

EFFECT OF SEED RATES, NITROGEN LEVELS AND ORGANIC MATTER ON WEED GROWTH AND GRAIN YIELD IN DRY SEEDED RICE IN THE LOAMY SANDS OF KILINCHCHI DISTRICT

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ABSTRACT

Investigations carried out between 1984 and 1991, using different seed rates (100, 200, 300 and 400 kg/ha), nitrogen levels (0 to 180 kg N/ha) and organic matter (rice straw and *Thespesia indica* leaves-10 t/ha), revealed that seed rates did not either increase yields or give consistent reductions in weed counts or weights. However, with every increment of nitrogen grain yield increased up to 150 kg N/ha and incorporation of organic matter resulted in significant increases in yield and reductions in weed weights at every level of nitrogen.

KEY WORDS: Moisture stress, Nitrogen losses, Organic matter, Rice straw, *Thespesia indica*, Weed growth

INTRODUCTION

In the Kilinochchi district of Sri Lanka, of the 23,000 hectares cultivated to rice every wet season (*maha*) 50% is dependent on rainfall and 95% is dry seeded. Further north, in the Jaffna peninsula all the rice fields occupying an extent of the 10,000 hectares so cultivated are under rainfed cultivation, while 97% is dry seeded (Ministry of Agriculture, Lands and Forestry, 1994).

In wet seeding, sprouted seed is sown on puddled soil, where the moisture status is at various levels of the water holding capacity to saturation. In transplanting, seedlings with leaves at different stages of growth are established under similar moisture status. In these rice cultures, the crop enjoys standing water or an aqueous medium, which the rice crop desires. Thus, draining of the field for field operations and inundation after operations to prevent a new flush of weeds are possible.

In contrast, in dry seeding untreated seed is sown on dry soil and the duration of the period between seeding and emergence varies with the onset of the rains or the first irrigation. Seed emergence and a major part of the vegetative phase of the crop is subjected to varying degrees of the maximum water holding capacity of the soil till the groundwater table rises to provide standing water. In this culture the weeds and the crop emerge together (Estroninos *et al.*, 1980) and the soil moisture status being more favourable to the weed, it smothers the crop. Suzuki *et al.* (1975) reported that 90% of the water holding capacity of the soil is best suited for weeds. Yamamoto and Ohaba (1976) had reported that 70 to 80% of the water holding capacity of the soil is favourable for the growth of 12 species of weeds in rice. Bhan (1981) indicated that the predominant grass species *Echinochloa* spp. emerges and grows best in these conditions and growth ceases and plant dies when the water depth reaches 10 to 15 cm (Arai and Matsunaka, 1969). Therefore, in dry seeded rice, the crop does not enjoy the head start that the other cultures have and the strategy should be to shift the competition in favour of the crop by whatever means possible.

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De Datta and Nawarez (1983) and IRRI (1981) reported that increased seed rates or spacing did not achieve significant increases in yield or reduced weed weights. Moody (1977), on the other hand indicated that at higher densities the rice plant becomes more competitive, thus reducing weed weights, but not providing significant increases in yield. Siriwardena (1980, Unpubl.) had reported that increasing seed rates from 50 to 400 kg/ha had resulted in a 18 % decrease in the number of weeds with a dwarf cultivar, while this value was 25 % with a taller variety. He also reported that at harvest there was a 59 % decrease in the number of weeds with the tall cultivar.

A survey conducted prior to the commencement of this study in 21 farmers' fields in close proximity to the experimental site revealed that a seed rate of 3 bushels per acre (150 kg / ha) was being used, instead of the recommended 100 kg/ha. This, the farmers claimed was due to viability losses they expect between seeding and seed emergence in dry seeding. In Batticaloa, where dry seeding is practised, farmers use up to 400 kg/ha, specifically with the purpose of controlling weeds. One of the objectives of this study was to determine the effect of seed rates or plant density on weed management. If a grain yield advantage is not realised, the cost of using higher seed rates and gains from reduced weed management measures become relevant.

