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RESEARCH PAPER

Effect of system rice intensification on microbial population, nutrient status, growth and yield of rice

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Abstract : Field experiments were carried out during *Rabi* 2007-08 and 2008-09, to evaluate the crop establishment techniques and weed management practices under system of rice intensification. The experiments were laid out in Split Plot Design with three replications with main plot consisted of three levels age of seedlings *viz*., 14, 18 and 22 days old seedlings were evaluated with two levels of planting methods *viz*., SRI planting and mechanical planting. Four levels of weed management practices *viz*., hand weeding two times at 25 and 45 DAT, mechanical weeding three times at 10, 25 and 45 DAT, pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT and unweeded check were assigned to sub plot. Transplanting of 14 days old seedlings with manual planting and pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT significantly higher microbial population, nutrient uptake and improved the growth parameters, yield attributes and yield of rice.

Key Words : SRI, Age of seedlings, Planting methods, Nutrient uptake, Yield

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INTRODUCTION

Rice (*Oryza sativa* L.) is the major source of food for nearly half of the world's population. The cultivation of rice and its productivity is a challenge of coming decades due to potential changes in temperature, precipitation and sea level, as a result of global warming. Geometric growth of population and arithmetic increase in food grain production leave a vast gap in food supply. This gap is further widened due to urbanization and industrialization of fertile lands. In the global scenario, the present population of 6 billion is expected to reach a figure of 9 billion by 2050 (FAO, 2001). The global requirement of rice by 2025 AD would be 800 million tones, which is 26 per cent higher than the present level of production. In India, it is grown over an area of 44.6 million ha (m.ha) with a total production of 87 million tones (mt) in 2003-2004 amounting to 41.8 per cent of total food grain production (Malik *et al*., 2006). The SRI has its own components *viz.*, transplanting of young seedlings usually 12 to 14 days as single seedling per hill at wider spacing in a square geometry and use of mechanical weeder, need-based fertilizer application and optimum use of water for better growth especially soil aeration (Kumar and Shivay, 2004). Due to wider spacing of 25 × 25 cm, there are more weeds with SRI than conventional cultivation (Jiaguo Zheng *et al*., 2004). Due to SRI method of cultivation larger increased root proliferation with larger canopies led to more photosynthates which reach the soil through root exudation and other forms of rhizodeposition. This supports more diverse and active population of soil organisms and enhanced root activity as evidence from lengthier roots and root volume subsequently increased nutrient uptake and total DMP (Uphoff, 2006). Hence, keeping

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all the above aspects in view, the present investigation was carried out under SRI method of rice cultivation.

MATERIAL AND METHODS

Field experiments were conducted at Agricultural College and Research Institute, Madurai during *Rabi*, 2007-08 and 2008-09. The experimental soil was sandy clay loam with pH of 7.5, which was medium organic carbon (0.52), low in available nitrogen (245.3 kg ha^{-1}), medium in phosphorus (19.5 kg ha^{-1}), and medium in potassium (249.5 kg ha^{-1}). The experiments were laid out in Split Plot Design with three replications. The main plot consisted of age of seedlings and planting methods. Three age of seedlings *viz*., 14, 18 and 22 days old seedlings were evaluated with two levels of planting methods *viz*., SRI planting (25 x 25 cm) and mechanical planting (23.8 x 17 cm). Four levels of weed management practices *viz*., hand weeding two times at 25 and 45 DAT, mechanical weeding three times at 10, 25 and 45 DAT, pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT and unweeded check were assigned to sub plot. Medium duration rice cultivar ADT 39 was grown during *Rabi* (October – February) season of the years 2007-08 and 2008-09. The nursery was prepared by the modified dapog mat nursery method. The seedlings were transplanted by transplanter was wheel driven and fitted with diesel engine and riding type which transplants seedlings from mat type nursery in eight rows in a single pass and manual planting as per the treatments followed. Hand operated mechanical weeder (Rotary weeder) developed by Department of Agricultural Engineering, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu was used for mechanical weeding. Application of pre-emergence herbicide butachlor @ 1.25 kg ha^{-1} on third day after transplanting was made. Nitrogen was applied as urea based on LCC schedule. The LCC values were recorded as per the standard procedure (IRRI, 1996) at weekly intervals starting from 14 DAT to flowering. Whenever LCC values were found to be below the fixed critical level (No. 4), nitrogen @ 35 kg ha^{-1} was applied. The entire dose of phosphorus (50 kg ha^{-1}) as single super shosphate (16 % P_2O_5) was applied as basal and potassium (50 kg ha^{-1}) in the form of muriate of potash (60 % K_2O) was applied in four splits *viz*., 25 per cent each at active tillering, panicle initiation, booting and flowering stages after the weeding was over. Zinc sulphate @ 25 kg ha^{-1} was applied as basal to crop during both the seasons. Appropriate need based plant protection measures were taken up to control pest and diseases. Soil and plant samples were collected for microbial load and nutrient analysis as per standard procedures followed. The data were analyzed as per the statistical procedures given by Gomez and Gomez (1984). The trend of data was similar in both years, pooled data are presented.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect on microbial population :

