# *SESBANIA ROSTRATA* AS A GREEN MANURE FOR IRRIGATED LOWLAND RICE IN THE LOW COUNTRY INTERMEDIATE ZONE

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ABSTRACT

**In a monthly planting trial carried out at Agricultural Research Station, Girandurukotte in 1986, biomass production of *Sesbania rostrata* was found to be satisfactory throughout the year. The best stage of incorporation of *S. rostrata* into a rice field was 40 — 50 days after emergence and this *in situ* period could be easily fitted into the turn - around - period of the rice - rice cropping pattern of the region using 3 - 3½ month duration rice varieties. For this purpose, *S. rostrata* should be sown in the first week of April for yala and the last week of September for maha. Four season data showed that for *S. rostrata* optimum plant density was 40,000 to 60,000 plants/ha and incorporation of the biomass produced resulted in about 50% saving in the chemical N fertilizer required for rice crop at Girandurukotte. There is however a need to carry out adaptive research trials in farmers fields in order to determine the feasibility of using *S. rostrata* in System C of the Mahaweli River Diversion Project and its acceptability by farmers.**

**KEY WORDS:** Biomass production, Green manure, Rice (*Oryza sativa*), *Sesbania rostrata*

## INTRODUCTION

The System C of Mahaweli River Diversion Project comes mainly under the low country intermediate zone (agroecological region, DL 2). Total area of the system is 66,000 ha of which 24,000 ha comes under irrigated agriculture. The predominant soils are the Reddish Brown Earths and rice is the main crop grown in both maha and yala seasons. Irrigation water in issued normally in mid-April (yala) and mid-October (maha).

New improved rice varieties are extensively grown along with the application of chemical fertilizer. Although chemical fertilizers especially N fertilizers, play a major role in increasing rice production, farmers

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are reluctant to apply the optimum levels owing to their high prices. In this context green manures could play an important role in providing part of the N requirement of rice.

Of the different green manures, *Sesbania rostrata* (origin: Senegal, West Africa), which is a flood and drought tolerant quick growing annual legume, has recently gained popularity. It forms nodules on both roots and stem. Due to its profuse stem nodulation, this plant has 5—10 times more nodules than most legumes (Dreyfus and Dommergues, 1981). It has been reported that $N_2$-fixation is more prominent by root nodules in the early part of plant growth and by stem nodules in the latter stages of plant growth (Daroy *et al.*, 1987). On incorporation into flooded soils, *S. rostrata* has been shown to increase $NH_4$-N, K, P, Fe and Mn supply in the soil solution (Nagarajah *et al.*, 1989). According to Rinaudo *et al.* (1988) *S. rostrata* grown for 8—9 weeks is capable of providing about 100 kg N/ha to a rice crop.

*S. rostrata* grows well on waterlogged soils (Dreyfus *et al.*, 1983). However, it is highly sensitive to photoperiod and temperature. For example, in Senegal it grows well only during the rainy season (June to September); in the dry and cold season (December to March) its growth is poor and flowering takes place abnormally early (Dreyfus *et al.*, 1983). In the Philippines favourable growth period is from March to May or April to June while growth is poor between August and October (Ventura *et al.*, 1987).

Thus introduction of *S. rostrata* as an *in situ* green manure crop for rice cultivation in Girandurukotte could provide relief to the farmers by reducing the money spent on chemical N fertilizers. This paper reports the results of a series of experiments carried out to determine the feasibility of using *S. rostrata* as a green manure for rice in the Girandurukotte region.

## MATERIALS AND METHODS

Three experiments were carried out at the Agricultural Research Station, Girandurukotte. The soil of the experimental area belongs to the Reddish Brown Earths and some of its characteristics are given in Table 1. Climatic data are given in Table 2.