Nitrogen is an essential element for rice at the vital stages of tiller formation, panicle initiation and heading, each stage determining the yield components and final grain yield. It had been observed at Paranthan that using N levels recommended by the Department of Agriculture for the low country dry zone resulted in the crop exhibiting N deficiency in the newly improved varieties. The low cation exchange capacity (CEC) of the loamy sand soil could contribute to high rates of leaching. Moody (1977) had stated that in dry seeded rice higher proportion of the N was taken up by the *Echinochloa* spp. growing in association with rice. It had been observed that using the recommended rate of nitrogen, when using a seed rate of 100 kg/ha, N deficiency symptoms were exhibited. In the experiments conducted, as higher seed rates were used that could lead to intra specific competition in rice, rates up to 180 kg N/ha were used. Also, earlier studies on the subject by Jeganathan *et al.* (1984) had given positive yield gains up to 180 kg N/ha.

Incorporation of organic matter (OM) could be a strategy to increase CEC and thereby reduce N losses, making more of it available to the crop. Apart from this, OM has other qualities, which are favourable for crop growth and thus provide the dry seeded rice crop a competitive advantage. Supplement of OM helps in retaining moisture 20 times its weight, forms soil aggregates increasing permeability, establishes stabilised soil structure, through chelation forms stable availability of nutrients, being insoluble in water prevents leaching, through its buffer action maintains pH and by mineralization makes available the essential elements that enhances microbial activity (Stevenson, 1982). Alexander (1977) had determined that in general, level of microbial activity is positively correlated to the level of OM. It has been established that through microbial activity in rice soils 30 to 40kg N/ha could be generated (Firth *et al.*, 1973). The present study therefore was undertaken to determine the effect of seed rates, N levels and organic matter application on weed growth and grain yields in dry seeded rice.

MATERIALS AND METHODS

Experimental site and physical resources

All the experiments were conducted at the Rice Research Station (RRS), Paranthan, which is located 79° 59' E and 8° 89' N at 4 m above mean sea level. This region falls under the low country dry zone of the agroecological regions of Sri Lanka (DL 3, DL 4). The annual rainfall of the region ranges between 1,200 to 1,600 mm, 55 to 65 % of which is received during the months of October, November and December. The experimental site receives supplementary irrigation from the Iranaimadhu tank during the wet season (*maha*) and almost all the water during the dry season (*yala*).

The annual average temperature ranges between 26 to 28°C, with the lowest ranging between 16 to 18°C during the months of January and February and the highest of 32 to 36°C during July and August (Annual Report 1980, Rice Research Station, Paranthan, Unpubl.). The rice soils are alluvial in nature and loamy sand in texture, with a pH (1:1) of 5.1. The CEC was 3.58 me/100g while total nitrogen was 0.07 %. The organic matter (OM) content was 0.5 %.

Experimental material

The rice variety used in these investigations was Bg 34-6, as farmers in these areas preferred this variety for its high yield potential (5 t/ha), red pericarp, non-lodging nature and more importantly its resistance to rice blast. Rainfed areas in the north cultivated the red pericarp variety 62-355 till it became very susceptible to rice blast. Bg 34-6 another red pericarp variety of the same age group replaced 62-355, as it possessed tolerance to rice blast at that time. Its parents were IR 8-246/Pachchaiperumal/Mas/H 501. This is a 3.5 month age variety, with a culm length of 64.8 cm (Department of Agriculture, 1983). As Bg 34-6 became susceptible to blast at the latter stage of this study, it was replaced by Bg 94-1 a white pericarp variety in *maha* 89/90. Bg 94-1 belongs to the same age group, but produces many erect tillers and has a yield potential of 7 t/ha. Its parents were 1R 262/ LD 66.

Experimental procedure

Land preparation was done by disc ploughing followed by one or two passes with a tyne tiller. Untreated dry seeds were broadcast sown at the rate of 100 kg/ha and covered with a thin soil layer using a hand implement (mammoty). Plots were 6m x 3m with 30cm wide bunds between treatments and 60cm wide bund between replicates. Fertilizer rates used were those used in the Co-ordinated Rice Variety Trials (CRVT) viz. 48 kg P₂O₅/ha and 24.2 kg K₂O/ha. The N levels used in the different trials along with the different treatments and designs used are given in Table 1. Plant protection measures recommended by the Department of Agriculture were taken when necessary. In all the experiments, a hand weeding operation was performed at 5 weeks after emergence (WAE).

