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Effect of non-conventional systems of cultivation with varied N levels on growth, yield and water management of rice *(Oryza sativa)*

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Abstract: Field experiments were conducted at the Tamil Nadu Agricultural University, Coimbatore, to study the performance of different systems of rice cultivation under varied nitrogen levels. The systems were, direct seeding of sprouted seeds under puddled condition, direct seeding of sprouted and dry seeds under unpuddled condition and transplanting of seedlings under unpuddled condition. In the puddled soil, 5 cm depth of water was maintained throughout the crop growing period. In respect of unpuddled condition, 5 cm depth of irrigation was given at 80 per cent of the available soil moisture. The nitrogen levels were 50, 75, 100, 125 and 150 per cent of recommended dose of nitrogen. The results revealed that the direct seeding of sprouted seeds under puddled condition recorded higher growth and yield parameters than other systems studied. Beneficial effect was evident at 100 per cent of recommended dose of nitrogen which was comparable with that at 125 and 150 per cent. In case of water savings, the direct seeding of sprouted seeds under unpuddled soil condition recorded the higher water productivity than the puddled condition.

Key words : Rice (Oryza sativa), puddled condition, unpuddled condition, N levels, water productivity, yield.

Introduction

Rice production systems of Asia undergo major adjustments in response to the increasing scarcity of land, labour, capital and water, the major adjustments are to be ushered in the method of crop establishment (Pandey and Velasco, 1999). Another major concern in rice production systems is the dwindling trend of availability of water resources. It is also a known fact that the water use efficiency of rice is much lower than other crops. On an average, more than 5000 litres of water are used to produce one kilogram of rice. Efficient management of water is of paramount importance for sustaining and increasing agricultural production. In irrigated wet seeded rice culture, water-use efficiency on the farm can be increased by applying only the amount of water needed. In water scarce areas, the farmers prefer direct seeding method as an alternative to traditional method of transplanting during the period of delayed receipt of water in the canal (Dubey, 1995). Therefore, an attempt was made to raise the crop under different unconventional eco-systems

Materials and Methods

Field experiments were conducted during *late samba* 2001 (Oct. 2001 - Feb. 2002) and *kuruvai* 2002(July - Oct. 2002) seasons at the wetland farm of Tamil Nadu Agricultural University, Coimbatore, (11ºN, 77ºE and 427 m). The experimental fields were clay loamy soil texture and taxonomically classified as

Table 1. Effect of systems of cultivation and nitrogen levels on maximum root length (cm) of rice

Treatments	*Late samba* 2001					*Kuruvai* 2002				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
50% RDN	16.6	15.4	15.1	14.6	15.4	17.3	15.9	15.5	14.2	15.7
75% RDN	17.1	15.8	15.5	15.0	15.9	18.1	16.8	16.5	15.3	16.7
100% RDN	17.5	16.2	15.9	15.5	16.3	18.9	17.7	17.4	16.2	17.6
125% RDN	17.7	16.5	16.2	15.7	16.5	18.9	17.8	17.3	16.6	17.7
150% RDN	17.8	16.5	16.3	15.8	16.6	19.1	17.9	17.5	16.4	17.7
Mean	17.3	16.1	15.8	15.3	16.1	18.5	17.2	16.8	15.7	17.1
Source		SEd		CD (P = 0.05)			SEd		CD (P = 0.05)	
M		0.1		0.3			0.3		0.8	
N		0.2		0.4			0.4		0.8	
M at N		0.4		NS			0.8		NS	
N at M		0.4		NS			0.8		NS	

RDN- Recommended Dose of Nitrogen (120 kg ha^{-1} for *kuruvai* and 150 kg ha^{-1} for *late samba)*
M_1 - Direct seeding of sprouted seeds under puddled condition
M_2 - Direct seeding of sprouted seeds under unpuddled condition
M_3 - Direct seeding of dry seeds under unpuddled condition
M_4 - Transplanting under unpuddled condition

Table 2. Effect of systems of cultivation and nitrogen levels on root volume (cm^3 $hill^{-1}$) of rice

Treatments	*Late samba* 2001					*Kuruvai* 2002				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
50% RDN	12.10	11.60	11.50	9.11	11.08	12.83	12.11	12.10	9.71	11.69
75% RDN	12.37	11.91	11.81	9.27	11.34	13.10	12.41	12.32	10.02	11.96
100% RDN	12.70	12.20	12.12	9.63	11.66	13.47	12.63	12.57	10.21	12.22
125% RDN	12.71	12.31	12.13	9.71	11.71	13.50	12.71	12.61	10.22	12.26
150% RDN	12.77	12.31	12.14	9.72	11.73	13.51	12.71	12.63	10.30	12.28
Mean	12.53	12.06	11.94	9.48	11.50	13.28	12.51	12.45	10.09	12.08

