the control (0.52 g) and the normal practice receiving 100 kg N per ha (1.36 g).

4.3.8 Leaf Area Duration (LAD) (days)

The data on leaf area duration as influenced by in situ incorporation of S. rostrata green manure along with different nitrogen levels at various growth stages are presented in Table 9.

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on LAD at all growth stages.

Maximum LAD was observed during 61 to 90 DAP in all the treatments. The treatment receiving S.rostrata + 100 kg N per ha recorded the maximum LAD (155.79), closely followed by the treatment S. rostrata + 75 kg N per ha (151.06) and both were significantly higher than all others.

The LAD recorded with the treatment S. rostrata + 50 kg N per ha (141.32) was on par with that of the normal practice receiving 100 kg N per ha (140.68) and significantly superior to the control (97.73).

At 30 to 60 DAP and at 91 days to harvest, maximum LAD was recorded with the treatment receiving S.rostrata + 100 kg N per ha closely followed by S. rostrata + 75kg N per ha, which were significantly superior to the normal practice receiving 100 kg N per ha. The treatment receiving S. rostrata + 50 kg N per ha and the normal practice

Table 9. Leaf area duration (LAD)(days) of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different N-levels at various growth stages

Treatments	30-60 DAP	61-90 DAP	91-harvest
T_1 : No *S. rostrata* + no nitrogen (control)	52.96	97.73	62.04
T_2 : *S. rostrata* only	66.53	116.27	75.04
T_3 : *S. rostrata* + 25 kg N	75.26	129.08	81.38
T_4 : *S. rostrata* + 50 kg N	83.81	141.32	91.93
T_5 : *S. rostrata* + 75 kg N	91.56	151.06	99.26
T_6 : *S. rostrata* + 100 kg N	94.10	155.79	105.01
T_7 : Normal practice (100 kg N/ha)	83.24	140.68	91.11
Mean	78.21	133.13	86.54
S.Em.±	1.60	1.97	2.08
C.D. at 5%	4.93	6.09	6.43

receiving 100 kg N per ha were on par and both were significantly superior to control.

4.4 Yield parameters of rice

4.4.1 Grain yield (q/ha), straw yield (q/ha) and Harvest index (HI)

The data on grain yield, straw yield and harvest index as influenced by *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels are presented in Table 10 and depicted in Fig.4.

Incorporation of *S. rostrata* green manure along with different nitrogen levels had significant effect on grain yield, straw yield and also on harvest index.

Highest grain yield was recorded with the treatment receiving *S. rostrata* + 100 kg N per ha (67.64 q/ha), closely followed by *S. rostrata* + 75 kg N per ha (65.55 q/ha), which were significantly superior to the grain yield recorded with all other treatments. The treatment receiving *S. rostrata* + 50 kg N per ha (59.73 q/ha), was on par with that of the normal practice

Table 10. Grain yield (q/ha), straw yield (q/ha) and harvest index (HI) of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different N-levels

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest Index
T_1 : No *S. rostrata* + no nitrogen (control)	39.51	59.20	0.400
T_2 : *S. rostrata* only	48.19	67.91	0.415
T_3 : *S. rostrata* + 25 kg N	53.42	72.93	0.423
T_4 : *S. rostrata* + 50 kg N	59.73	78.12	0.433
T_5 : *S. rostrata* + 75 kg N	65.55	81.20	0.447
T_6 : *S. rostrata* + 100 kg N	67.64	85.25	0.442
T_7 : Normal practice (100 kg N/ha)	58.38	76.92	0.431
Mean	56.06	74.50	0.427
S.Em.±	1.15	1.56	0.005
C.D. at 5%	3.55	4.81	0.016

receiving 100 kg N per ha (58.38 q/ha). The grain yield recorded with the control treatment receiving no _S. rostrata_ and no nitrogen (39.51 q/ha) was significantly lower as compared to the treatments, which received _S. rostrata_ green manure alone (48.19) and _S. rostrata_ + 25 kg N per ha (53.42 q/ha).

Highest straw yield was recorded with the treatment receiving _S. rostrata_ + 100 kg N per ha (85.25 q/ha) which was on par with that of _S. rostrata_ + 75 kg N per ha (81.20 q/ha). These were significantly superior to all other treatments, except the treatment receiving _S. rostrata_ + 50 kg N per ha (78.12 q/ha), which was on par with that of _S. rostrata_ + 75 kg N per ha (81.20 q/ha) and the normal practice receiving 100 kg N per ha (76.92 q/ha). Significantly lowest straw yield was recorded with the control treatment (59.20 q/ha) compared to the treatment receiving _S. rostrata_ green manure alone (67.91 q/ha) and _S. rostrata_ + 25 kg N per ha (72.93q/ha).

Maximum harvest index was observed with the treatment receiving _S. rostrata_ + 75 kg N per ha (0.447) followed by _S. rostrata_ + 100 kg N per ha (0.442) and

LEGEND

T_1 = No *Sesbania rostrata* + No nitrogen (CONTROL)
T_2 = *Sesbania rostrata* Green manure only
T_3 = *Sesbania rostrata* + 25kg N per ha
T_4 = *Sesbania rostrata* + 50kg N per ha
T_5 = *Sesbania rostrata* + 75kg N per ha
T_6 = *Sesbania rostrata* + 100kg N per ha
T_7 = Normal practice (100kg N per ha)

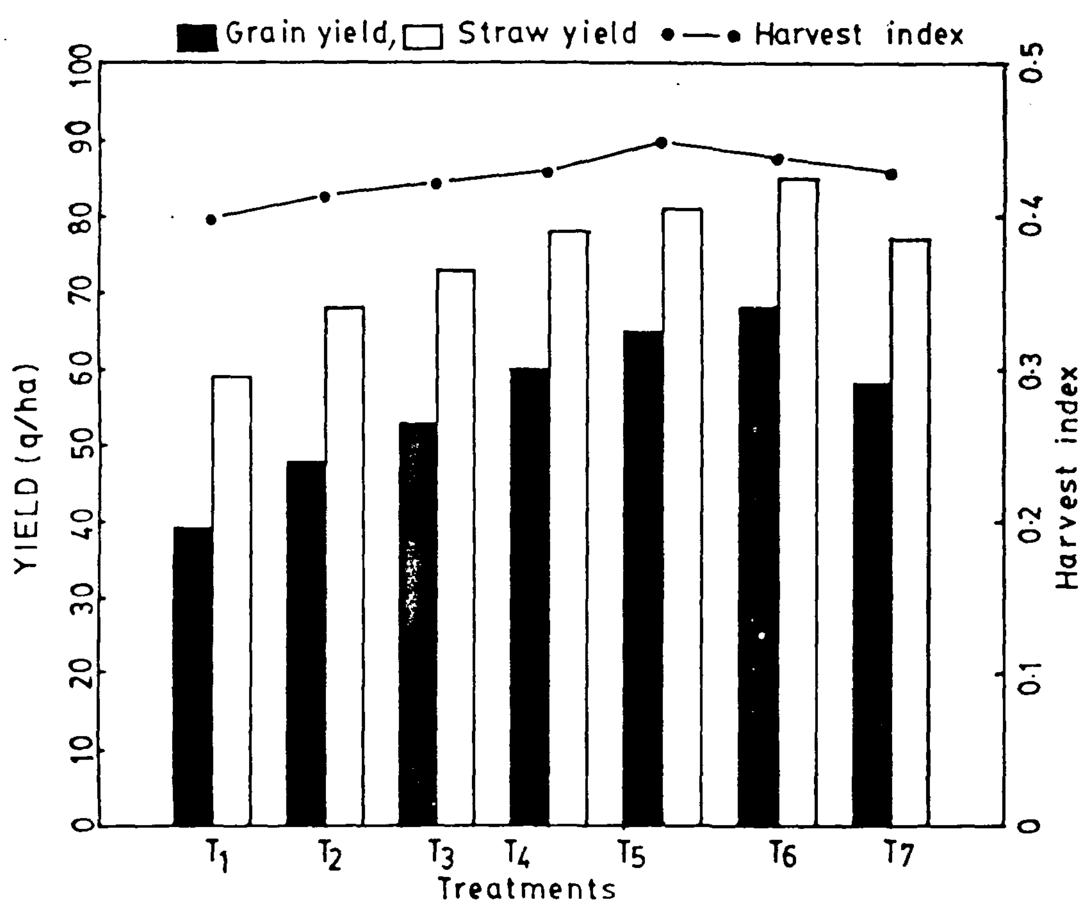

FIG. 4. GRAIN YIELD (q/ha), STRAW YIELD (q/ha) AND HARVEST INDEX OF RICE AS INFLUENCED BY INSITU INCORPORATION OF *S. rostrata* GREEN MANURE ALONG WITH DIFFERENT NITROGEN LEVELS.

both were significantly superior to the control (0.400). The harvest index recorded with the treatment receiving S. rostrata + 50 kg N per ha (0.433) was on par with that of S. rostrata + 75 kg N per ha (0.447), the normal practice receiving 100 kg N per ha (0.431) and also with that of S. rostrata + 25 kg N per ha (0.423).

