utilization of water along with other resources like light, nutrients, etc.

Applying 4.25 cm of water per irrigation through ridges and furrows increased the yield and WUE. Maintaining the population of 4.0 lakh plants improved the WUE.

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A COMPARATIVE STUDY OF TRADITIONAL AND NEW ESTABLISHMENT METHODS IN RICE FOR YIELD AND ECONOMICS

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ABSTRACT

Seedling broadcast method of stand establishment with different treatment combinations were studied in rice along with line planting and random planting during *Rabi* 1994-95 and *Kharif* 1995. The rice yield obtained by seedling broadcast planting was comparable with traditional random planting though line planting method produced enhanced yields during both seasons of study. However, the return per rupee invested was highest in the case of rice established by seedling broadcast planting (2.59 and 3.02 in *Rabi* and *Kharif* respectively). Studies on the evaluation of component technologies to enhance yields by seedling broadcast planting method revealed that irrespective of nursery method, 35 day old seedling broadcasted at 30 per cent more plant density produced an yield which was on par with line planting during *Rabi*, while in *Kharif* seedlings of semidry nursery which were 35 days old and broadcasted at normal plant density produced higher yield and higher return per rupee invested.

Rice is grown under different agro-ecosystems. The problems and prospects of rice production in different cultural systems vary greatly. Method of stand establishment is one cultural practice which influences the performance of rice through its effect on growth and development (Mian and Ahsan, 1969 and Nair *et al.*, 1973). The farmer is not able to carry out transplanting at the right time due to scarcity and high cost of labour. To overcome this, the need for development of a new establishment method with less labour utilization and quickness of operation was felt. In South East Asian countries, rice crop establishment by simply throwing the rice seedlings in the puddle has been developed for better management and yield (Matsushima, 1979). Hence, this study was undertaken to compare the three stand establishment methods (line planting, random planting and seedling broadcast planting) in terms of yield and economics and to develop the necessary component technologies for seedling broadcast planting in order to obtain yield and return comparable to the established methods of planting.

MATERIALS AND METHODS

Two field studies were undertaken in Tamil Nadu Agricultural University, Coimbatore during *Rabi* (1994-95) and *Kharif* (1995) to compare the different establishment methods in rice and to

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evolve the component technologies for seedling broadcast planting to obtain high yields and economic returns. Experiments were laid out in randomised block design with three replications. The 12 treatment combinations involved combinations from three types of seedlings from 2 nursery methods (wet nursery normal seedlings (N1), wet nursery seedlings dipped in 1:1 clay and cowdung slurry (N2) and seedlings from semidry nursery (N3); two ages of seedlings (25 days (A1) and 35 days (A2) old), and two plant densities (normal (D1) and 30 per cent more (D2)) for seedling broadcast method of planting. The performance of seedling broadcast planted crop under the above treatment combinations was compared with line and random planted crops that were grown with the recommended production practices.

In line planting, 25 day old wet nursery seedlings were transplanted at a spacing of 20 x 10 cm in *Rabi* and 15x10 cm in *Kharif* season. Twenty five day old seedlings of wet nursery were transplanted without adopting any definite plant geometry and density for random planting as is done in the farmers field.

For seedling throwing method, 25 and 35 day old seedlings of wet and semidry nursery were used. Two or three seedlings were separated as in normal transplanting and were broadcast at random by planting women from standing position without using force in the respective plots. The population under normal plant density in seedling broadcast planting method was maintained equal to the pre-decided population in line planting calculated according to the plant spacing adopted in the respective seasons. For treatments involving 30

Table 1. Effect of establishment methods and seedling broadcast planting treatments on grain and straw yield of rice, 1994-95.

Treatments	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
	Rabi	Kharif	Rabi	Kharif
Establishment methods				
Seedling broadcast planting (T_1-T_{12})	5280	6262	6621	7495
Line planting (T_{13})	5799	6645	7366	7907
Random planting (T_{14})	5277	6148	6650	7358
CD (P=0.05)	261	172	327	236
Treatments for seedling broadcast planted rice				
T_1 (N_1-A_1-D_1)	4721	5787	5857	6977
T_2 (N_1-A_1-D_2)	5000	5923	6201	7105
T_3 (N_1-A_2-D_1)	5551	6397	6768	7590
T_4 (N_1-A_2-D_2)	5734	6464	7127	7799
T_5 (N_2-A_1-D_1)	4999	6171	6355	7364
T_6 (N_2-A_1-D_2)	5110	6193	6508	7472
T_7 (N_2-A_2-D_1)	5492	6307	6883	7633
T_8 (N_2-A_2-D_2)	5666	6442	7179	7731
T_9 (N_3-A_1-D_1)	4488	5900	5579	7022
T_{10} (N_3-A_1-D_2)	5333	6284	6718	7497
T_{11} (N_3-A_2-D_1)	5656	6669	7241	7936
T_{12} (N_3-A_2-D_2)	5610	6600	7029	7809
CD (P=0.05)	172.4	113.6	216.3	153.7