**Table 1. Some physicochemical characteristics of the experimental soil (0—15 cm)**

| | |
|---|---|
| pH | 6.4 |
| Organic matter (%) | 1.2 |
| Total N (%) | 0.06 |
| Olsen's P (ppm) | 9.5 |
| Exch. K. (me/100g) | 0.16 |
| C/N ratio | 11.6 |

**Table 2. Mean maximum and minimum temperatures, sunshine and rainfall at Girandurukotte, during maha and yala seasons (Five - year average of weekly mean, 1982 - 1986)**

| *Month* | *Maximum temperature (C°)* | *Minimum temperature (C°)* | *Sunshine (hours/day)* | *Rainfall (mm)* |
|---|---|---|---|---|
| **Maha Season** | | | | |
| September | 32.8 | 22.1 | 7.3 | 145 |
| October | 30.5 | 22.1 | 5.3 | 200 |
| November | 31.0 | 21.9 | 5.1 | 300 |
| December | 28.0 | 20.8 | 4.1 | 450 |
| January | 27.9 | 20.5 | 3.4 | 270 |
| February | 31.8 | 21.4 | 7.0 | 190 |
| **Yala Season** | | | | |
| March | 32.2 | 22.7 | 7.3 | 210 |
| April | 32.9 | 23.1 | 6.8 | 70 |
| May | 33.4 | 23.4 | 7.9 | 80 |
| June | 34.4 | 24.1 | 5.5 | 15 |
| July | 35.7 | 22.3 | 8.2 | 70 |
| August | 35.5 | 23.5 | 7.0 | 35 |

## Selection of green manure species

Eight leguminous green manure species, *Sesbania rostrata*, *S. aculeata*, *S.* china type, *S. chizea*, *S. sesban* (local), *S. sesban* (exotic), *Crotalaria juncea* and *C. caricia* were used in the experiment which was carried out in 1986. Each set of species was planted on the first day of every month. Each species was planted in a row (3 m length) at a spacing of 30 cm × 100 cm. There were four rows for each species. Dry matter yields at one month after emergence, at flowering stage and at pod filling stage were determined.

**Determination of the best stage for incorporation of *S. rostrata***

A non-replicated experiment was carried out in maha 1986/87 to determine the biomass yield of *S. rostrata* at 30, 40, 50, 60, 70 and 80 days after emergence.

With the onset of monsoon rains the field was ploughed. Pre-germinated seeds of *S. rostrata* were dibbled on 20 September at a spacing of 25 cm × 10 cm (population of 400000 plants/ha). Ten days after emergence of seeds, the field was flooded. Biomass yield and N content of whole plant (10 randomly selected) were determined at the different times of plant sampling.

**Determination of optimum plant density of *S. rostrata***

The effect of incorporating *S. rostrata* biomass obtained at 3 plant densities (280000, 400000 and 600000 plants/ha) with and without 40 kg/ha fertilizer N on yield of rice was tested for 4 seasons (maha 87/88, yala 88, yala 89 and maha 89/90). Two other treatments, control (no *Sesbania* and no N fertilizer) and fertilizer only (80 kg N/ha) were also included in the evaluation.

The experiment was laid out in a randomized complete block design with 3 replicates. The plot size was 5 m × 5 m. With the onset of monsoon rains the field was ploughed. Pre-germinated *S. rostrata* seeds were dibbled at spacings of 15 cm × 10 cm, 25 cm × 10 cm and 35 cm × 10 cm to have 600000, 400000 and 280000 plants/ha, respectively. The field was flooded 10 days after emergence.

Forty-five days after emergence *S. rostrata* plants were incorporated into the soil using a mould—board plough after determining the biomass in each treatment. Seven days later the plots were levelled and rice seedling of the variety Bg 94—1 (3½ months) was transplanted (3 plants/hill) at a spacing of 20 cm × 15 cm. The rice was planted in mid-June in yala and mid-December in maha.

Recommended post-planting weedicides were applied. Irrigation was given according to the water issue of the area. The grain yield of rice at 14% moisture content was determined at harvest. The nutrient content of *S. rostrata* (whole plant) used in maha 87/88 is given in Table 3.