Table 1. Designs and treatments used in the experiments

Experiment	Season	Seed rate (kg/ha)	N level (kgN/ha)	Organic matter (10t/ha)	Design
Seed rates and N levels	yala 84 & maha 84/85	100, 200, 300 & 400	0, 90 & 180	—————	4x3 factorial RCBD 4 replicates
N levels and organic matter	maha 85/86	125	90 & 180	<i>Thespesia indica</i> leaves, Straw & control	Observation trial
N levels and organic matter	yala 86	125	30,60,90 &120	Straw and control	4x2 factorial RCBD 4 replicates
N levels and organic matter	yala 88 & maha 88/89	125	60,90,120, 150 & 180	Straw and control	5x2 factorial RCBD 4 replicates

Nitrogen split applied as 6% at seedling, 30% at 2 WAE, 22 % at 5 WAE and 40% at 7 WAE

Data collection

Weed counts by species were taken at 5WAE and at final harvest by placing quadrants (40cm x 50cm) at pre-marked areas. Weed dry weight by species was determined at harvest. Grain yield and chaff weights were obtained from the harvested area (5.4m x 2.4m). Data were statistically analysed using the relevant ANOVA procedures.

RESULTS AND DISCUSSION

The dominant weed species present in the experimental area were as follows: Annual grasses: *Echinochloa colona* and *E. crusgalli* spp., *Digitaria sanguinalis*, *Leptocloa chinensis* and, *Eleusine indica*. Annual sedges: *Cyperus iria*, *C. difformis* spp., and *Fimbristylis littoralis*. Annual broad leaf weeds: *Commelina benghalensis*, *C.indica*, *C.diffusa*, *Aeschynomene indica* and *Ageratum conyzoides*. The annual grasses and sedges were predominant throughout the season. The broad leaf weeds went down with standing water.

Seed rates and nitrogen levels

Yala 1984 and maha 1984/85

In the experiments conducted in yala 1984 a significant yield increase (39 %) was obtained with the increase of seed rate from 100 to 400 kg/ha, while in maha 84/85 there was no significant difference in yield with respect to seed rates (Tables 2 and 3). With regard to population density of the predominant sedge *Cyperus* spp. seed rates of rice did not have any significant effect in yala 84 (Table 4), but in maha 84/85 where dry weights of weeds were taken, there were significant reductions with

increased seed rates of rice (Table 5). In the case of the predominant grass *Echinochloa* spp. the seed rates of rice did not have any significant effect on either weed counts or dry weights in *yala* 84, but in the *maha* 84/ 85 there were no consistent changes in these parameters according to seed rates (Table 6). There was a significant reduction (50%) of dry weight of *Echinochloa* spp. when the seed rate was increased from 100 to 200 kg/ha (Table 6). The results clearly indicated that such reductions were not consistent with seed rates and thus could not be considered conclusive. This could be attributed to the heterogeneity that could exist from plot to plot in respect of the weed seed populations in soil.

Table 2. Effect of seed rates and nitrogen levels on grain yield of rice (Bg 34-6) - Rice Research Station, Paranthan, *yala* 1984

N level (kg/ha)	Grain yield (t/ha)				
	Seed rate (kg/ha)				
	100	200	300	400	Mean
0	0.66	0.75	0.96	0.99	0.84
90	1.07	1.37	1.39	1.77	1.40
180	1.88	2.21	2.24	2.26	2.15
Mean	1.20	1.44	1.53	1.67	
CV (%)	= 20.54				
LSD for N 5 % - 0.26 and 1 % - 0.29 t/ha; LSD for seed rates 5 % - 0.25 and 1 % - 0.34 t/ha					
LSD for two means 5 % - 0.43 and 1 % - 0.58 t/ha					

Table 3. Effect of seed rates and nitrogen levels on grain yield - Rice Research Station, Paranthan, *maha* 1984/85

N level (kg/ha)	Grain yield (t/ha)				
	Seed rate (kg/ha)				
	100	200	300	400	Mean
0	0.85	0.92	0.89	0.91	0.89
90	1.89	1.93	2.17	1.87	1.97
180	2.57	2.55	2.49	2.37	2.37
Mean	1.77	1.80	1.85	1.72	
CV (%)	= 17.27				
LSD for N 5 % - 0.17 and 1 % - 0.23 t/ha					
LSD for two means 5 % - 0.33 and 1 % - 0.45 t/ha					

Table 4. Effect of seed rates and nitrogen levels on population of *Cyperus iria* - Rice Research Station, Paranthan, yala 1984

N level (kg/ha)	Population of <i>Cyperus iria</i> (transformed data)				
	Seed rate (kg/ha)				
	100	200	300	400	Mean
0	8.15	7.60	11.25	8.29	8.82
90	8.17	6.51	3.35	8.31	6.59
180	4.37	2.84	2.84	2.84	3.23
Mean	6.90	5.65	5.81	6.48	

LSD for N 5 % - 0.45 and 1 % - 0.65.