Source	SEd	CD (P = 0.05)	SEd	CD (P = 0.05)
M	0.09	0.21	0.09	0.21
N	0.11	0.23	0.12	0.25
M at N	0.22	NS	0.23	NS
N at M	0.23	NS	0.24	NS

RDN- Recommended Dose of Nitrogen (120 kg ha^{-1} for *kuruvai* and 150 kg ha^{-1} for *late samba)*

M_1 - Direct seeding of sprouted seeds under puddled condition

M_2 - Direct seeding of sprouted seeds under unpuddled condition

M_3 - Direct seeding of dry seeds under unpuddled condition

M_4 - Transplanting under unpuddled condition

Table 3. Number of panicles as affected by systems of cultivation and nitrogen levels on (m^{-2})

Treatments	*Late samba* 2001					*Kuruvai* 2002				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
50% RDN	308	265	257	232	266	312	276	269	246	276
75% RDN	319	279	271	248	279	326	292	286	264	292
100% RDN	332	292	287	259	293	341	318	312	289	315
125% RDN	335	297	293	264	297	344	325	320	298	322
150% RDN	338	301	298	265	301	348	331	326	307	328
Mean	326	287	281	254	287	334	308	303	281	307

Source	SEd	CD (P = 0.05)	SEd	CD (P = 0.05)
M	6	14	6	15
N	6	13	7	14
M at N	13	NS	14	NS
N at M	13	NS	14	NS

RDN- Recommended Dose of Nitrogen (120 kg ha^{-1} for *kuruvai* and 150 kg ha^{-1} for *late samba)*

M_1 - Direct seeding of sprouted seeds under puddled condition

M_2 - Direct seeding of sprouted seeds under unpuddled condition

M_3 - Direct seeding of dry seeds under unpuddled condition

M_4 - Transplanting under unpuddled condition

typic haplustalf. The soil was low in available nitrogen (N), medium in available phosphorus (P) and high in available potassium (K). The medium duration rice Cv.Co 43 and short duration Cv.Co 47 were used as test varieties during *late samba* 2001 and *kuruvai* 2002, respectively. The experiments were conducted in split-plot design with three replications. Methods of cultivation *viz.,* direct seeding of sprouted seeds under puddled condition (M_1), direct seeding of sprouted seeds under unpuddled condition (M_2), direct seeding of dry seeds under unpuddled condition (M_3) and transplanting under unpuddled condition (M4) were assigned to main plots. In the sub plots, the nitrogen levels were followed as 50, 75, 100, 125 and 150 per cent of recommended dose. The recommended dose of N for medium (Co 43) and short duration (Co 47) varieties was 150 and 120 kg ha^{-1}, respectively. The nitrogen was applied at 75, 112.5, 150, 187.5 and 225 kg N ha^{-1} for medium duration *late samba* season crop and 60, 90, 120, 150, and 180 kg N ha^{-1} for short duration *kuruvai season* crop at 50, 75, 100, 125 and 150 per cent of recommended dose of nitrogen, respectively. Nitrogen was applied in the form of urea in four equal splits at seedling, active tillering, panicle initiation and heading stages. The entire dose of phosphorus was applied basally in the form of single super phosphate (50 kg P_2O_5 ha^{-1} during *late samba* and 38 kg P_2O_5 ha^{-1} during *kuruvai* seasons, respectively) before sowing. Potassium was applied in two equal splits in the form of muriate of potash (50 kg K_2O ha^{-1} during *late samba* and 38 kg K_2O ha" during *kuruvai* seasons, respectively) at basal and heading stages. A seed rate of 100 kg ha^{-1} was adopted for the direct sown treatments. The rice seeds were sown in line continuously at 20 cm apart in small furrows which were formed with the help of a sharp marker at a depth of two to three cm and subsequently covered with soil. Under transplanted treatment (M_4), the nursery was raised on the same day of sowing of direct sown crops. The seedlings aged 25 days for medium and 21 days for short duration crops, were transplanted immediately after irrigation in the main fields for the transplanted treatment plots with spacing of 20 x 15 cm for medium and 20 x 10 cm for short duration crops, respectively, hi puddled condition (M_1), irrigation was maintained at 5 cm throughout the crop period. Incase of unpuddled condition (M_2 and M_3), irrigation water was given immediately after sowing and thereafter at 80 percent of the available soil moisture. For transplanting under unpuddled condition (M_4), irrigation was given prior to transplanting and thereafter at 80 percent of the available soil moisture. Irrigation water was let into the plots at 5 cm depth by measuring with parshall flume of 7.5 cm throat width. The soil moisture content was determined gravimetrically before every irrigation to identify the 80 per cent of the available soil moisture.