**Table 3. Nutrient content of *S. rostrata* (whole plant) at 45 days after germination – maha 87 / 88**

| *Nutrient* | *Content* (%) |
|---|---|
| N | 2.70 |
| P | 0.14 |
| K | 1.56 |

## RESULTS AND DISCUSSION

### Biomass production of the different green manure crops

Table 4 gives the dry matter yield (DMY) of the 8 green manure crops planted at monthly intervals in 1986. DMY of all the green manure crops increased with time and the highest yield was at the pod filling stage.

*Sesbania rostrata*, *S.* china type, *S. chizea* and *Crotalaria juncea* gave the highest and similar DMY at pod filling stage for all plantings. On the other hand *S. sesban* (e), *S. sesban* (l) and *C. caricia* gave low but similar DMY for all plantings. *S. aculeata* gave high DMY only for February, March and April plantings.

It was found that *S. rostrata* gave better DMY even for the other sampling stages (1 MAP and flowering stage). However, highest DMYs were obtained when *S. rostrata* was planted in early May and early November. Thus biomass production by *S. rostrata* at Girandurukotte has been satisfactory throughout the year despite the fact that it is highly photosensitive (Dreyfus *et al.*, 1983). It is probable that the climatic factors such as temperature, day length and rainfall (Table 2) found in Girandurukotte are favourable for the growth of *S. rostrata*.

Table 4. Dry matter yields of different green manure species planted at monthly intervals during 1986

| Month | *S. rostrata* | | | *S. aculeata* | | | *S. 'China' type* | | | *S. chizea* | | | *S. sesban (e)* | | | *S. sesban (l)* | | | *C. juncea* | | | *C. caricia* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Dry matter yield (g / plant)* | | | | | | | | | | | | | | | | | | | | | | | |
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| January | 27 | 115 | 189 | 18 | 28 | 91 | 22 | 70 | 170 | 21 | 40 | 150 | 08 | 30 | 50 | 03 | 16 | 33 | 47 | 105 | 205 | 05 | 65 | 88 |
| February | 18 | 105 | 168 | 22 | 52 | 188 | 23 | 98 | 150 | 26 | 52 | 191 | 10 | 40 | 60 | 09 | 18 | 34 | 57 | 97 | 193 | 06 | 75 | 117 |
| March | 23 | 103 | 187 | 23 | 25 | 150 | 42 | 125 | 195 | 32 | 85 | 185 | 28 | 60 | 80 | 07 | 15 | 35 | 42 | 95 | 217 | 08 | 91 | 114 |
| April | 30 | 113 | 175 | 12 | 25 | 140 | 19 | 55 | 130 | 23 | 54 | 240 | 07 | 22 | 40 | 06 | 10 | 23 | 27 | 78 | 187 | 07 | 87 | 84 |
| May | 45 | 145 | 228 | 06 | 13 | 78 | 15 | 31 | 125 | 16 | 45 | 180 | 05 | 22 | 25 | 05 | 12 | 31 | 35 | 77 | 180 | 05 | 62 | 71 |
| June | 33 | 123 | 183 | 04 | 10 | 56 | 16 | 44 | 150 | 08 | 21 | 110 | 04 | 38 | 75 | 06 | 13 | 31 | 38 | 81 | 192 | 04 | 52 | 62 |
| July | 27 | 113 | 180 | 03 | 11 | 40 | 15 | 45 | 150 | 03 | 16 | 180 | 02 | 55 | 97 | 07 | 19 | 44 | 40 | 88 | 189 | 03 | 42 | 58 |
| August | 30 | 118 | 175 | 02 | 12 | 48 | 20 | 67 | 185 | 04 | 16 | 160 | 03 | 22 | 87 | 08 | 16 | 34 | 44 | 90 | 196 | 02 | 30 | 56 |
| September | 38 | 125 | 187 | 06 | 18 | 57 | 40 | 113 | 330 | 05 | 23 | 168 | 05 | 28 | 98 | 08 | 17 | 32 | 40 | 105 | 220 | 03 | 47 | 51 |
| October | 41 | 137 | 195 | 04 | 13 | 56 | 31 | 28 | 264 | 08 | 25 | 175 | 08 | 31 | 115 | 08 | 18 | 37 | 49 | 112 | 220 | 03 | 51 | 62 |
| November | 58 | 155 | 215 | 01 | 18 | 70 | 26 | 68 | 150 | 12 | 30 | 150 | 10 | 40 | 61 | 09 | 19 | 35 | 51 | 122 | 241 | 04 | 49 | 51 |
| December | 37 | 118 | 181 | 13 | 18 | 80 | 25 | 69 | 140 | 23 | 60 | 200 | 10 | 50 | 58 | 08 | 17 | 38 | 54 | 115 | 237 | 05 | 67 | 72 |