Table 5. The effect of seed rates and nitrogen levels on dry weight of *Cyperus iria* at harvest - Rice Research Station, Paranthan, maha 1984/85

N level (kg/ha)	Dry weight (kg/ha)				
	Seed rate (kg/ha)				
	100	200	300	400	Mean
0	957	1902	1171	465	1125
90	1167	432	607	167	593
180	802	411	704	386	576
Mean	976	915	828	339	

CV (%) = 66.42; LSD for N 5 % - 275 and 1 % - 371kg/ha; LSD for two means 5 % - 551 and 1% - 742 kg/ha

Table 6. The effect of seed rates and nitrogen levels on dry weight of *Echinochloa colona* - Rice Research Station, Paranthan, maha 1984/85

N level (kg/ha)	Dry weight (kg/ha)				
	Seed rate (kg/ha)				
	100	200	300	400	Mean
0	216	93	201	139	162
90	232	93	224	147	174
180	401	239	77	131	212
Mean	283	142	167	1396	

CV (%) = 56.05; LSD for seed rate 5 % - 130 and 1 % - 176 kg/ha; LSD for N 5 % - 113 and 1% - 152 kg/ha

In contrast, when N level was increased from 0 to 90 and 90 to 180 kg N/ha, grain yields increased by 1.67 and 1.53 fold, respectively in yala 84 (Table 2) and by 2.2 and 1.2 fold respectively in maha 84/85 (Table 4). Also the population of *Cyperus* spp. decreased significantly with every increment of N in yala 84 (Table 3), while in

maha 84/85 the dry weight of it decreased significantly by 40 % when the N level was increased from 0 to 90 kg N/ha (Table 5).

More weeds are C4 plants compared to agricultural crops, which are mostly C3 plants. Rice belongs to the latter category. C4 plants have admirable qualities of carrying out photosynthesis on hot dry days, have high light saturation points ranging between 8,000 to 10,000 ft.c. (Barden *et al.*, 1987; Black, 1973) and their average water requirement is 300 g/g dry matter (Shantz and Piemeisel, 1927). The maximum photosynthetic rate is 100 mg/g hr. and CO₂ compensation point is 5ppm. The C3 plants, on the other hand, close their stomata on dry days leading to reduce rates of photosynthesis, the maximum being 55 mg /g hr. and CO₂ compensation point is 50 ppm. Bright sunlight promotes photo-respiration, have lower light saturation points (6,000 ft.c) and the average water requirement is 628 g/g of dry matter. In this context, it should be noted that many weeds though not belonging to the C4 category are classified as efficient plants bearing characters similar to C4 plants (Black *et al.*, 1969).

The rice growing environment at Paranthan is hot and dry, where the aerobic upland and anaerobic lowland conditions alternate with each other for a good part of the crop all favouring the C4 weed and not the C3 crop rice. This is further supported by the findings of Yamamoto and Ohaba (1976) who reported that the optimum soil moisture should be 70 to 80 % of the maximum water holding capacity of the soil for the emergence and growth of 12 weed species in rice. Thus, the assumption made by Moody (1977) that higher seed rates will give rice the competitive advantage is open to question. Higher seed rates could lead to intra-specific competition instead. De Datta and Nawarez (1983) have confirmed that higher seed rates or spacing will not have any effect on yield or weed weights. However, the final outcome could depend on prevalent environmental conditions. Nevertheless, realising the viability and other losses that could occur between seeding and seedling emergence in dry seeded rice, a seed rate of 125 kg/ha (2 bushels per acre) could be recommended.

On the other hand, response of rice yield to N had been positive in the present study. The loamy sand texture of the soil with a CEC of 3.55 me/100g within the first 60 cm of soil could lead to high levels of leaching of N. According to Lehr and Wessemael (1981), low CEC could lead to high volatilization of urea. The exposure of the soil surface to oxygen by alternate flooding and drying (Patrick and Gotoh, 1961) and high temperatures (Reddy and Patrick, 1976) could also lead to denitrification. As a result, the environment prevalent at Paranthan could lead to heavy nitrogen losses through various means predominant among them being leaching. In such a situation the little nitrogen that is available has to be shared by the crop and weeds. The C4 weed with a higher metabolic rate thrives in the prevalent environment, gets the better share of the available N, thus depriving the rice crop. This is in agreement with Moody (1977) who established that higher proportion of the available N is taken up by *Echinochloa* spp.