N_1 - wet nursery
N_2 - N_1 seedlings dipped in slurry
N_3 - semidry nursery

A_1 - 25 day old
A_2 - 35 day old

D_1 - normal density
D_2 - 30% more density

per cent more population 30 per cent more seedlings were broadcast.

Grain and straw yields were recorded for each treatment separately during both the seasons. Net return was calculated for the treatment combinations by subtracting the total cost of cultivation from the gross return. The net return per rupee invested was calculated using the formula.

$$\text{Returns per rupee invested} = \frac{\text{Net return (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

RESULTS AND DISCUSSION

The data pertaining to the grain and straw yield during *Rabi* and *Kharif* are presented in Table 1. The data showed that in *Rabi* the grain yield obtained by seedling broadcast planting was on par with the yield obtained by the farmers method of planting at random. However, line planting method gave the highest yield (5799 kg ha^{-1}). The higher grain yield in line planting might be due to better nutrient uptake and yield parameters as they were able to grow without great competition due to proper planting and observance of spacing.

A similar trend was observed in *Kharif* also, but 35 day old seedlings of semidry nursery broadcasted at normal plant density recorded an yield of 6669 kgha^{-1} which was comparable to the yield of rice established by line planting method (6645 kg ha^{-1}). Higher grain yield with this method has earlier been documented by Matsushima (1979) and Varughese *et al.*, (1993).

During *Rabi*, the nursery methods did not play a major role in enhancing yields, while in *Kharif*

Table 2. Economics of different establishment methods and seedling broadcast planting treatments in *Rabi*, 1994-95

Treatments	Total cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net returns (Rs ha^{-1})	Returns per rupee invested
Establishment methods				
Seedling broadcast planting (T_1-T_{12})	9194	23770	14493	2.59
Line planting (T_{13})	10507	26142	15635	2.49
Random planting (T_{14})	9486	23768	14282	2.51
Treatments for seedling broadcast planted rice (T_1-T_{12})				
T_1 (N_1-A_1-D_1)	8923	21232	12309	2.38
T_2 (N_1-A_1-D_2)	9312	22481	13169	2.41
T_3 (N_1-A_2-D_1)	8923	24915	15992	2.79
T_4 (N_1-A_2-D_2)	9312	25790	16478	2.77
T_5 (N_2-A_1-D_1)	8993	22542	13549	2.51
T_6 (N_2-A_1-D_2)	9383	23048	13667	2.46
T_7 (N_2-A_2-D_1)	8993	24722	14729	2.75
T_8 (N_2-A_2-D_2)	9383	25536	16153	2.72
T_9 (N_3-A_1-D_1)	9081	20188	11107	2.22
T_{10} (N_3-A_1-D_2)	9471	24019	14548	2.54
T_{11} (N_3-A_2-D_1)	9081	25520	16439	2.81
T_{12} (N_3-A_2-D_2)	9471	25252	15781	2.67
T_{13} (Line planting)	10507	26142	15635	2.49
T_{14} (Random planting)	9486	23768	14282	2.51

N_1 - wet nursery; N_2 - N_1 seedlings dipped in slurry; N_3 - semidry nursery

A_1 - 25 day old; A_2 - 35 day old

D_1 - normal density; D_2 - 30% more density

Table 3. Economics of different establishment methods and seedling broadcast planting treatments in *Kharif*, 1995

Treatments	Total cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net returns (Rs ha^{-1})	Returns per rupee invested
Establishment methods				
Seedling broadcast planting (T_1-T_{12})	9280	28045	18765	3.02
Line planting (T_{13})	10319	29743	19424	2.88
Random planting (T_{14})	9440	27539	18099	2.92
Treatments for seedling broadcast planted rice (T_1-T_{12})				
T_1 (N_1-A_1-D_1)	8947	25939	16992	2.90
T_2 (N_1-A_1-D_2)	9461	26534	17073	2.80
T_3 (N_1-A_2-D_1)	8947	28628	19681	3.20
T_4 (N_1-A_2-D_2)	9461	28980	19519	3.06
T_5 (N_2-A_1-D_1)	9017	27630	18613	3.06
T_6 (N_2-A_1-D_2)	9531	27765	18234	2.91
T_7 (N_2-A_2-D_1)	9017	28281	19264	3.14
T_8 (N_2-A_2-D_2)	9531	28861	19330	3.03
T_9 (N_3-A_1-D_1)	9105	26409	17304	2.90
T_{10} (N_3-A_1-D_2)	9619	28135	18516	2.92
T_{11} (N_3-A_2-D_1)	9105	29850	20745	3.28
T_{12} (N_3-A_2-D_2)	9619	29528	19909	3.07
T_{13} (Line planting)	10319	29743	19424	2.88
T_{14} (Random planting)	9440	27539	18099	2.92