4.4.2 Number of panicles per hill and number of grains per panicle of rice

The data on number of panicles per hill and number of grains per panicle as influenced by *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels are presented in Table 11 and depicted in Fig. 5.

Incorporation of *S. rostrata* green manure along with different nitrogen levels had significant effect on number of panicles per hill and on number of grains per panicle.

Highest number of panicles per hill was recorded with the treatment receiving *S. rostrata* + 100 kg N per ha (9.53) closely followed by *S. rostrata* + 75 kg N per ha (9.47) and both were significantly superior to all other treatments. The number of panicles per hill recorded with the treatment receiving *S. rostrata* + 50 kg

Table 11. Number of panicles per hill and number of grains per panicle as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different N-levels

Treatments	Number of panicles per hill	Number of grains per panicle
T_1 : No *S. rostrata* + no nitrogen (control)	4.87	69.40
T_2 : *S. rostrata* only	6.27	83.50
T_3 : *S. rostrata* + 25 kg N	7.40	88.77
T_4 : *S. rostrata* + 50 kg N	8.43	97.93
T_5 : *S.rostrata* + 75 kg N	9.47	105.97
T_6 : *S. rostrata* + 100 kg N	9.53	108.80
T_7 : Normal practice (100 kg N/ha)	7.87	96.87
Mean	7.69	93.03
S.Em.±	0.33	1.04
C.D. at 5%	1.00	3.20

LEGEND

T1 = No *Sesbania rostrata* + No nitrogen (CONTROL)
T2 = *Sesbania rostrata* Green manure only
T3 = *Sesbania rostrata* + 25kg N per ha
T4 = *Sesbania rostrata* + 50kg N per ha
T5 = *Sesbania rostrata* + 75kg N per ha
T6 = *Sesbania rostrata* + 100kg N per ha
T7 = Normal practice (100kg N per ha)

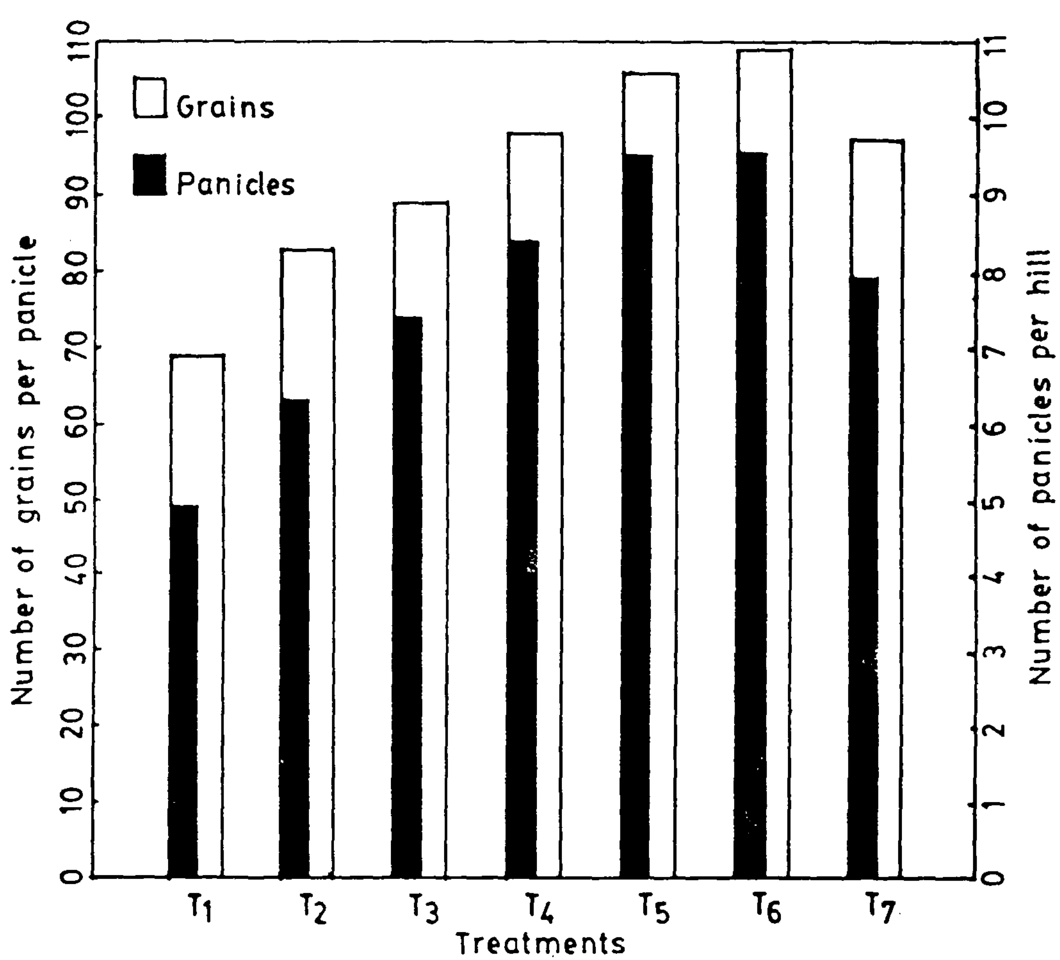

FIG. 5. NUMBER OF PANICLES PER HILL AND NUMBER OF GRAINS PER PANICLE AS INFLUENCED BY *IN SITU* INCORPORATION OF *S. rostrata* GREEN MANURE ALONG WITH DIFFERENT NITROGEN LEVELS.

N per ha (8.43) was on par with that of the normal practice receiving 100 kg N per ha (7.87), but both were superior to control (4.87). Treatments receiving S. rostrata alone (6.27) and S. rostrata + 25 kg N per ha (7.40) were significantly superior to control(4.87).

Maximum number of grains per panicle was obtained with the treatment receiving S. rostrata + 100 kg N per ha (108.8) followed by S. rostrata + 75 kg N per ha (105.97), which were significantly higher over all other treatments. The number of grains per panicle recorded with the treatment receiving S. rostrata + 50 kg N per ha (97.93) was on par with that of the normal practice receiving 100 kg N per ha (96.87). The number of grains per panicle obtained with the control treatment (69.40) was significantly lower as compared to the treatment receiving S. rostrata alone (83.50) and S. rostrata + 25 kg N per ha (88.77).

4.4.3 Panicle length(cm) and single panicle weight(g) of rice

The data on panicle length(cm) and single panicle weight(g) of rice as influenced by *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels are furnished in Table 12.

Incorporation of *S. rostrata* green manure along with different nitrogen levels had significant effect on panicle length and panicle weight.

Panicle length recorded with the treatments *S. rostrata* + 100 kg N per ha (23.60 cm) and *S. rostrata* + 75 kg N per ha (23.20 cm) were identical and both were significantly superior to all other treatments. The treatment receiving *S. rostrata* + 50 kg N per ha recorded a panicle length of 22.43 cm, which was on par with that of the normal practice receiving 100 kg N per ha (22.47 cm). The lowest panicle length was recorded in control treatment (18.40 cm), which was significantly less as compared to the treatments, which received *S. rostrata* alone (19.93 cm) and *S. rostrata* + 25 kg N per ha (21.50 cm).

Highest panicle weight was obtained in the treatment receiving *S. rostrata* + 100 kg N per ha (2.07 g)

Table 12. Panicle length and panicle weight of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different nitrogen levels.

Treatments	Panicle length (cm)	Panicle weight (g)
T_1 : No *S. rostrata* + no nitrogen (control)	18.40	1.22
T_2 : *S. rostrata* only	19.93	1.57
T_3 : *S. rostrata* + 25 kg N	21.50	1.86
T_4 : *S. rostrata* + 50kg N	22.43	1.98
T_5 : *S. rostrata* + 75 kg N	23.20	2.01
T_6 : *S. rostrata* + 100 kg N	23.60	2.07
T_7 : Normal practice (100 kg N/ha)	22.47	1.83
Mean	21.65	1.79
S.Em.±	0.14	0.09
C.D. at 5%	0.43	0.27

which was on par with that of S. rostrata + 75 kg N per ha (2.01 g). These were significantly superior to the control treatment (1.22 g). The panicle weight recorded with the treatment receiving S. rostrata + 50 kg N per ha (1.98 g) was on par with the treatment S. rostrata + 25 kg N per ha (1.86 g), S. rostrata + 75 kg N per ha (2.01 g) and with the normal practice receiving 100 kg N per ha (1.83 g). Panicle weight recorded with the control plot (1.22 g) was significantly lower than that of the treatments receiving S. rostrata alone (1.57 g) and S. rostrata + 25 kg N per ha (1.86 g).

