21.0 per cent of the total P content. Ca-P ranged from 52.6 to 115.3 mg kg^{-1} in Suryanallur and Dasarapatti series, respectively. This fraction constituted the predominant fraction occupying about 23.6 to 53.3 per cent of the total P content in the surface soils. Though the soils belong to acid soil group except Dasarapatti series, with pH ranging from 6.0 to 7.1 where sufficient amount P fixation leading to non-availability of P to crops, Ca-P was observed to be the major fraction. This peculiar situation might be due to moderately higher amount of organic carbon in these soils which might have been hydrolyzed by the acid extractant namely 0.5 N H_2SO_4 used in the fractionation procedure.

The organic P ranged from 21.4 to 25.7 mg kg^{-1} which constituted 10.9 to 26.4 per cent of the total P content of the soil.

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INFLUENCE OF ORGANIC AND INORGANIC FERTILISATION AND PLANT DENSITY ON PRODUCTION POTENTIAL OF RICE-RICE CROPPING SYSTEM

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An investigation was carried out at Agricultural College, Madurai, Tamil Nadu, to study the direct and residual effects of organic manures integrated with inorganic N levels and plant densities on the production potential of rice-rice cropping system. Application of cattle manure (FYM or sheep penning) had pronounced direct effect on rice grain yield (7.92 and 7.86 t ha^{-1}, respectively) as against 7.41 t ha^{-1} with green manure (*Sesbania rostrata*) application in *kharif* season, and residual effect with 6.01 and 5.71 t ha^{-1} respectively, in *rabi* season. Though the plant densities (8.33 and 6.67 lakh hills ha^{-1}) did not affect the grain yield significantly in *Kharif*, low plant density recorded higher grain yield (5.61 t ha^{-1}) in *rabi* season. The most economical level of N was found to be 160 kg ha^{-1} for both the seasons.

In order to meet the food demand of the ever increasing human population, it is imperative to maximise the productivity of rice, the staple food, as land and water resources are limited for extending the area under rice (Chauhan *et al.*, 1985). To harness the natural resources of crop

production more efficiently and to maximise the productivity of rice, the agronomic requirements such as plant density and fertilizer need of the genotypes should be met with. According to Sharma and Mittra (1989), the response of rice to N is generally very high and its supply is essential for realization of the full potential of the rice cultivar. The global energy crisis and increasing fertilizer N cost necessitated the need for the use of supplemental N sources. Integrated use of organic and biological sources of N with mineral fertilizer is a possible way not only for sustaining atleast part of N, but also achieving ecologically sound and sustainable agriculture (Swaminathan, 1987).

A uniform crop stand containing an optimum plant density is essential for proper crop development and high grain yields. Rate of fertilizer application can also affect the yield response to plant density (Nguu and De Datta, 1979). These factors viz., organic manures, inorganic N and plant density not only just act independently rather they strongly interact with each other and influence the yield of rice (Anon, 1987). As the optimum level of these inputs vary with cultivar, soil type, climate and management practices, this study was made to optimise the above inputs to maximise the productivity of transplanted lowland rice-rice system in Periyar-Vaigai command area.

MATERIALS AND METHODS

A field experiment was conducted at the Agricultural College and Research Institute Farm, Madurai, Tamil Nadu during *Kharif* and *rabi* season, on a Madukkur series sandly clay loam soil in a rice-rice system. The nutrient status of the soil was low, medium and high in available N, P_2O_5 and K_2O content respectively. The farm receives canal water from Periyar - Vaigai Project.

Two transplanted rice crops were grown in sequence during *kharif* and *rabi* season to study the interactive effects of organic manures, inorganic N levels and plant densities on the productivity of rice-rice cropping system. Three sources of organic manures (sheep penning 6750 heads ha^{-1}, FYM 12.5 t ha^{-1} and green manure 6.25 t ha^{-1} (*Sesbania rostrata*) in main plots and two plant densities (6.67 and 8.33 lakh hills ha^{-1}) in sub-plots under three levels of inorganic N (100, 150 and 200 kg ha^{-1}) in sub-sub plots were studied in split-split design, replicated thrice during *kharif* season. During *rabi* season, a second crop of rice was grown to study the residual effect of organic manures in the same field layout of *kharif* season under the above plant densities and N levels.

Sheep penning was done in the respective plots itself 15 days before transplanting and the voiding were incorporated into the soil by ploughing. *Sesbania rostrata* raised in a separate field was used as green manure. The required quantity of *Sesbania rostrata* (60 days old) were incorporated in the puddle ten days before planting, maintaining a standing water of 5± 2 cm during the period. The calculated amount of well decomposed FYM was uniformly spread and ploughed and incorporated in the soil at the time of sheep voiding incorporation.

Fertiliser N, as per treatments was applied as prilled urea in four equal splits at planting, tillering, panicle initiation and heading stages. A common dose of 50 kg ha^{-1} each of P_2O_5 and K_2O were applied. Two plant densities of 6.67 (15 x 10 cm spacing) and 8.33 (15 x 8 cm spacing) lakh hills ha^{-1} were adopted. Twenty six day old ADT. 36 seedlings were transplanted as per plant density treatment. Biometric observations were recorded adopting standard procedures and crop yield was determined from net plot area and expressed in t ha^{-1} at 14 per cent moisture.