N_1 - wet nursery
N_2 - N_1 seedlings dipped in slurry
N_3 - semidry nursery

A_1 - 25 day old
A_2 - 35 day old

D_1 - normal density
D_2 - 30% more density

semidry nursery was found to be favourable. Aged seedlings (35 day old) performed better in seedling broadcast planting during both seasons. This result is in confirmation of Matsushima (1979), while in *Kharif* normal plant density was enough to obtain comparable yields, in *Rabi*, the seedling density had to be increased by 30 per cent to overcome loss in establishment of seedlings due to incessant rains. Lal *et al.* (1986) is also of the similar view.

The data pertaining to cost of cultivation, net return and return per rupee invested during *Rabi* and *Kharif* are presented in Tables 2 and 3. The cost of cultivation was lowest with seedling broadcast planting compared to line or random planting. This was primarily because of the less number of labour involved in planting and the ease and quickness of operation of this method. Such reduction in labour force was reported earlier by Lal *et al.* (1986) and Mao Bi Jun (1983) (unpublished). Thus, the lower grain yield with seedling broadcast planting compared to line planting was overscored by the lower cost of cultivation which was further manifested by recording highest return per rupee invested. Varughese *et al.* (1993) have also recorded similar observations.

During both seasons, broadcasting of 35 day old seedlings of semidry nursery at normal density recorded the highest return per rupee invested (2.81 and 3.28 during *Rabi* and *Kharif* respectively) followed by 35 day old wet nursery seedlings broadcasted at normal density. The cost for 30 per cent more seedlings and increased labour needed to broadcast it counteracted the higher return from treatments involving 30 per cent more plant density.

From the results, it is concluded that seedling broadcast planting method of crop establishment is favourable compared to line and random planting to obtain higher returns per rupee invested. However, this practice requires a careful water management for the first 7-10 days of establishment stage. Older seedlings (35 day old) from semidry nursery broadcasted at normal density is favourable during *Kharif*, while during *Rabi* there is need to increase seedlings by 30 per cent to get higher yields.

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GENETIC VARIABILITY, CORRELATION AND PATH COEFFICIENT ANALYSIS IN UPLAND EARLY RICE GENOTYPES

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ABSTRACT

Twenty eight rice genotypes of *Oryza sativa*, L. were evaluated for genetic parameters under upland condition. High heritability estimate combined with high genetic advance was observed for grain yield indicating the presence of additive genes. Number of panicles/m^2 recorded high positive significant association with grain yield. In path coefficient analysis, number of panicles/m^2 exerted high positive direct effect with grain yield. Days to 50 per cent flowering exerted high positive indirect effect on grain yield through number of panicles/m^2.

KEY WORDS : Upland rice, Variability, Correlation, Path analysis

Rice is cultivated under rainfed conditions in parts of Chengalpattu, Pudukottai, Sivagangai, Virudhunagar and Ramanathapuram districts of Tamil Nadu. Rice genotypes are being evaluated under upland conditions at the Directorate of Rice Research, Rajendra Nagar, Hyderabad. Twenty eight such rice genotypes were evaluated in terms of variability, correlation and path co-efficient analysis.

MATERIALS AND METHODS

Twenty eight rice genotypes were dry seeded on 28th September 1994 before the onset of North, East monsoon. The trial was laid out in a randomised block design with three replications. The plot size was 3.5 m x 2.5 m with a spacing of 20 cm x 10 cm between rows and plants respectively. The recommended fertiliser dose of 50:25:25 kg of N, P, K ha^{-1} was adopted. Entire P was applied as basal, entire N as top dress and the half of K as basal and the another half of K as top dress. The other recommended agronomic practices were followed. Observations were recorded on five randomly selected plants in each replication for four biometric characters. The genotypic and phenotypic variances and genetic advance were worked out according to the formula given by Johnson *et al.*, (1955). The method suggested by