4.4.4 Thousand grain weight (g) and spikelet sterility (per cent)

The data on thousand grain weight and spikelet sterility of rice as influenced by in situ incorporation of S. rostrata green manure along with different nitrogen levels are presented in Table 13 and depicted in Fig. 6.

Incorporation of S. rostrata green manure along with different nitrogen levels had non-significant effect on thousand grain weight, but had significant effect on spikelet sterility.

Table 13. Thousand grain weight(g) and spikelet sterility (percentage) of rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different nitrogen levels

Treatments	1000-grain weight(g)	Spikelet sterility(%)
T_1 : No *S. rostrata* + no nitrogen(control)	29.97	25.43
T_2 : *S. rostrata* only	30.47	22.32
T_3 : *S. rostrata* + 25 kg N	30.36	21.06
T_4 : *S. rostrata* + 50 kg N	30.30	19.53
T_5 : *S. rostrata* + 75 kg N	30.20	17.55
T_6 : *S. rostrata* + 100 kg N	30.07	17.01
T_7: Normal practice (100 kg N/ha)	30.27	19.62
Mean	30.23	20.36
S.Em.±	0.29	0.32
C.D. at 5%	NS	0.99

NS = Non significant

LEGEND

T_1 = No *Sesbania rostrata* + No nitrogen (CONTROL)
T_2 = *Sesbania rostrata* Green manure only
T_3 = *Sesbania rostrata* + 25kg N per ha
T_4 = *Sesbania rostrata* + 50kg N per ha
T_5 = *Sesbania rostrata* + 75kg N per ha
T_6 = *Sesbania rostrata* + 100kg N per ha
T_7 = Normal practice (100kg N per ha)

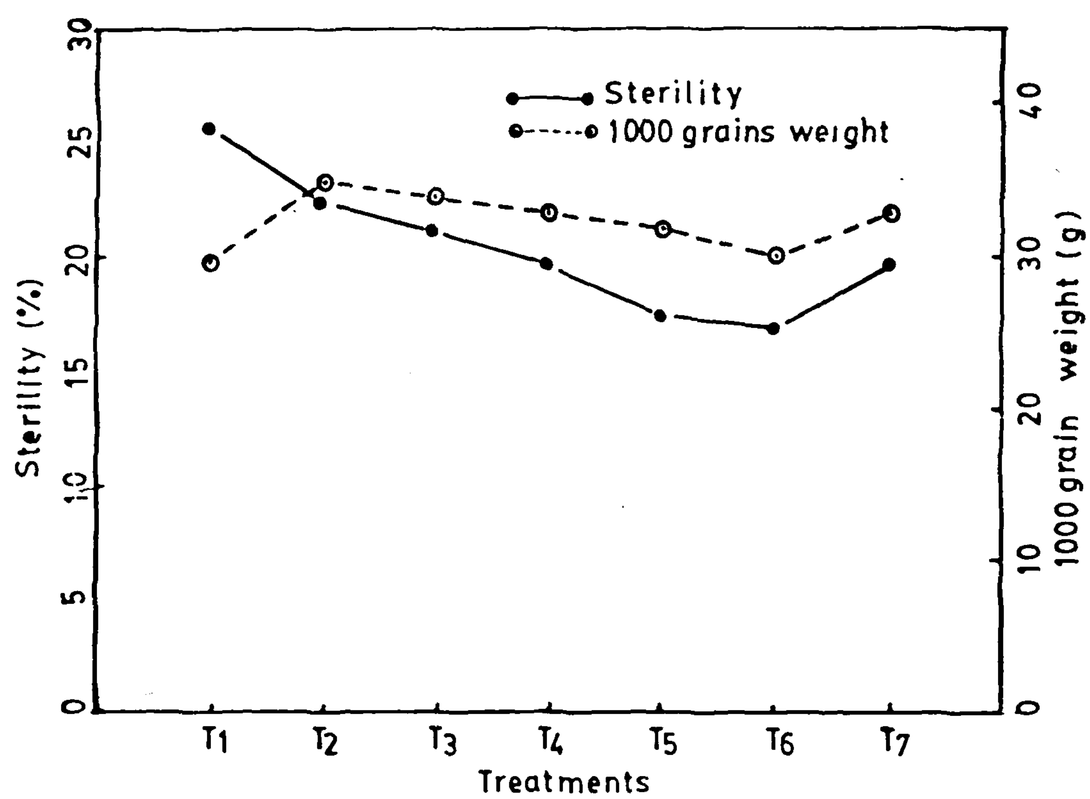

FIG. 6. THOUSAND GRAIN WEIGHT (g) AND SPIKELET STERILITY (%) OF RICE AS INFLUENCED BY *IN SITU* INCORPORATION OF *Sesbania rostrata* GREEN MANURE ALONG WITH DIFFERENT NITROGEN LEVELS.

The thousand grain weight recorded in different treatments ranged from 29.97 g to 30.47 g.

Highest spikelet sterility was recorded with the control treatment (25.43 per cent), which was significantly different from all other treatments. The spikelet sterility recorded with the treatment receiving S. rostrata + 50 kg N per ha (19.53 per cent) was on par with that of normal practice (19.62 per cent). The lowest spikelet sterility was recorded with S. rostrata + 100 kg N per ha (17.01 per cent) closely followed by S. rostrata + 75 kg N per ha (17.55 per cent) and both were significantly lower than all other treatments.

4.5 Nitrogen content in rice plant

4.5.1 Nitrogen content in rice straw (per cent)

The data on nitrogen content in rice straw as influenced by in situ incorporation of S. rostrata green manure along with different nitrogen levels at various growth stages are furnished in Table 14 and depicted in Fig.7.

Incorporation of S. rostrata green manure along

Table 14. Nitrogen per cent in rice straw as influenced by *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels at various growth stages

Treatments	30 DAP	60 DAP	90 DAP	At harvest
T_1 : No *S. rostrata* + no nitrogen (control)	2.86	1.58	1.32	0.44
T_2 : *S. rostrata* only	3.09	1.61	1.45	0.55
T_3 : *S. rostrata* + 25 kg N	3.15	1.64	1.52	0.59
T_4 : *S. rostrata* + 50 kg N	3.08	1.69	1.60	0.65
T_5 : *S. rostrata* + 75 kg N	3.27	1.77	1.65	0.71
T_6 : *S. rostrata* + 100 kg N	3.29	1.78	1.65	0.73
T_7 : Normal practice (100 kg N/ha)	3.18	1.69	1.59	0.65
Mean	3.13	1.68	1.54	0.62
S.Em.±	0.03	0.01	0.03	0.02
C.D. at 5%	0.11	0.05	0.08	0.05

with different nitrogen levels had significant effect on the nitrogen content of rice straw at all growth stages. Maximum nitrogen content was recorded in the straw at 30 DAP in all the treatments.

Maximum nitrogen content in rice straw was recorded at 30 DAP, with the treatment receiving S. rostrata + 100 kg N per ha (3.29 per cent) followed by S. rostrata + 75 kg N per ha (3.27 per cent),which were significantly superior to all other treatments. The nitrogen content in straw decreased with increase in age of the crop.

At harvest, the highest nitrogen content in the straw was recorded with treatment receiving S.rostrata + 100 kg N per ha (0.73 per cent) followed by S.rostrata + 75 kg N per ha (0.71 per cent), which were significantly higher than that of the normal practice(0.65 per cent). Nitrogen content recorded with the control (0.44) was significantly lower than that of the treatment receiving S. rostrata alone (0.55 per cent). However, the nitrogen content in straw recorded with the treatment receiving S. rostrata + 50 kg N per ha (0.65 per cent) was on par with that of the normal practice (0.65 per cent).