1=One month after planting (MAP); 2=At flowering; 3=At Pod filling stage; (e)=exotic type; (1)=local type

**Determination of the best stage for incorporation of *S. rostrata***

Although growth rate of *S. rostrata* is apparently slow during the first month of its growth, it subsequently increased rapidly up to 40 days and then declined fairly fast (Fig. 1). The biomass production

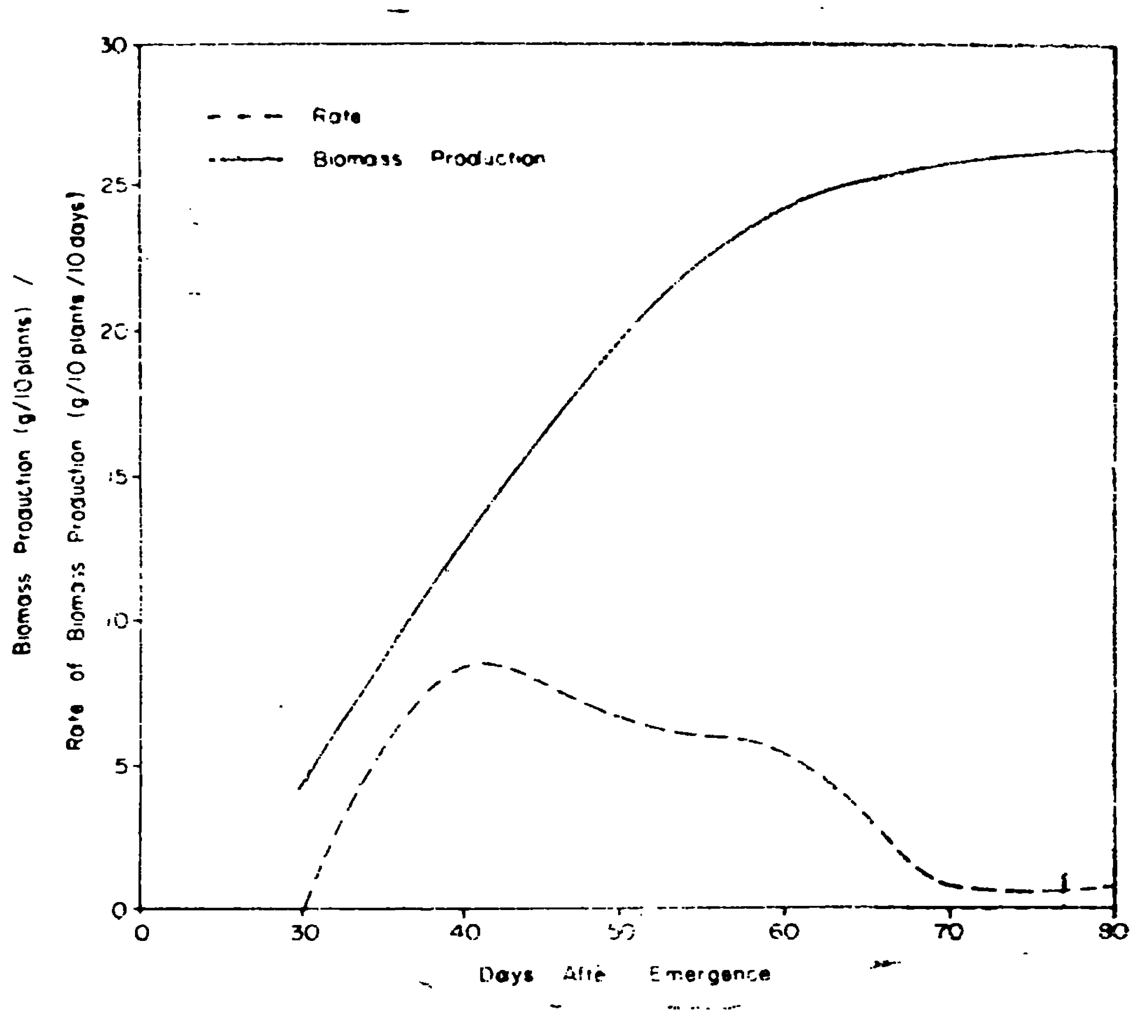


**Fig. 1. Total biomass production and rate of biomass production of *S. rostrata* at Girandurukotte — Maha 1986 / 87**

however increased very rapidly up to 60 days after emergence. The N content of the whole plant was about 3% up to 80 days after emergence. It also had a K content of about 1% (Table 5). The best stage for incorporation of *S. rostrata* as a green manure could be at 40 to 50 days after emergence and this *in situ* growth period

**Table 5. Changes in nutrient content of *S. rostrata* (whole plant) with time — maha 86/87**

| *Days after emergence* | *Nutrient content (%)* | | |
|---|---|---|---|
| | *N* | *P* | *K* |
| 30 | 3.23 | 0 27 | 2.18 |
| 40 | 2.72 | 0.13 | 1.45 |
| 50 | 3.00 | 0.17 | 0.95 |
| 60 | 3.14 | 0.16 | 0.98 |
| 70 | 3.08 | 0.18 | 1.25 |
| 80 | 3.06 | 0.19 | 1.07 |

could be conveniently fitted into the turn-around-period of rice-rice cropping pattern of the region using 3—3½ month duration varieties; this also gives an appreciable amount of biomass for application.

**Plant density of *S. rostrata* to obtain optimum amount of N for rice crop**

The dry matter production of *S. rostrata* in maha is higher than in yala (Fig. 2). The biomass yield under the different plant densities of *S. rostrata* varied and the biomass yield and total N contribution were higher at the higher plant densities. At the highest plant density (600000 plant/ha) biomass yield (dry weight) at 45 days after seed germination was about 3.5 t/ha in yala and 4.0 t/ha in maha. The Department of Agriculture (DOA) recommendation of N (80—100 kg/ha) for a 3—3½ month rice variety can be easily provided by the biomass produced from plant densities between 400000 to 600000 plants/ha (Table 6).

**Table 6. Biomass production and N contribution as affected by plant density of *S. rostrata* — maha 87/88**

| *Plant density of S. rostrata (plants / ha)* | *Biomass production (dry basis – kg / ha)* | *N accumulation (kg N / ha)* |
|---|---|---|
| 600,000 | 3800 | 105 |
| 400,000 | 2800 | 77 |
| 280,000 | 2400 | 65 |