RESULTS AND DISCUSSION

Yield Components

Generally, a higher level of yield components and yield were recorded during *kharif* than *rabi*, which is attributable to the favourable climatic conditions prevailed in *kharif*, than in *rabi*, being a rainy season. Marked influence of FYM on plant growth and tiller production had resulted in

Table 1. Effect of integrated N management on yield and economics of transplanted lowland rice-rice cropping system

Treatments	*Kharif* rice					*Rabi* rice				
	LAI at flowering	Panicles m^{-2}	Grain yield (t ha^{-1})	Net income (Rs. ha^{-1})	B:C ratio	LAI at flowering	Panicles m^{-2}	Grain yield (t ha^{-1})	Net income (Rs. ha^{-1})	B:C ratio
Organic manures										
Sheep penning	6.51	587	7.86	14762	2.88	4.81	461	5.71	1038	2.78
Green manure	5.60	550	7.41	14228	3.02	4.15	395	4.91	8111	2.39
Farm yard manure	6.92	581	7.92	14818	2.88	5.13	488	6.01	11253	2.94
CD 5%	0.17	30.1	1.95	-	-	0.13	16.6	1.97	-	-
Plant densities										
6.67 lakh hills ha^{-1}	6.25	570	7.79	14832	2.98	4.63	456	5.61	10143	2.78
8.33 lakh hills ha^{-1}	6.44	576	7.67	14374	2.86	4.76	440	5.48	9691	2.63
CD 5%	0.09	NS	NS	-	-	0.06	8.36	1.26	-	-
N levels										
100 kg ha^{-1}	6.18	553	7.45	14044	2.91	4.57	438	5.37	9660	2.73
150 kg ha^{-1}	6.34	574	7.75	14678	2.93	4.70	446	5.57	9962	2.71
200 kg ha^{-1}	6.50	591	7.98	15085	2.39	4.82	461	5.71	10129	2.67
CD 5%	0.05	8.00	0.94	-	-	0.04	5.56	0.86	-	-

substantial increase in LAI (23.6 per cent) over green manure during both the seasons. By virtue of more number of hills per unit area resulting in taller plants with longer leaves under high plant density of 8.33 lakh hills ha^{-1}, LAI was more in both the seasons in this plant population compared to wider spaced crop. Throat and Patil (1987) observed similar results on crop growth under varying plant densities. As expected, for every increase in N application there was proportionate increase in LAI irrespective of season of cropping.

Number of panicles m^{-2} did not show response to cattle manures during *kharif* season. However, there was an appreciable residual effect of organic manures on panicle number in *rabi* season. The number of panicles were increased by 20-22 per cent by cattle manures over green manuring. Varying plant densities did not influence this parameter in *kharif season*, while,more number of panicles were produced under low plant density during *rabi* season. Graded levels of inorganic N application markedly increased the panicles per unit area and the rate of response was more in *kharif* season, being more favourable season for rice crop.

Grain yield

The difference in yield due to organic manures was significant. Application of cattle manure (FYM or sheep penning) produced higher grain yield (7.92 and 7.86 t ha^{-1} respectively) as against 7.41 t ha^{-1} with green manure incorporation, in *Kharif* season. Though the yield difference between organic manures was very small due to their direct effect, the residual effect of FYM in *rabi* rice was spectacular with an yield increase of 3 q ha^{-1} over the residual effect of sheep penning and 11 q ha^{-1} over green manuring. Kulkarni *et al.* (1983) explained that the cattle manures by virtue of their nutrients content and organic carbon content are decisively more effective in their direct as well as residual effect in a rice-rice cropping system than green manure.

The magnitude of change in grain yield as a function of plant density was quite small in *Kharif* season, whereas planting 6.67 lakh hills ha^{-1} (low

density) recorded higher grain yield of 5.61 t ha^{-1} as against 5.48 t ha^{-1} with higher density (8.33 lakh hills ha^{-1}) in *rabi* season experiencing cool weather and low light intensity compared to *Kharif* season. Raju and Rao (1987) described the mutual shading under high density planting leading to decreased light transmission into the canopy upsetting the photosynthesis as a possible reason for reduced grain yield under higher plant density.

Economics

Though every additional increment in N increased the yield, the response tended to be quadratic. The most profitable levels of N application at the price levels existed estimated through response function were 162.3 and 159.3 kg ha^{-1} for *kharif* and *rabi* seasons, respectively. Verma *et al.*, (1988) reported similar results to graded levels of N application. In *kharif*, applicatin of cattle manures resulted in higher net income over green manured plots as a result of increased yields. However, benefit-cost ratio was highest with green manuring (3.02) compared to 2.88 with cattle manures, due to low cost of production of green manure. In *rabi* season, both net income and benefit cost ratio were higher with cattle manures.

Low plant density treatment gave higher net income and benefit-cost ratio in both the seasons. Though the economic indices were more with higher levels of N in *kharif* season, benefit-cost ratio declined beyond 100 kg N ha^{-1}, due to marginally decreasing response of yield to increasing N levels, especially in cool and monsoon *rabi* season.

Therefore, to maximise the rice yields in sandy loam soils of Tamil Nadu, recommended level of FYM at 12.5 t ha^{-1} and plant density of 6.67 lakh hills ha^{-1} can be adopted in combination with a fertiliser N of 160 kg ha^{-1}. As the FYM source is inadequate, sheep penning is an equivalent replacement of FYM. Maximum yield of 7.97 t ha^{-1} could be obtained in *kharif* season. The residual effect of the above organic manures could be advantageously exploited in a rice-rice cropping system with the addition of some level of fertilizer N and plant density, to get the maximum grain yield of 5.70 t ha^{-1} in *rabi* season.

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