LEGEND

T1 = No *Sesbania rostrata* + No nitrogen (CONTROL)
T2 = *Sesbania rostrata* Green manure only
T3 = *Sesbania rostrata* + 25kg N per ha
T4 = *Sesbania rostrata* + 50kg N per ha
T5 = *Sesbania rostrata* + 75kg N per ha
T6 = *Sesbania rostrata* + 100kg N per ha
T7 = Normal practice (100kg N per ha)

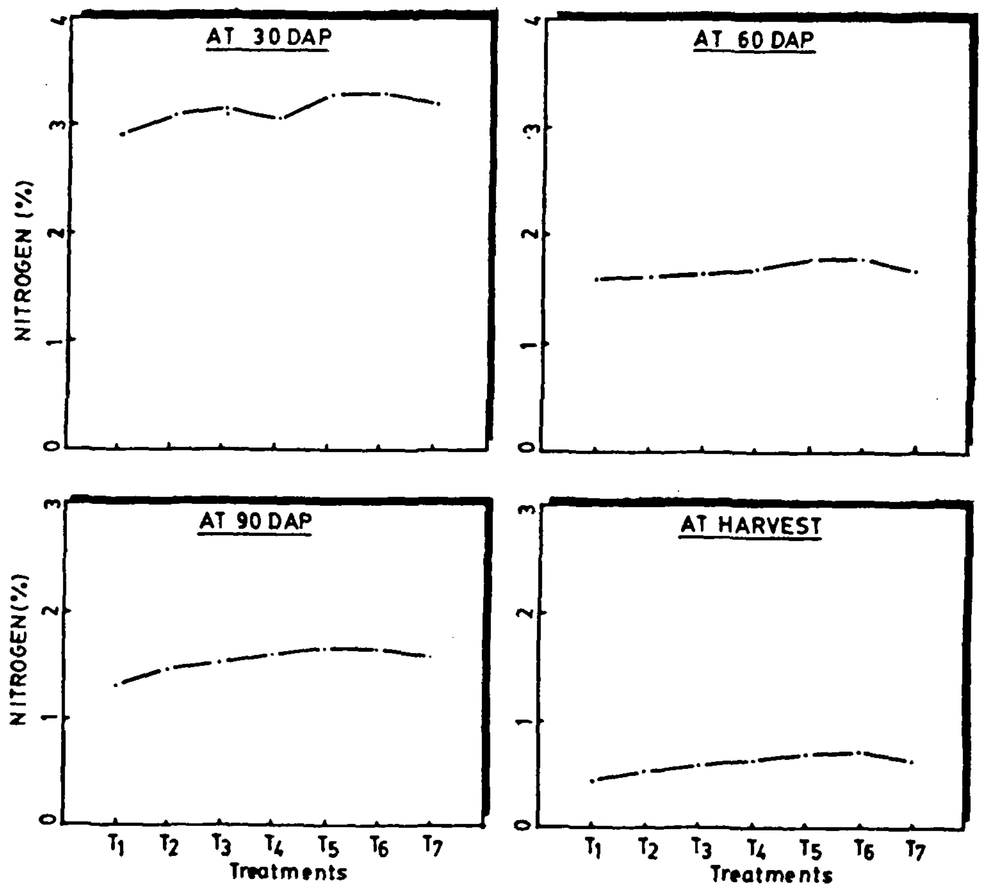

FIG.7. NITROGEN PER CENT IN RICE STRAW AS INFLUENCED BY IN SITU INCORPORATION OF S. rostrata GREEN MANURE ALONG WITH NITROGEN LEVELS AT VARIOUS GROWTH STAGES.

At 30 DAP and 60 DAP, the maximum nitrogen content in straw was recorded with the treatment receiving S. rostrata + 100 kg N per ha closely followed by S. rostrata + 75 kg N per ha and both were significantly superior to all other treatments.

4.5.2 Nitrogen content in rice grains (per cent)

The data on nitrogen content in grains of rice as influenced by in situ incorporation of S.rostrata green manure along with different nitrogen levels at 90 DAP and at harvest are presented in Table 15 and depicted in Fig.8.

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on nitrogen content of the grains both at 90 DAP and at harvest.

At harvest, highest nitrogen content in grains was obtained with the treatment receiving S.rostrata + 100 kg N per ha(1.48 per cent) followed by S.rostrata + 75 kg N per ha(1.47 per cent), which were significantly higher than the control (1.14 per cent).Nitrogen content in grains recorded with the treatment receiving

Table 15. Nitrogen per cent in panicles of rice as influenced by *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels at 90 DAP and at harvest

Treatment	90 DAP	At harvest
T_1 : No *S. rostrata* + no nitrogen (control)	0.94	1.14
T_2 : *S. rostrata* only	1.01	1.32
T_3 : *S. rostrata* + 25 kg N	1.06	1.37
T_4 : *S. rostrata* + 50 kg N	1.07	1.42
T_5 : *S. rostrata* + 75 kg N	1.09	1.47
T_6 : *S. rostrata* + 100 kg N	1.11	1.48
T_7 : Normal practice (100kg N/ha)	1.06	1.40
Mean	1.05	1.37
S.Em.±	0.02	0.03
C.D. at 5%	0.05	0.08

LEGEND

T_1 = No <u>Sesbania rostrata</u> + No nitrogen (CONTROL)
T_2 = <u>Sesbania rostrata</u> Green manure only
T_3 = <u>Sesbania rostrata</u> + 25kg N per ha
T_4 = <u>Sesbania rostrata</u> + 50kg N per ha
T_5 = <u>Sesbania rostrata</u> + 75kg N per ha
T_6 = <u>Sesbania rostrata</u> + 100kg N per ha
T_7 = Normal practice (100kg N per ha)

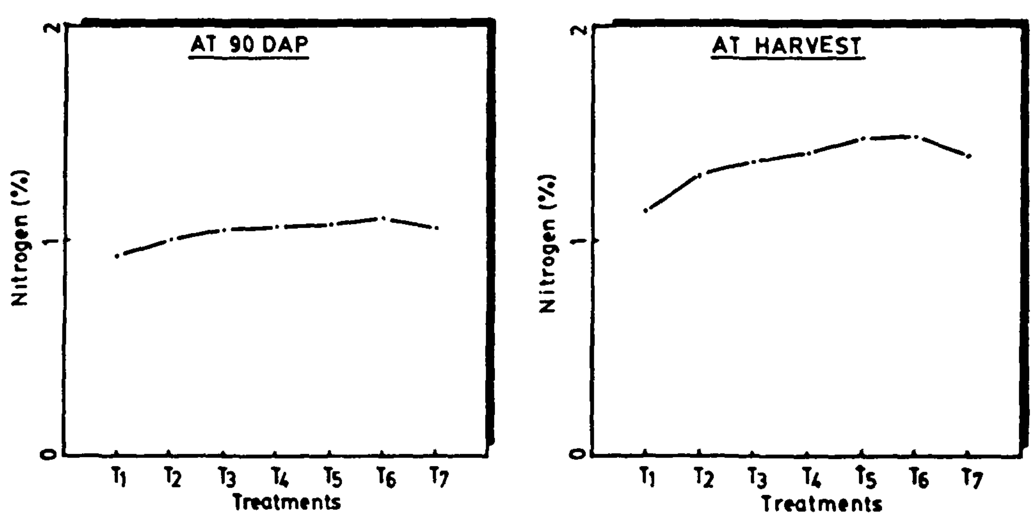

FIG.8. NITROGEN PER CENT IN PANICLES OF RICE AS INFLUENCED BY <u>INSITU</u> INCORPORATION OF <u>S.rostrata</u> GREEN MANURE ALONG WITH DIFFERENT NITROGEN LEVELS AT 90 DAP AND AT HARVEST

S. *rostrata* + 50 kg N per ha (1.42 per cent) was on par with that of S. *rostrata* + 75 kg N per ha (1.47 per cent) and the normal practice (1.40 per cent).

At 90 DAP, highest nitrogen in grains was obtained with the treatment receiving S. *rostrata* + 100 kg N per ha (1.11 per cent) followed by S. *rostrata* + 75 kg N per ha (1.09 per cent) and S. *rostrata* + 50 kg N per ha (1.07 per cent), which were significantly superior to the control (0.94 per cent).

4.6 Nitrogen uptake by rice (kg/ha)

4.6.1 Nitrogen uptake (kg/ha) by rice straw

The data on nitrogen uptake by rice straw as influenced by *in situ* incorporation of S. *rostrata* green manure along with different nitrogen levels at various growth stages are furnished in Table 16.

Incorporation of S. *rostrata* green manure along with different nitrogen levels had significant effect on nitrogen uptake by rice straw at all growth stages.

Maximum nitrogen uptake by rice straw was recorded at 90 DAP and decreased at harvest. At

Table 16. Uptake of nitrogen(kg/ha) by rice straw as influenced by in situ incorporation of S. rostrata green manure along with different Nitrogen levels at various growth stages

Treatments	30 DAP	60 DAP	90 DAP	At harvest
T_1 : No S. rostrata + no nitrogen(control)	6.50	27.58	46.05	14.58
T_2 : S. rostrata only	13.60	37.02	60.09	22.22
T_3 : S. rostrata + 25 kg N	18.98	44.81	70.07	24.27
T_4 : S. rostrata + 50 kg N	25.93	52.40	76.28	27.89
T_5 : S. rostrata + 75 kg N	28.71	60.93	87.29	33.38
T_6 : S. rostrata + 100 kg N	29.83	62.70	88.92	34.70
T_7 : Normal practice (100 kg N/ha)	24.25	51.40	75.48	27.46
Mean	21.12	48.12	72.03	26.36
S.Em.±	0.75	1.31	2.42	1.02
C.D. at 5%	2.30	4.04	7.44	3.14

90 DAP, maximum nitrogen uptake was recorded with the treatment receiving S. rostrata + 100 kg N per ha (88.92 kg/ha) which was on par with that of S. rostrata + 75 kg N per ha (87.29 kg/ha). They were significantly higher than all other treatments. Nitrogen uptake with the treatments receiving S. rostrata + 50 kg N per ha (76.28 kg/ha), the normal practice (75.48 kg/ha) and the treatment receiving S. rostrata + 25 kg N per ha (70.07 kg/ha), were on par and significantly higher than the nitrogen uptake with the control treatment (46.05 kg/ha) and the treatment which received S. rostrata alone (60.09 kg/ha).