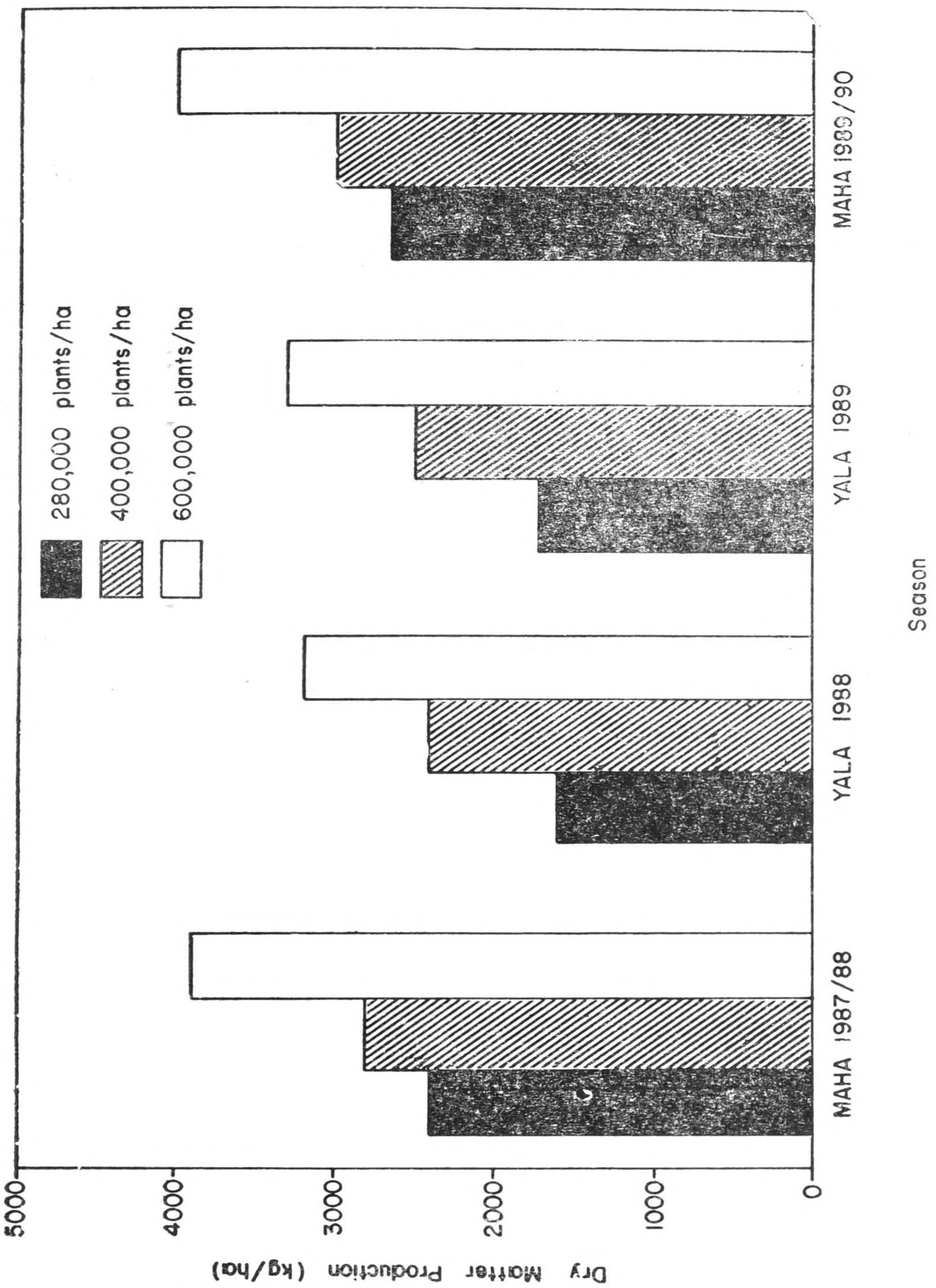


Fig. 2. Dry matter production of *S. rostrata* (45 days after germination) at different plant populations

The results also clearly show that in *S. rostrata* the biomass yield and resulting total N contribution can be adjusted by varying the plant population. It is relevant to note that germination percentage of green manure seeds, crop sanitation, supplementary irrigation and favourable environment for vegetative growth are some of the important requirements for obtaining high plant population.