Results and Discussion

Growth attributes

Among the four systems of cultivation, the direct seeding of sprouted seeds under puddled condition favourably influenced the growth parameters of rice. Favorable soil condition for plant growth including soil moisture and nutrient availability had resulted in higher tiller production. The root length and root volume were also significantly higher in this system. Higher root penetration (maximum root length) of 17.3 and 18.5 cm was recorded during *late samba* and *kuruvai* season, respectively (Table 1). The availability of optimum soil moisture condition prevailed throughout the crop growth period favoured for such effect. This was facilitated due to lower soil mechanical

Table 4. Influence of systems of cultivation and nitrogen levels on grain yield (kg ha^{-1})

Treatments	*Late samba* 2001					*Kuruvai* 2002				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
50% RDN	5296	4438	4328	3372	4359	5442	4672	4583	3516	4553
75% RDN	5552	4659	4542	3613	4592	5729	4948	4857	3795	4832
100% RDN	5891	4992	4798	3894	4894	5996	5237	5236	4028	5124
125% RDN	5976	5063	4859	3953	4963	6068	5288	5278	4064	5175
150% RDN	6028	5114	4912	4022	5019	6112	5337	5307	4117	5218
Mean	5749	4853	4688	3711	4765	5869	5096	5052	3904	4980

Source	*Late samba* 2001 SEd	*Late samba* 2001 CD (P = 0.05)	*Kuruvai* 2002 SEd	*Kuruvai* 2002 CD (P = 0.05)
M	93	226	98	238
N	107	218	112	228
M at N	213	NS	223	NS
N at M	214	NS	224	NS

RDN- Recommended Dose of Nitrogen (120 kg ha^{-1} for *kuruvai* and 150 kg ha^{-1} for *late samba)*

M_1 - Direct seeding of sprouted seeds under puddled condition

M_2 - Direct seeding of sprouted seeds under unpuddled condition

M_3 - Direct seeding of dry seeds under unpuddled condition

M_4 - Transplanting under unpuddled condition

Table 5. Impact of unconventional methods of rice cultivation on water productivity (kg grain m^{-3})

Treatments	*Late samba* 2001					*Kuruvai* 2002				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
50% RDN	0.42	0.46	0.45	0.33	0.42	0.44	0.49	0.49	0.36	0.45
75% RDN	0.44	0.49	0.47	0.36	0.44	0.46	0.53	0.52	0.39	0.48
100% RDN	0.47	0.52	0.50	0.38	0.47	0.48	0.58	0.58	0.43	0.52
125% RDN	0.48	0.53	0.51	0.39	0.48	0.49	0.56	0.56	0.43	0.52
150% RDN	0.48	0.53	0.51	0.39	0.48	0.49	0.57	0.59	0.42	0.53
Mean	0.46	0.51	0.49	0.37		0.47	0.55	0.53	0.41	

Source	SEd	CD (P = 0.05)	SEd	CD (P = 0.05)
M	0.01	0.02	0.02	0.04
N	0.01	0.02	0.01	0.02
M at N	0.01	NS	0.02	NS
N at M	0.02	NS	0.02	NS

RDN- Recommended Dose of Nitrogen (120 kg ha^{-1} for *kuruvai* and 150 kg ha^{-1} for *late samba)*

M_1 - Direct seeding of sprouted seeds under puddled condition

M_2 - Direct seeding of sprouted seeds under unpuddled condition

M_3 - Direct seeding of dry seeds under unpuddled condition

M_4 - Transplanting under unpuddled condition

resistance for roots. The increase in plant height, leaf area index (LAI), tiller production and root growth might have positively influenced the photosynthetic rate of plants which in turn produced more drymatter under direct seeding of sprouted seeds in puddled condition. Early establishment of direct sown crop under puddled system favoured the crop growth throughout the growth period than under unpuddled condition. Similar findings were also reported by several workers (De Datta, 1986, Rachel Sophia Alexander, 1994 and Pal *et al.,* 1999).

Under unpuddled soil condition either through direct seeding or transplanting, plants had lesser root length because of the reduction in soil moisture content and may be due to higher resistance for the penetration of root hairs offered by the soil (Table 2). Yellamanda Reddy and Kulandaivelu (1992) observed that the rice root growth decreased due to increased soil strength from 5 to 20 bars.