At 30 DAP, 60 DAP and at harvest, maximum nitrogen uptake was obtained with the treatment receiving S.rostrata + 100 kg N per ha followed by S. rostrata + 75 kg N per ha and S. rostrata + 50 kg N per ha, which were significantly superior to the control treatment.

4.4.2 Nitrogen uptake by rice grains (kg/ha)

The data on nitrogen uptake by rice grains as influenced by in situ incorporation of S. rostrata green manure along with different nitrogen levels at 90 DAP and at harvest are presented in Table 17.

Table 17. Uptake of nitrogen (kg/ha) by rice grains as influenced by *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels at 90 DAP and at harvest

Treatment	90 DAP	At harvest
T_1 : No *S. rostrata* + no nitrogen (control)	2.43	34.33
T_2 : *S. rostrata* only	4.49	47.25
T_3 : *S. rostrata* + 25 kg N	6.42	55.91
T_4 : *S. rostrata* + 50 kg N	7.78	66.25
T_5 : *S. rostrata* + 75 kg N	8.72	74.16
T_6 : *S. rostrata* + 100 kg N	9.69	75.62
T_7 : Normal practice (100 kg N/ha)	7.24	62.76
Mean	6.68	59.47
S.Em.±	0.39	1.45
C.D. at 5%	1.21	4.48

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on nitrogen uptake by rice grains both at 90 DAP and at harvest.

At harvest, maximum nitrogen uptake was recorded with the treatment receiving S. rostrata + 100 kg N per ha (75.62 kg/ha) followed by S. rostrata + 75 kg N per ha (74.16 kg/ha), which were significantly superior to all other treatments. Significantly lower nitrogen uptake by rice grains was recorded with the control (34.33 kg/ha) as compared to the treatment, which received S.rostrata alone (47.25 kg/ha). Nitrogen uptake in grains with the treatment S. rostrata + 50 kg N per ha was (66.25 kg/ha) on par with that of the normal practice (62.76 kg/ha) and both were superior to the control (34.33 kg/ha).

At 90 DAP, highest nitrogen uptake in grains was obtained with the treatment receiving S. rostrata + 100 kg N per ha (9.69 kg/ha) followed by S. rostrata + 75 kg N per ha (8.72 kg/ha), which were significantly higher than the control treatment (2.43 kg/ha). However, the nitrogen uptake in grains recorded with the treatment receiving S. rostrata + 50 kg N per ha (7.78 kg/ha) was on par with that of treatment receiving S. rostrata + 75 kg N per ha (8.72 kg/ha) and the normal practice (7.24 kg/ha).

4.6.3 Total uptake of nitrogen by rice (kg/ha)

Data on total uptake of nitrogen by rice as influenced by the in situ incorporation of S.rostrata green manure along with different nitrogen levels at various growth stages are presented in Table 18 and depicted in Fig.9.

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on total uptake of nitrogen by rice at all growth stages.

At harvest, maximum uptake of nitrogen by rice was recorded with the treatment receiving S. rostrata+ 100 kg N per ha (110.32 kg/ha) which was on par with that of S. rostrata + 75 kg N per ha (107.54 kg/ha) and both were significantly superior to all other treatments. The uptake of nitrogen obtained with control treatment was 48.91 kg per ha, which was significantly lower than

Table 18. Total uptake of nitrogen (kg/ha) by rice as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different nitrogen levels at various growth stages

Treatment	30 DAP	60 DAP	90 DAP	At harvest
T_1 ; No *S. rostrata* + no nitrogen (control)	6.50	27.58	48.48	48.91
T_2 : *S. rostrata* only	13.60	37.02	64.58	69.47
T_3 : *S. rostrata* + 25 kg N	18.98	44.81	76.49	80.18
T_4 : *S. rostrata* + 50 kg N	25.93	52.40	84.06	94.14
T_5 : *S. rostrata* + 75 kg N	28.71	60.93	96.01	107.54
T_6 : *S. rostrata* + 100 kg N	29.83	62.70	98.61	110.32
T_7 : Normal practice (100 kg N/ha)	24.25	51.40	82.72	90.22
Mean	21.12	48.12	78.71	82.83
S.Em.±	0.75	1.31	2.65	1.82
C.D. at 5%	2.30	4.04	8.16	5.62

LEGEND

T1 = No *Sesbania rostrata* + No nitrogen (CONTROL)
T2 = *Sesbania rostrata* Green manure only
T3 = *Sesbania rostrata* + 25kg N per ha
T4 = *Sesbania rostrata* + 50kg N per ha
T5 = *Sesbania rostrata* + 75kg N per ha
T6 = *Sesbania rostrata* + 100kg N per ha
T7 = Normal practice (100kg N per ha)

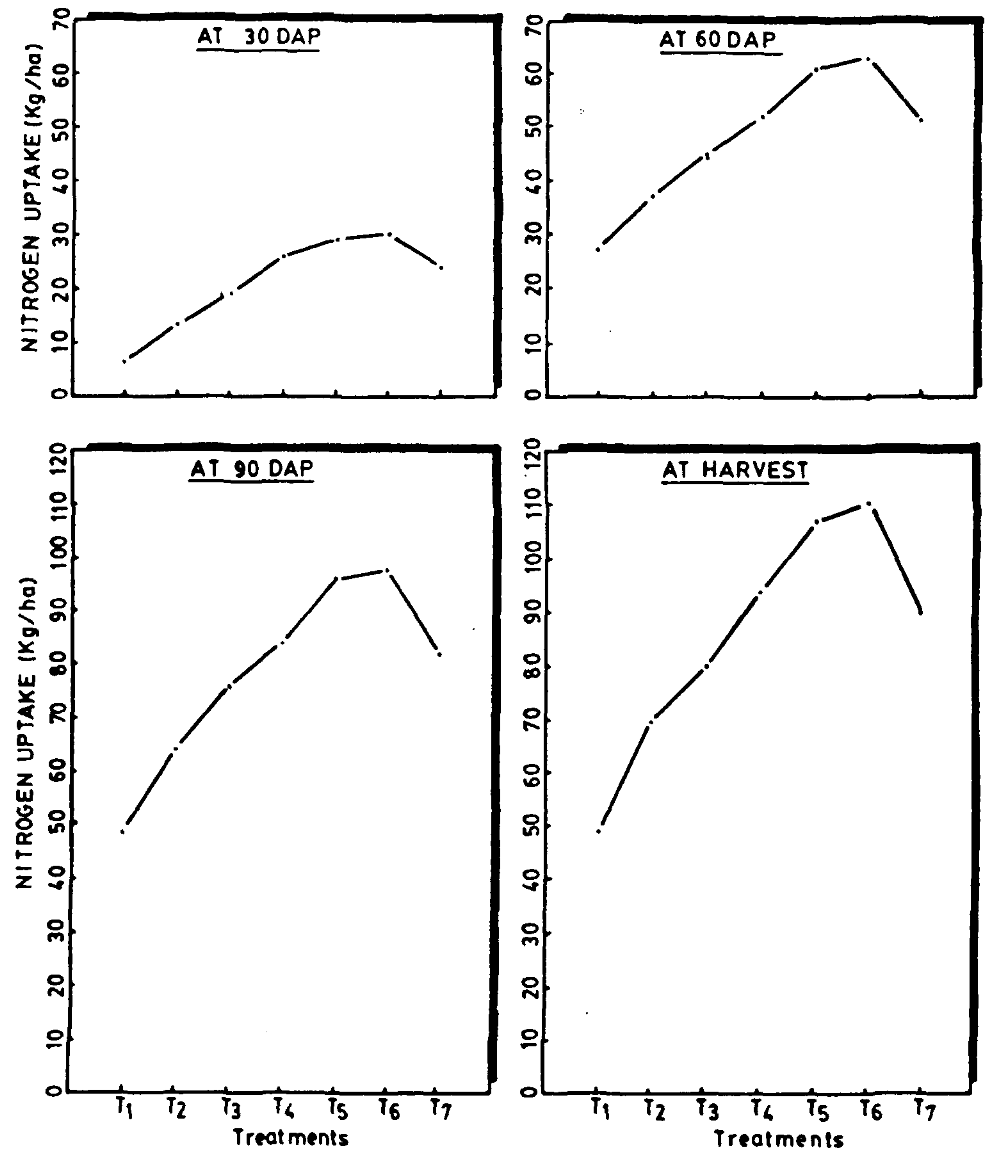

FIG. 9. TOTAL UPTAKE OF NITROGEN (Kg/ha) BY RICE AS INFLUENCED BY *IN SITU* INCORPORATION OF *Sesbania rostrata* GREEN MANURE ALONG WITH DIFFERENT NITROGEN LEVELS AT VARIOUS GROWTH STAGES

the treatment, which received *S. rostrata* green manure alone (69.47 kg/ha). However, uptake of nitrogen recorded in the treatment receiving *S. rostrata* + 50 kg N per ha (94.14 kg/ha) was on par with that of the normal practice (90.22 kg/ha) but were significantly superior to the treatment receiving *S. rostrata* only (69.47 kg/ha).