**Table 7. Effect of application of *S. rostrata* with and without chemical fertilizer N on grain yield of rice**

| *Treatment* | *Grain yield (t / ha)* | | | |
|---|---|---|---|---|
| | *maha 87 / 88* | *yala 88* | *yala 89* | *maha 89 / 90* |
| Control (no *Sesbania* or N fertilizer) | 5.1 d | 4.7 e | 4.3 d | 5.4 c |
| 280,000 plants / ha *Sesbania* only | 6.5 abc | 4.8 e | 5.9 c | 6.6 b |
| 280,000 plants / ha *Sesbania* and 40 kg N / ha | 6.1 bcd | 4.7 e | 6.3 bc | 6.5 b |
| 400,000 plants / ha *Sesbania* only | 6.1 bcd | 4.9 e | 6.0 c | 5.8 c |
| 400,000 plants / ha *Sesbania* and 40 kg N / ha | 6.2 bcd | 6.0 ab | 6.8 b | 7.3 a |
| 600,000 plants / ha *Sesbania* only | 6.0 bcd | 5.9 abc | 7.9 a | 6.3 bc |
| 600,000 plants / ha *Sesbania* and 40 kg N / ha | 6.8 a | 6.1 a | 8.9 a | 7.5 a |
| 80 kg N / ha only (Departmental recommendation) | 6.4 abc | 5.5 cd | 7.6 ab | 7.0 a |
| CV (%) | 3.9 | 4.5 | 12.1 | 7.5 |

Means followed by the same letter are not significantly different at 5% level; All treatments received 54 kg $P_2O_5$ / ha + 45 kg $K_2O$ / ha (Recommendation of the Department of Agriculture); Chemical N fertilizer was applied at planting, and 2 and 5 weeks after planting.

Table 7 shows that all treatments have given better rice yields than the control. The plant density of 600000 plants/ha capable of providing 105 kg N/ha, when combined with 40 kg N/ha has given the highest yield in all seasons. In two out of 4 seasons tested, this treatment was not significantly different from that where plant density of 400000 plants/ha was combined with 40 kg N/ha. Also in 3 out of 4 seasons these two treatments were not significantly different from the treatment which received the DOA recommendation of N. Palm *et al.* (1988) in a similar study at Maha Illuppallama found that *Sesbania sesban* (4 t/ha dry biomass containing 92 kg N/ha) combined with 40 kg N/ha chemical N fertilizer gave appreciably better rice yields than the DOA recommendation (80 kg N/ha) of chemical N fertilizer. Thus it appears that by having a plant density of 400000 to 600000 plants/ha in a *S. rostrata* crop, around 50% saving in chemical N fertilizer requirement of rice can be achieved.

**Fitting *S. rostrata* into rice-rice cropping pattern**

Although the highest biomass yield was obtained from *S. rostrata* planted in early May and early November, the rainfall pattern (Fig. 3) and the irrigation schedule of the area do not provide the appropriate turn-around-time for fitting this practice into the rice-rice cropping pattern of the region if *S. rostrata* is planted at these times. Therefore *S. rostrata* has to be sown in first week of April, incorporated into the soil in mid-May and rice seedlings planted in first week of June for the yala season (Fig. 3). During the maha season *S. rostrata* should be sown in last week of September, incorporated into the soil in early November and rice planted in mid-November. However, this way the very short time available between *S. rostrata* incorporation and planting rice (7—10 days) is not sufficient for the puddling of the field and plastering of field bunds which are essential practices for water conservation and weed control. But if 3—3½ month rice varieties are grown and if sufficient labour is available the problem could be overcome (Fig. 3). The 3—3½ month rice varieties could be conveniently fitted into this system to give sufficient time for growing a 45—day old green manure crop and for land preparation. One harrowing with two-wheeled tractor or one ploughing and harrowing by animal-drawn implements will be sufficient for transplanting of rice.