Addition of higher rates of N will result in higher rates of leaching, though more N is made available to the crop. The former is not desirable environmentally and not feasible economically, especially after drastic reductions of subsidies on fertilizers.

Maha 1985/86.

In the experiments carried out to minimize N losses through the use of organic matter in *maha* 85/86, a seed rate of 125 kg/ha was inadvertently used and owing to early rains wet sowing of pre-germinated seed under puddled conditions had to be resorted to. This resulted in a thick crop stand and aided by the atmospheric conditions prevailing during *maha*, the crop was affected by leaf and neck blast caused by *Pyricularia oryzae*. At the early stages plots receiving 180 kg N/ha with OM gave a leaf blast score of 6, while corresponding plots without OM had a score 3. The other plots were not affected at this stage, but at heading all the plots were affected by neck blast and the degree of infestation was heavier in plots having higher levels of N and OM.

Grain yields (Fig. 1) were reduced at higher levels of N. At the corresponding levels of N in the presence of OM, the reductions in yields were higher. The chaff weights (Fig.1) indicated a reverse trend where weights were higher at higher levels of N and also in the presence of OM. These results partly explain the reverse trend in yields caused by blast. Plots with *Thespesia* leaves exhibited this trend more than those having rice straw.

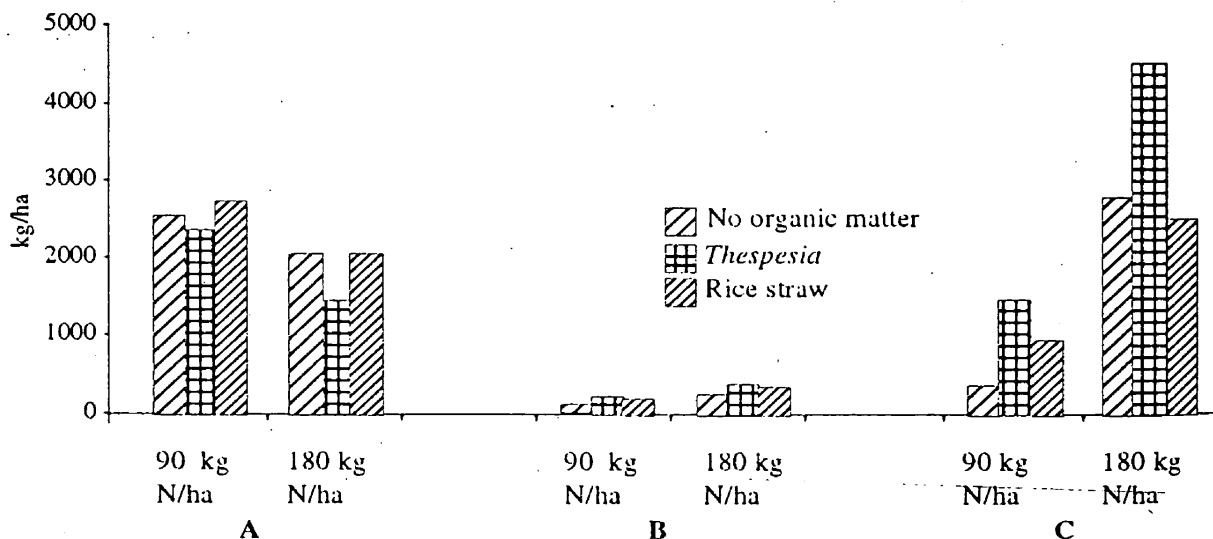


Fig.1. Effect of nitrogen levels and organic matter, *Thespesia indica* leaves and rice straw, on grain yield (A), chaff weight (B) and dry weight of weeds (C) at harvest-*maha* 1985/86

Fig. 2 gives the N content of the grain and straw of different treatments. Nitrogen content of grain and straw in plots with OM was greater than that in those without it. Interestingly, the straw obtained from *Thespesia* treated plots had less N

than that obtained from the straw amended plots, while a reverse trend (Fig.2) was observed with regard to the grain. This could be an indication that *Thespesia* leaves were able to provide more N at the latter stages of the crop and longer benefit to the crop.