At all other growth stages, significantly highest nitrogen uptake by rice was recorded by the treatment receiving *S. rostrata* + 100 kg N per ha, followed by *S. rostrata* + 75 kg N per ha and *S. rostrata* + 50 kg N per ha as compared to the control.

4.7 Total soil nitrogen (kg/ha)

The data on total soil nitrogen as influenced by the *in situ* incorporation of *S. rostrata* green manure along with different nitrogen levels and the initial soil total nitrogen before sowing *S. rostrata* are furnished in Table 19 and depicted in Fig.10.

There was no significant variation in total soil nitrogen before sowing *S. rostrata* green manure crop in the experimental plots. Average initial soil total nitrogen was 691.22 kg per ha.

Table 19. Total soil nitrogen (kg/ha) before sowing *Sesbania rostrata* and after harvest of rice crop as influenced by *in situ* incorporation of *Sesbania rostrata* green manure along with different nitrogen levels

Treatment	Before sowing	After harvest
T_1 : No *S. rostrata* + no nitrogen (control)	693.00	652.26
T_2 : *S. rostrata* only	692.79	744.71
T_3 : *S. rostrata* + 25 kg N	690.20	763.57
T_4 : *S. rostrata* + 50 kg N	693.95	787.72
T_5 : *S. rostrata* + 75 kg N	688.67	806.77
T_6 : *S. rostrata* + 100 kg N	690.91	829.90
T_7 : Normal practice (100 kg N/ha)	689.03	707.98
Mean	691.22	756.13
S.Em.±	2.09	2.92
C.D. at 5%	NS	8.98

NS = Non significant

LEGEND

T_1 = No *Sesbania rostrata* + No nitrogen (CONTROL)
T_2 = *Sesbania rostrata* Green manure only
T_3 = *Sesbania rostrata* + 25kg N per ha
T_4 = *Sesbania rostrata* + 50kg N per ha
T_5 = *Sesbania rostrata* + 75kg N per ha
T_6 = *Sesbania rostrata* + 100kg N per ha
T_7 = Normal practice (100kg N per ha)

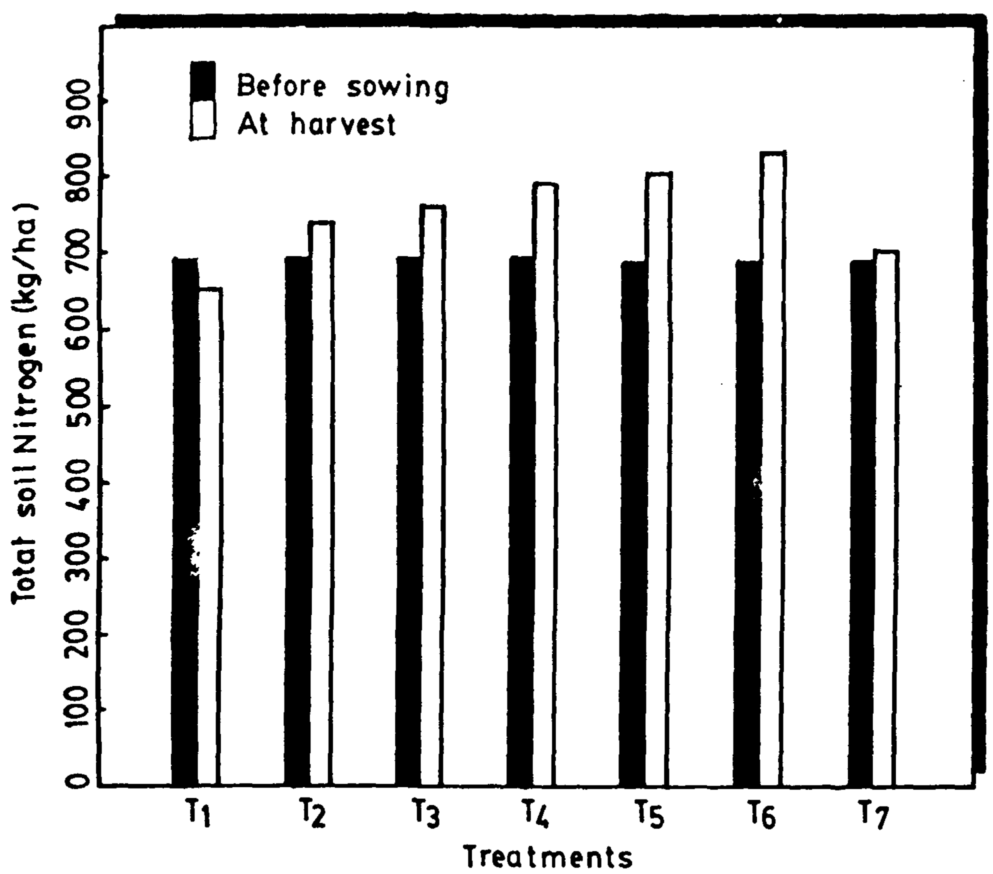

FIG.10. TOTAL SOIL NITROGEN (Kg/ha) BEFORE SOWING *S. rostrata* AND AFTER HARVEST OF RICE CROP AS INFLUENCED BY *IN SITU* INCORPORATION OF *S. rostrata* GREEN MANURE ALONG WITH DIFFERENT NITROGEN LEVELS.

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on total soil nitrogen as observed after the harvest of rice crop.

Significantly highest total soil nitrogen was recorded with the treatment receiving S. rostrata + 100 kg N per ha (829.90 kg/ha) followed by S.rostrata + 75 kg N per ha (806.77 kg/ha) as compared to all other treatments. The treatment receiving S. rostrata + 50 kg N per ha recorded the total soil nitrogen of 787.72 kg per ha, which was superior to that of normal practice (707.98 kg/ha) and the control (652.26 kg/ha).

Lowest total soil nitrogen was recorded with the control (652.26 kg/ha) as compared to the treatment receiving S. rostrata alone (744.71 kg/ha) and S.rostrata + 25 kg N per ha (763.57 kg/ha) and the difference was significant.

DISCUSSION

V. DISCUSSION

Use of green manures has gained importance in fertilizer use efficiency of nitrogen in rice production. Due to the high prices as well as low supply of fertilizers green manuring needs a new look. Keeping this in view a field experiment was conducted to study the effect of green manure of _Sesbania_ _rostrata_ in conjunction with nitrogen levels on the growth, yield and nitrogen economy of rice during _kharif_ 1990-91 at the Agricultural Research Station, Kathalagere. The results of the experiment presented in the previous chapter are discussed here.

5.1 Effect on growth and growth-parameters of rice

Incorporation of _S_. _rostrata_ green manure along with different nitrogen levels had pronounced effect on the plant height of rice at all growth stages(Table 2). The treatment receiving _S_. _rostrata_ green manure alone was distinctly superior to the control, which received no _S_. _rostrata_ and no nitrogen in improving the plant height. Nitrogen application along with _S_. _rostrata_ green manure increased the plant height considerably. The treatment receiving _S_. _rostrata_ + 100 kg N per ha, was superior to the normal practice receiving 100 kg N per ha only in attaining the increased plant height. Earlier investigations of Beri and Meelu (1981), Rinaudo *et al*. (1982) and Dreyfus *et al*. (1985) indicated that *S. rostrata* along with increased levels of nitrogen had favourable influence on the plant height. Chew *et al*. (1978) also reported that green manured soil produced increased plant growth.

An increase in nitrogen level from 'no nitrogen' to 100 kg N per ha along with *S. rostrata* increased the total number of tillers per hill from 8.2 to 13.73, which resulted in higher biomass yield (Table 3). Incorporation of *S. rostrata* green manure alone had pronounced effect in increasing number of tillers per hill by 30.8 per cent over the control. Ishizuka (1971) found that higher levels of nitrogen gave maximum tillers per hill by giving equilibrium between photosynthesis and nitrogen concentration. Morris *et al*. (1989), Palaniappan and Budhar (1989), Rabindra *et al*. (1989) and Thangaraju and Kannaiyan (1989) opined that green manure incorporation increased the tiller number in rice.