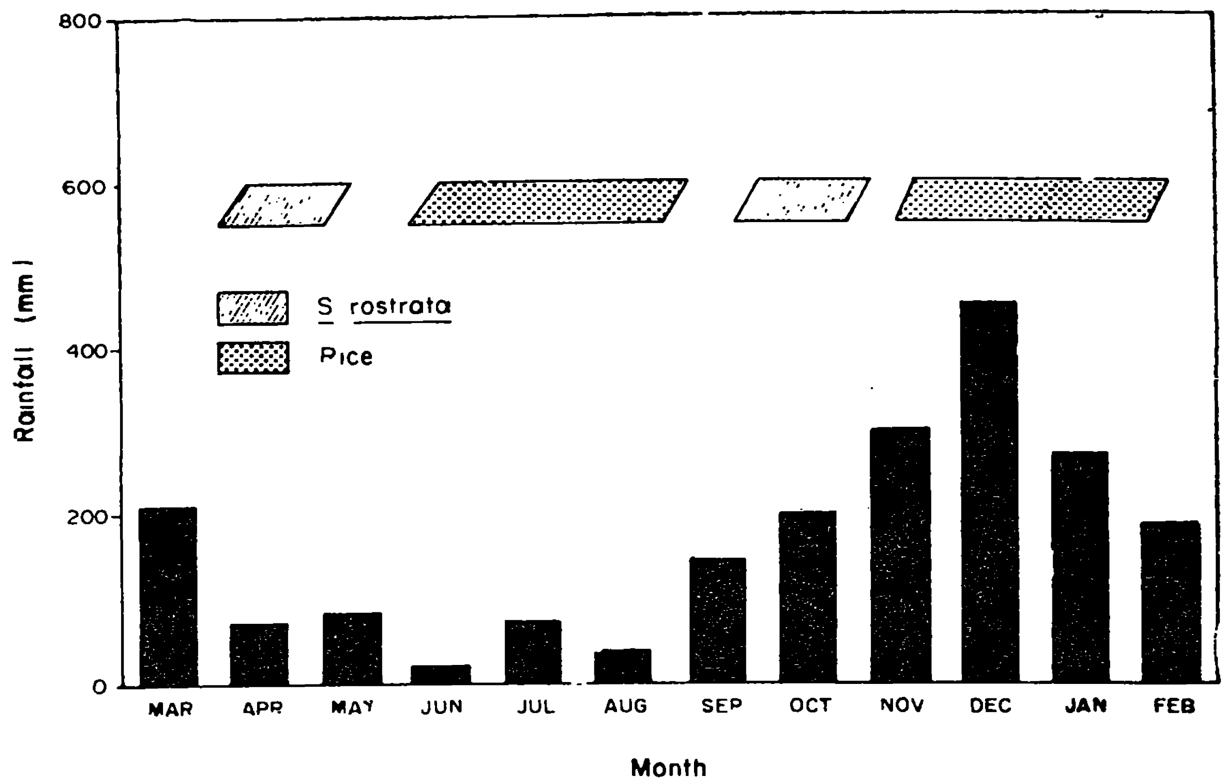


**Fig. 3. Depiction of the probable times of growing a 45 – day old *S. rostrata* crop before planting rice (3–3 1/2 month variety) in yala and maha seasons at Girandurukotte**

The rainfall distribution of the area (Fig. 3) at the time of sowing of *S. rostrata* is enough for minimum tillage operation and emergence of green manure seeds. The seasonal water issue will subsequently provide water to inundate the field thereby promoting the growth of *S. rostrata*.

Due to the water issue problems farmers harvest their yala rice crop mostly in September. Therefore the harvesting period of the rice crop will not be affected by adopting the suggested procedure for applying *in situ* grown *S. rostrata*.

Adaptive research trials are being planned in farmers' fields in the region to study the problems the farmers will encounter if this system is introduced as a practice in rice cultivation.

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