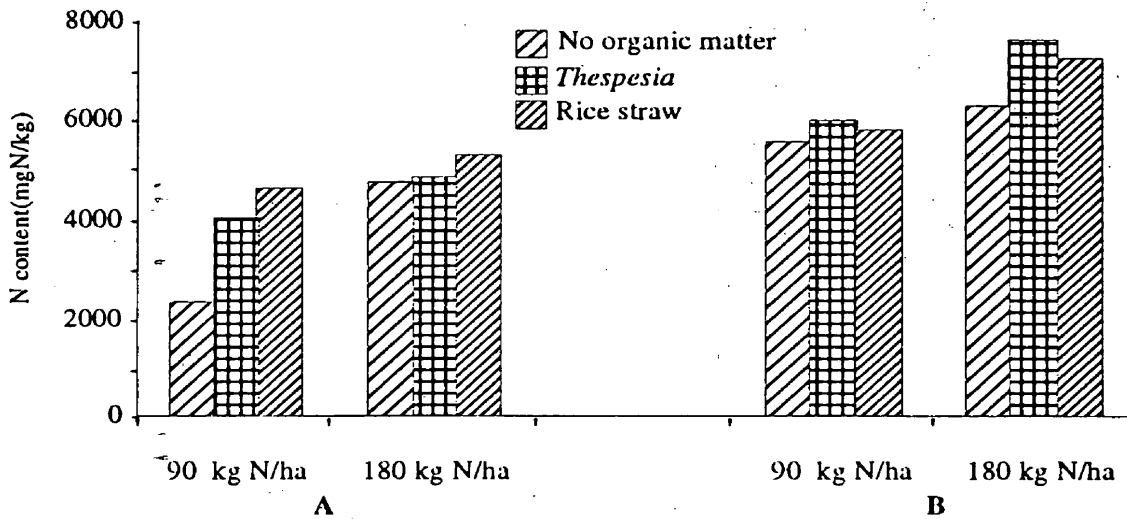


Fig.2. Effect on nitrogen levels and organic matter, *Thespesia indica* leaves and rice straw, on nitrogen content of harvested straw (A) and grain (B) - maha 1985/86

At harvest the weed weights were higher at higher levels of N and OM (Fig.1). This could be due to the higher incidence of blast in these plots, thus creating vacant patches for weeds to emerge and make the crop less competitive.

Nitrogen levels and rice straw as organic matter

In *yala* 86 a trend was observed for grain yield to increase at higher N levels and significant differences were obtained between grain yields at 60 and 90 kg N/ha and those at 90 and 120 kg/ha (Fig.3). OM incorporated plots gave significantly higher yields than those without OM. On the other hand, for N levels of 60 to 120 kg N/ha, chaff weight in the presence of OM was lower than those without OM. Thus, it appears OM leads to better grain filling. Chaff weights, on the other hand, had increased at higher N levels, but there were noticeable reductions in the presence of OM at every level of N (Fig.3). Though weed weight increased dramatically at N levels of 90 and 120 kg N/ha, at every level of N the weed weights decreased with OM, this being significantly by 50% at 90 and 120 kg N/ha (Fig.4). This is in accordance with the grain yield and chaff weights obtained in the present study.

In *yala* 1988, grain yields increased with each increment of N, but significant increases in yields were obtained at 60 and 90 kg N/ha with the incorporation of OM (Fig.5). Plots with 180 kg N/ha in the presence of OM gave the highest yield of 3.82 t/ha, which was 16% higher than the plots without OM. Weed weights decreased in the presence of OM, when compared to plots without OM amendments (Fig.5).