Plate 2. plant of *Sesbania rostrata* with profuse nodulation on the stem.

The differences in dry matter production and its accumulation into different plant parts at various growth stages were mainly responsible for the differences in grain and straw yields between the treatments. Increase in the level of nitrogen along with S.rostrata increased the total dry matter of different plant parts (Table 5) at different growth stages. The maximum dry matter of 19.76 g per hill was recorded with the treatment receiving S. rostrata + 100 kg N per ha. Cock and Yoshida (1972), Singh et al. (1988), Halepyati and Sheelavantar (1990b) also observed the similar increase in dry matter production with application of nitrogen along with green manure.

The leaf area, which indicates the photosynthetic ability of the plant depends largely on leaf mass. Leaf area index increased with increased level of nitrogen along with S. rostrata (Table 4). A steady increase in LAI was observed as the age advanced and attained its peak at 90 DAP and declined at harvest, obviously due to senescence. Even at harvest the treatment, which received S. rostrata alone and S. rostrata + 100 kg N per ha have exhibited significantly higher LAI than the control and normal practice, respectively. The increase in LAI with increased levels of nitrogen along with S. rostrata is attributed to the increased number of tillers per hill and increased size of successive leaves. Murata(1969) opined that nitrogen increases the LAI or weight of leaf blades and this effect was greatest before panicle initiation. Yanagisawa et al. (1967) and Reddy (1986) obtained higher leaf area with increased level of nitrogen. Balasubramaniyan and Palaniappan (1989) also found a positive effect of green manure on LAI of rice.

The leaf area duration (LAD) indicates the photosynthetic potential of the crop. The leaf area duration recorded was the highest during 61 to 90 days growth period of the crop (Table 9). LAD was highest with the treatment receiving S. rostrata + 100 kg N per ha and significantly more than that of the normal practice. Similarly, LAD with the treatment receiving S.rostrata alone was significantly more than that of control receiving no S. rostrata and no nitrogen. This focuses that incorporation of S. rostrata green manure has a dominating influence on the LAD both in the presence and absence of the chemical nitrogen.

Watson *et al.* (1963) opined that the formation of optimum photosynthetic area and maintaining the leaves photosynthetically active for longer duration during reproductive phase of the crop were essential for increasing the grain yield. Mandal and Dasmahapatra (1983) also opined that grain yield and LAD from flowering to maturity were positively correlated.

5.2 Effect on yield and yield components

Incorporation of *S. rostrata* green manure along with different nitrogen levels influenced the grain yield significantly (Table 10). *S. rostrata* along with nitrogen levels at 100 kg N per ha and 75 kg N per ha significantly increased the grain yield by 16 per cent and 12 per cent, respectively over the normal practice receiving 100 kg N per ha. The data permit to infer that application of *S. rostrata* along with 50 kg N per ha resulted in the grain yield of 59.73 q per ha equivalent to that of the normal practice (58.38 q/ha). This indicates that fifty per cent saving in the required quantity of fertilizer nitrogen for rice culture could be achieved by the use of *S. rostrata* green manure. Similar results were reported by Camara and Diara (1986). This result is also in close concordance with the findings of several workers in the usage of other green manures in rice production (Tiwari et al., 1980; Deol et al., 1982; Khind et al., 1982; Meelu et al., 1986; Ireneo et al., 1987; Rabindra et al., 1987; Singh et al., 1987; Bhagat et al., 1988, Ramasamy et al., 1988; Padalia et al., 1989 and Joseph et al., 1991).

The grain yield with the treatment receiving S. rostrata + 75 kg N per ha (65.55 q/ha) was on par with that of the treatment receiving S. rostrata+ 100 kg N per ha (67.64 kg/ha). Thus, S. rostrata green manure along with 75 kg N per ha is found to be an optimum combination to get higher yield of rice. These findings are in close conformity with those of Rabindra et al. (1989), Kalidurai and Kannaiyyan (1990) and Thakur (1991),working on S. rostrata green manure incorporation studies in rice production. Several workers obtained similar high response to the combined application of green manure and fertilizer nitrogen (Misra et al., 1969; Dargan et al., 1975; Tiwari et al., 1980; Khind et al., 1982; Bhardwaj and Dev, 1975; Meelu et al., 1986; Morris et al., 1986; Singh et al., 1988; Morris et al., 1989; Halepyati and Sheelavantar, 1990b and Patel et al., 1990).

Incorporation of *S. rostrata* green manure alone increased the grain yield by about 22 per cent over the control in the present investigation. This may be due to the reason that *S. rostrata* green manure had accumulated 149 kg per ha of nitrogen, which might have influenced the rice yields favourably. Dreyfus *et al.* (1985), Diack (1986) and Ranvir Singh *et al.* (1988) also reported that mere incorporation of *S. rostrata* green manure doubled the grain yield over the control receiving no *S. rostrata*. Halepyati and Sheelavantar (1990a) also opined that incorporation *S. rostrata* green manure alone gave as much grain yield as did the treatment receiving 100 kg N per ha as urea.

Higher grain yield obtained with the incorporation of *S. rostrata* green manure along with increased nitrogen levels might have been due to the adequate supply of nutri -ents throughout the growth period, because of continuous production of ammonia through mineralization and decomposition of green manure in conjunction with inorganic fertilizers.

Grain yield is a function of yield contributing characters such as number of panicles per plant and number of grains per panicle (Matasushima, 1976). Incorporation of *S. rostrata* along with 100 kg N per ha and

75 kg N per ha significantly increased the number of panicles per hill (21 per cent and 20 per cent) and number of grains per panicle (12 per cent and 9 per cent) over the normal practice receiving 100 kg N per ha. About 28 per cent increased number of panicles per hill and 20 per cent increased number of grains per panicle were obtained by incorporation of *S. rostrata* alone as compared to the control. The improvement in these yield components due to incorporation of *S. rostrata* might have resulted in the increased grain yields in the treatments receiving *S. rostrata* along with different nitrogen levels. Morris *et al*. (1989) and Palaniappan and Budhar (1989) indicated that there was significant increase in productive tillers and panicles per m^2 of rice by the incorporation of *S. rostrata* green manure as observed in the present investigations. Halepyati and Sheelavantar (1990b) also obtained higher number of grains per panicle by the use of *S. rostrata* green manure in rice production. Higher yield components due to combined application of nitrogen and green manure in general have also been observed by De Datta *et al*. (1972), Sanchez (1972) and Setty *et al*. (1987).

Grain yield and yield contributing characters are the reflections of panicle length, panicle weight and dry matter accumulation in panicles. Significantly higher dry matter accumulation in panicles was recorded in treatment receiving S. rostrata + 100 kg N per ha (10.19 g) and S. rostrata + 75 kg N per ha (10.04 g) over the normal practice (8.97 g). There was decrease in dry matter accumulation in panicles per hill with lower nitrogen levels combined with S. rostrata green manure. This may be due to the lower photosynthetic ability of plant and lower translocation of metabolites from leaf and stem during reproductive phase. Green manures provide adequate plant nutrients for the development of panicle and to have more number of grains per panicle. Higher grain yield due to more number of panicles and higher panicle weight was in lines with the findings of Black (1965b), De Datta (1981) and Subbaiah *et al.* (1983).

Incorporation of S. rostrata green manure along with different nitrogen levels significantly influenced the rice straw yield and harvest index (Table 10). The treatment receiving S. rostrata alone increased the rice straw yield by 14.7 per cent over control. The straw yield recorded with the treatment receiving S. rostrata + 100 kg N per ha was higher by 10.8 per cent than that of normal practice, which received 100 kg N per ha only. The increase in straw yield may be due to the increased plant height, more number of tillers per hill and improvement in leaf area and dry matter accumulation. Rajagopalan (1967) also opined that plant height and number of tillers per hill were the prime characters influencing the straw yield. Plants supplied with only fertilizers, recorded low plant growth rate. This might have resulted in early senescence and quick drying of leaves, which in turn reduced the size of the photosynthesising surface consequently reduced the total straw yield. These findings are in close conformity with the work of Halepyati and Sheelavantar (1990b), Kalidurai and Kannaiyan (1990) and Thangaraju and Kannaiyyan (1990) in respect of S. rostrata incorporation studies in rice culture. Similar results were reported by several workers on the usage of different green manure crops in rice culture (Lanuza, 1965; Ries et al., 1976; Mandal and Bharati, 1983 and Subbaiah et al., 1983).