The crop growth rate has increased with increased nitrogen level, at all the stages of growth. The rate of increase started declining at and above 100 per cent of recommended dose of nitrogen. This enhancement in growth may be attributed to optimum availability of N at the respective crop growth stages

Yield attributes and Grain Yield

Direct seeding of sprouted seeds under puddled condition had positively influenced the yield parameters *viz.,* number of productive tillers, panicle length and number of filled grains panicle^{-1} as compared to direct seeding of sprouted or dry seeds or transplanting under unpuddled condition (Table 3). Better root growth and higher nutrient uptake had cumulative effect in influencing the number of productive tillers, number of filled spiklets per panicle and grain weight.

The direct seeding of sprouted or dry seeds or transplanting under unpuddled soil condition invariably recorded lesser values of yield parameters when compared to direct seeding of sprouted seeds under puddled condition. The reduction in yield parameters in these treatments was due to unconducive soil environment which favoured higher weed growth. The increased weed density and higher weed drymatter production resulted in a severe competition for resources like light, nutrients and moisture between the rice crop and weeds. Further, the reduction in the root growth as reflected by lesser root volume and dry weight in turn reduced the uptake of nutrients. A delay in 50 per cent of flowering (5 days) and maturity (11 days) was observed in transplanted rice under unpuddled soil condition as compared to wet seeded rice under puddled condition. The lower soil moisture regime under unpuddled condition caused this delay in transplanted rice. The effect of lower soil moisture regime under unpuddled condition affecting the yield parameters of rice had been brought out by many workers (Sheik Dawood *et al.*, 1990; Yellamanda Reddy and Kulandaivelu, 1995 and Balasubramanian, 1998).

During both *late samba* and *kuruvai* seasons, the direct seeding of sprouted seeds under puddled condition recorded higher grain yield. The increasing grain yield was 54.9 per cent in *late samba* and 50.3 percent in *kuruvai* season when compared to transplanting the seedlings under unpuddled condition (Table 4). Higher leaf area index, drymatter production and number of filled grains panicle^{-1} were the reasons for higher grain yield in the wet seeded rice under puddled condition.

Under unpuddled situations, there was considerable yield reduction in both the seasons for direct seeding of sprouted or dry seeds or transplanting. The reduction in grain yield ranged from 15.6 to 35.5 per cent in *late samba* and 13.2 to 33.5 per cent in *kuruvai* season as compared to direct seeding of sprouted seeds under puddled condition. Most of the growth characters like LAI, shoot dry weight, number of tillers and yield parameters like number of productive tillers, panicle length and number of filled grains panicle^{-1} were adversely affected in unpuddled soil condition.

Application of higher levels of N increased the grain yield at 100 per cent of recommended dose of nitrogen which was comparable with 125 and 150 per cent of recommended dose of nitrogen. The rate of increase started declining at and above 100 per cent of recommended dose of nitrogen. The increased grain yield was 15.1 percent in *late samba* and 12.7 percent in *kuruvai* season, respectively, compared to that in 50 per cent of recommended dose of nitrogen. The overall effect of better yield parameters like number of panicles per unit area and number of filled grains panicle^{-1} have ultimately reflected in higher grain yield recorded under higher levels of nitrogen.

Water productivity

The total quantity of water used was lesser (1014 to 1004mm) to under unpuddled situations when compared to puddled condition (1324 to 1348mm). However, the water productivity was higher, when irrigation was given at 80 per cent of the available soil moisture condition in direct seeding of sprouted seeds under unpuddled condition (0.51 kg m^{-3} in *late samba* & 0.55 kg m^{-3} in *kuruvai)* and dry seeding under unpuddled condition (0.49 kg m^{-3} in *late samba* & 0.53 kg m^{-3} in *kuruvai)* compared to that of irrigation regime brought to 5 cm depth of submergence (0.46 & 0.47 kg m^{-3} during *late samba* and *kuruvai* seasons, respectively).

There was a considerable reduction in grain yield to an extent of 13 to 16 percent for *late samba* and *kuruvai* season, respectively, when irrigation was given at 80 per cent of the available soil moisture under direct seeding of sprouted seeds in unpuddled situation, whereas there is saving of water use by 23 per cent as compared to direct seeding under puddled condition. Application of 100% recommended dose of nitrogen improved the water productivity compared to 50 and 75% recommended dose of nitrogen. The importance of increased nitrogen application for enhancing the water use efficiency had been stressed by Sharma and Sharma (1999).

Among the different systems of rice cultivation, direct seeding of sprouted seeds under puddled condition performed better in growth and yield parameters compared to other systems of cultivation. The Nitrogen application at 100 per cent of the recommended dose (150 kg N ha^{-1} in the *late samba* and 120 kg N ha^{-1} in the *kuruvai* season) was found to be optimum in terms of grain yield.

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