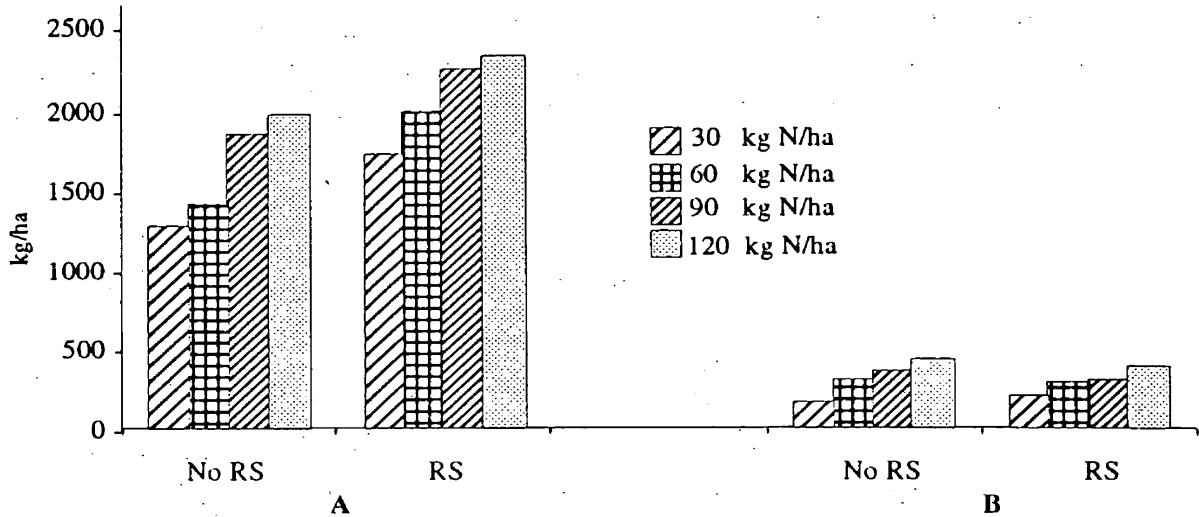


Fig.3. Effect of nitrogen levels and rice straw (RS) on grain yield (A) and chaff weight (B) -yala 1986

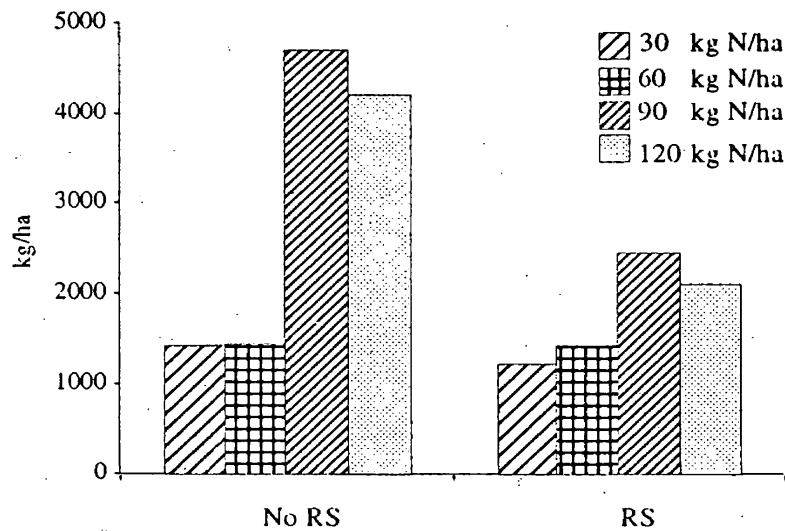


Fig.4. Effect of nitrogen levels and rice straw (RS) on dry weed weight - yala 1986

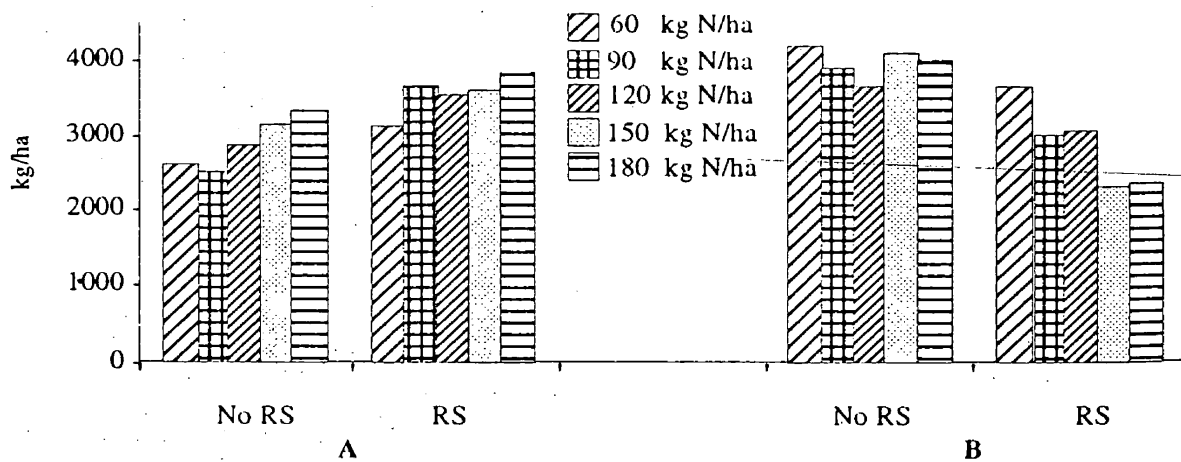


Fig.5. Effect of nitrogen levels and organic matter (rice straw-10 t/ha) on grain yield (A) and dry weight of weeds (B) - yala 1988