Incorporation of S. rostrata green manure along with different nitrogen levels had significant effect on spikelet sterility (per cent) but not on thousand grain weight (Table 13). Thousand grain weight was less in the treatments receiving increased nitrogen levels along with S. rostrata. The treatment receiving S. rostrata + 100 kg N per ha recorded the lower thousand grain weight (30.07 g) than that of the treatment receiving S. rostrata green manure alone (30.47 g). The decrease in thousand grain weight with increasing nitrogen levels may be attributed to the increased number of grains per panicle, thus decreasing the individual grain size and weight. But, in lower levels of nitrogen, the size of the grain is probably larger having lesser number of grains per panicle attributing to the higher test weight. Gopinat et al. (1984) also opined that grain yield had negative correlation with thousand grain weight.

The spikelet sterility in the treatments receiving S. rostrata + 100 kg N per ha, S. rostrata + 75 kg N per ha, S. rostrata + 50 kg N per ha and S. rostrata alone was lesser by 8.42 per cent, 7.88 per cent, 5.9 per cent and 3.11 per cent, respectively over the control (25.42 per cent). The spikelet sterility was less with increase in the nitrogen levels along with S. rostrata, which had resulted in higher grain yields in these treatments. This is in close conformity with the findings of Halepyati and Sheelavantar (1990b). Wada (1969) observed a close correlation between per cent of grain filling and the amount of nitrogen in the plant at all the stages of spikelet initiation. Togari and Kashiwakura (1958) opined that the sterility under lower levels of nitrogen and low light intensities was caused by the initiation of pollination that resulted from incomplete dehiscence of anthers and abnormal behaviour of the filament at the time of flowering bringing about a decreased seed setting rate at maturity.

5.3 Effect of nitrogen content in plant and nitrogen uptake (kg/ha)

Results on the concentration of nitrogen in different plant parts showed that the highest concentration of nitrogen occurred in straw at early growth stages receiving 30 DAP (Table 14) and gradually decreased at every successive growth stages till harvesting stage. It can be related to the fact that with the advancement of age, dilution of tissue concentration occurred and thereby decreasing the concentration of nitrogen towards harvest. Sims and Place (1968) and Dreyfus *et al*. (1985) also reported that the percentage of nitrogen in the plant body was higher in the early stage of growth and decreased with increase in the age of the plant. The treatment receiving _S. rostrata_ + 100 kg N per ha and _S. rostrata_ + 75 kg N per ha recorded the highest concentration of nitrogen in straw at all growth stages and in panicles at harvest as compared to the normal practice which received 100 kg N per ha. The lowest N content was recorded in the control treatment. The higher nitrogen content of the plant may increase the metabolic activity of the plant leading to a greater accumulation of dry matter and consequently increasing the grain yield. Higher the nitrogen content in the plant higher is the photosynthetic rate as per the findings of Chatterjee and Maiti (1981). Sanchez (1972) also reported that paddy yields were positively correlated with adequate plant nitrogen levels at tillering stage and panicle primordium phase.

Significantly higher nitrogen uptake was observed at harvest with the treatments receiving _S. rostrata_ + 100 kg N per ha and _S. rostrata_ + 75 kg N per ha. The percentage increase in the uptake of nitrogen was 22.3 per cent in the treatment receiving _S. rostrata_ + 100 kg N per ha and 19.2 per cent in _S. rostrata_ + 75 kg N per ha over the normal practice receiving 100 kg N per ha. With _S. rostrata_ alone the increase in nitrogen uptake was of the order of 42 per cent over control. This is most likely due to microbial decomposition of the S. rostrata green manure, which was readily decomposed releasing more nitrogen to the crop. The higher uptake of nitrogen by rice crop with the incorporation of S. rostrata green manure along with increasing levels of nitrogen increased the rice grain yield significantly.

Investigations of Chew et al. (1978), Tiwari et al. (1980), Mahapatra et al. (1987), Rabindra et al.(1987) and Halepyati and Sheelavantar (1990a) have corroborated with the results of present investigations that incorporation of green manure along with increased levels of nitrogen resulted in higher nitrogen uptake by rice and higher yields. Craswell and Vlek (1979) identified denitrification, ammonia volatilization, runoff and leaching as potential nitrogen loss mechanism. Green manure along with added nitrogen must have ensured slow decomposition of green manure which matched soil solution nitrogen concentration to the nitrogen uptake rates by rice at all growth stages.

5.5 Effect of total soil nitrogen

The total soil nitrogen after harvest indicated that the treatment *S. rostrata* + 100 kg N per ha added higher amounts of nitrogen (138.99 kg/ha) followed by *S.rostrata* + 75 kg N per ha (118.1 kg/ha) as against the normal practice receiving 100 kg N per ha which added least amounts of nitrogen (18.95 kg/ha) to the initial total soil nitrogen. Mere incorporation of *S.rostrata* green manure added 51.92 kg N per ha to the initial total soil nitrogen(Table 19). The superior performance of the treatments which received combined application of green manure *S. rostrata* and nitrogen may be attributed not only to the continuous supply of nutrients, but also its profound influence on the chemical and biological processes of soils. Rinaudo *et al*. (1983) observed that when *S. rostrata* green manure was incorporated into the soil, one-third of the nitrogen added by green matter was transferred to the crop and two-third of the nitrogen added to the soil. Similar results were obtained by Halepyati and Sheelavantar(1990b) working on *S. rostrata* grain manure for rice.

SUMMARY

VI. SUMMARY

A field experiment was conducted at the Agricultural Research Station, Kathalagere, during _kharif_ 1990-91 to study the effect of green manure of _Sesbania rostrata_ in conjunction with nitrogen levels on the growth, yield and nitrogen economy of rice. The salient features of the results obtained in the experiment are summarised below.

1. There was significant improvement in growth parameters like plant height, number of tillers per hill and dry matter accumulation in plant parts due to the _in situ_ incorporation of _S. rostrata_ green manure alone as compared to the control. The treatments receiving _S. rostrata_ + 75 kg N per ha or _S. rostrata_ + 100 kg N per ha were superior to the normal practice receiving 100 kg N per ha.

2. The physiological parameters like leaf area index and leaf area duration were also significantly influenced by the incorporation of _S. rostrata_, green manure.

3. Incorporation of *S. rostrata* alone and with 100 kg N per ha or 75 kg N per ha significantly improved the yield parameters like number of panicles per hill, number of grains per panicle and panicle weight over the control receiving no *S. rostrata* and no nitrogen and the normal practice receiving 100 kg N per ha respectively.

4. Incorporation of *S. rostrata* green manure alone resulted in an increase in grain yield by 22 per cent over control. Incorporation of *S. rostrata* along with 75 kg N per ha increased the grain yield by 12.3 per cent over the normal practice receiving 100 kg N per ha.

5. The grain yield obtained with the treatment *S. rostrata* + 50 kg N per ha and the normal practice receiving 100 kg N per ha were on par. Thus, fifty per cent nitrogen substitution can be achieved by incorporation of *S.rostrata* green manure in rice production.

6. The grain yield obtained with *S. rostrata* + 75 kg N per ha and *S. rostrata* + 100 kg N per ha

were on par and were significantly more than all other treatments. Thus S. rostrata+75 kg N per ha would be an optimum combination to get higher yields of rice and in effecting nitrogen economy.

7. The effect of S. rostrata green manure incorporation was significant on the uptake of nitrogen at all growth stages and influenced the nitrogen uptake favourably both in the presence and absence of chemical nitrogen. It also improved the nitrogen status in the soil.

Future line of work

Further research is needed on the following aspects.

1. To find out the optimum fertilizer nitrogen and green manure combination to get best economic rice yields in different agro - ecological situation.

2. To investigate on the effect of S. rostrata green manure on nutrient availability, water retention in the soil and physical properties of the soil.

3. To work on feasibility of growing Sesbania rostrata under various rice based cropping systems under different agro-climatic zones.

4. To study the residual effects of S. rostrata green manure on succeeding crops.

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* Original not seen

APPENDIX

Appendix-1. Meteorological data indicating mean monthly average of ten years (1980-1989) and the actual crop growth period (1990) at the Agricultural Research Station, Kathalagere

Month	Total rainfall (mm) Average of 10 years (normal)	Actual (1990)	Maximum (°C) temperature Actual 1990	Minimum (°C) temperature Actual 1990	Relative (%) humidity Actual 1990
January	2.20	0.00	30.63	13.76	64.66
February	0.34	0.00	33.28	13.84	58.94
March	10.29	0.00	34.93	17.39	52.99
April	17.77	0.00	37.46	21.12	55.59
May	32.98	108.00	33.94	21.81	67.13
June	90.65	68.80	28.34	21.43	80.10
July	91.13	51.10	27.13	20.83	81.26
August	82.10	124.50	26.80	20.78	83.93
September	119.46	18.50	29.15	20.55	74.45
October	78.97	45.40	30.38	20.65	72.65
November	29.61	84.90	29.48	18.60	76.09
December	4.53	0.00	29.85	16.08	77.27
Total annual rainfall	559.98	501.20			

Note: * Crop season for the present study was from July to November 1990