In *maha* 89/90, the same trend was observed as in *yala* 88 with regard to grain yields (Fig.6). At 150 kg N/ha and in the presence of OM, significant yield increases were obtained over all treatments. Plots supplied with 180 kg N/ha in the presence of OM gave significantly lower yield and this could be attributed to the optimum leaf area index being reached at 150 kg N/ha and further addition of N had resulted in excessive vegetative growth.

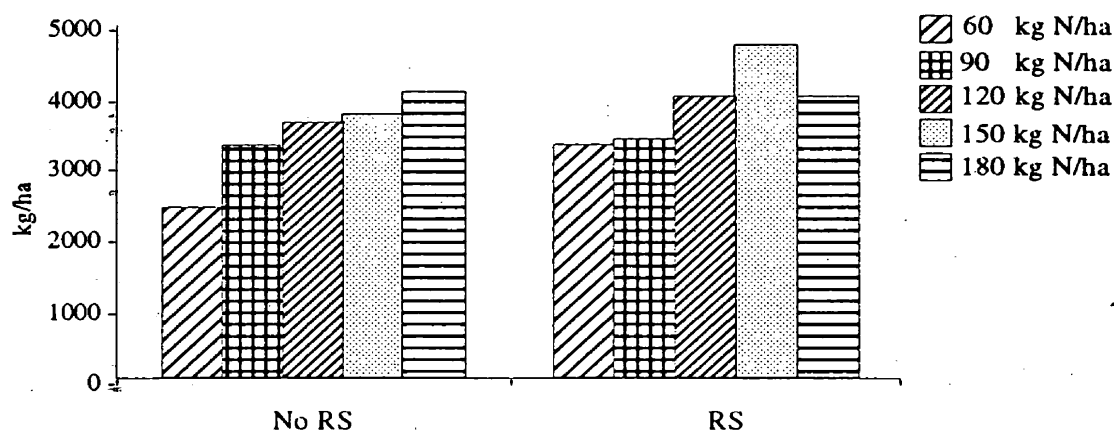


Fig.6. Effect of nitrogen levels and rice straw (RS) on grain yield - *maha* 1989/90

The results indicated that the optimum N level required could vary between 120 to 150 kg N/ha. The specific level could vary from season to season depending on various environmental factors over which the farmer has no control. Paying heed to economic considerations, a N level of 120 kg N/ha could be used along with all available OM. In the present experiments, organic matter was used at the rate of 10 t/ha. The harvest index in rice could vary between 0.3 to 0.7 (Vergara and Vispares, 1977) depending on the cultivar. On this basis the amount of straw that could be obtained with a grain yield of 4 t/ha would be 2 to 9 t/ha. This necessitates that the farmer has to seek other sources of OM to fulfil his requirement of OM.

The numerous benefits that could accrue to the soil and thereby the crop through incorporation of OM have been listed earlier. Hence, OM addition to the rice soils of Paranthan directly and indirectly creates an environment to the advantage of the rice crop thus giving it a competitive advantage, which is lacking in the prevalent environment.

It is important to note that dry seeded rice, under aerobic upland conditions, does not enjoy the head start that the other forms of rice culture do and one of the weed management strategies should be to shift the competition in favour of the crop. As discussed earlier OM would help in this regard.

CONCLUSIONS

In broadcast sown dry seeded rice under loamy sand conditions, seed rates higher than the recommended 100 kg/ha (2 bushels/acre) would give neither consistent weed management nor higher yields. A seed rate of 125 kg/ha is recommended to counter viability and other losses that could occur between seeding and emergence of

the crop. Nitrogen levels ranging between 120 to 150 kg N/ha could be recommended to achieve maximum grain yield and optimum weed control for dry seeded banded rice in loamy sand soils. Incorporation of OM at a minimum rate of 10 t/ha could help achieving optimum yields and control of weeds.

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