Increased population of bacteria (38.1), fungi (16.8) and actinomycetes (41.5) were found in 14 days old seedlings during flowering period. This might be due to the fact that larger increased root proliferation with larger canopies led to more photosynthates which reach the soil through root exudation and other forms of rhizodeposition. This supports more diverse and active population of soil organisms (Uphoff, 2006). More number of bacteria (36.1), fungi (15.9) and actinomycetes (39.3) are found in SRI method (Table 1). Larger root system with larger canopies leads to more photosynthates which go into soil through root exudation and other forms of rhizodeposition. The higher root volume and root biomass in SRI had provided a better environment to the soil micro-organisms. Increased aeration and alternate wetting and drying increased the microbial number in the soil (Bloem *et al*., 1992). A significant proportion of the soil micro organisms were destroyed on drying and rewetting. A regenerated microbial population developed after the rewetting of the soil. Weed incorporation in soil also helped to boost microbial population in soil. The soil that was supplemented with organic matter supported larger and diverse population of micro-organisms (Satyanarayana, 2006). At 20 DAT, the mechanical weeding three times at 10, 25 and 45 DAT resulted in higher number of microbial population *viz.*, bacteria, fungi and actinomycetes. But during later stages, microbial population were maximum with pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT followed by mechanical weeding three times at 10, 25 and 45 DAT. The mechanical weeding by rotary weeder facilitated soil aeration and increased the soil microbial population. Generally application of herbicide disturbed and altered the biological equilibrium in soil. This was supported by Grossbard (1985) who reported that the components present in the herbicide are unfavourable for the microbial growth and multiplication. Hence, at initial tillering, pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT resulted in lower soil microbial population. But at later stages this treatment recorded higher number of microbial population as two mechanical weeding was done at 25 and 45 DAT, which increased soil aeration, resulted in greater root growth and root activity thereby increased micro-organisms..

Effect on nutrient uptake and availability :

In general, the N, P and K uptake of rice were higher from tillering to harvest stage. Age of seedlings had

significant influence on the N uptake by the crop at different phonological phases. Nutrient uptake is an outcome of DMP and nutrient content of the plant. 14 days old seedlings resulted in more N (146.5), P (37.1) and K (154.6) uptake during the harvest stage. This should be due to enhanced root activity as evidence from lengthier roots and root volume subsequently increased nutrient uptake and total DMP. Younger seedling with better root activity supplies essential nutrients for the plant, which ultimately increased the nutrient uptake (Murty and Sahu, 1979). Higher uptake was mainly attributed to the better root activity and increased DMP besides less competition among plants. Similar findings were made by Kumari and Kumar (2006). The profuse root systems, observed under SRI, constitute a key feature for plant nutrient management, uptake and utilisation, and plant development. Extensive root systems per individual plant automatically raise the significance of soil microbiological processes including mycorrhizae and biological forms of nitrogen fixation in meeting the plants' nutrient requirements. An extensive root system is also more likely to profit from a greater synchronisation between rice N demand and the N released from organic residues (Toomsan *et al*., 2000) than is possible with mineral N top dressings. Among planting methods, SRI method with widely spaced plants will greatly affect competition, both above ground for radiation and below ground for plant nutrients. This helped in greater N, P and K uptake (140.6, 35.2 and 145.2 kg ha^{-1}, respectively) than machine transplanting. By comparison, the limited root systems of fully irrigated rice that are associated with anaerobic soil conditions and high plant densities will be less effective in nutrient uptake including the nitrogen from top dressings. The maximum nutrient uptake was recorded with pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT with 156.1, 39.5 and 165.2 kg ha^{-1} of NPK at harvest over unweeded check (Table 1). The effective weed control offered in this treatment enhanced the dry matter production of the crop resulting in greater nitrogen uptake. Dry matter production was positively correlated with N uptake and weed population and crop N uptake was negatively correlated. So the favourable environment was created for the crop growth and development which in turn favoured higher plant nutrient uptake with increased biomass production. This was supported by Victor Viren *et al*. (2005). Generally, the dry matter production was less in unweeded check due to weed competition and consequently resulted in lower availability of nutrients to the crop which ultimately reduced the nutrient uptake by crops.

Table 1 : Effect of age of seedlings, planting methods and weed management practices on microbial population, nutrient uptake and nutrient availability of rice (Pooled data of two years)

Treatments	Microbial population of rice rhizosphere at flowering stage			Nutrient uptake at harvest stage (kg ha^{-1})			Post harvest analysis of nutrients (kg ha^{-1})		
Age of seedlings	Bacteria (× 10^6 CFU g^{-1} dry soil)	Fungi (× 10^3 CFU g^{-1} dry soil)	Actinomycetes (× 10^4 CFU g^{-1} dry soil)	Nitrogen	Phosphorus	Potassium	N	P_2O_5	K_2O
A_1 – 14 DAS	38.1	16.8	41.5	146.5	37.1	154.6	211.9	13.4	237.5
A_2 – 18 DAS	33.6	14.8	36.6	130.8	33.1	135.9	227.4	14.4	254.9
A_3 – 22 DAS	31.2	13.8	33.9	122.9	29.9	126.3	251.7	15.9	282.5
S.E. ±	0.69	0.31	0.76	2.75	0.67	2.73	3.75	0.24	4.25
C.D. (P=0.05)	1.54	0.68	1.69	6.11	1.50	6.09	8.36	0.53	9.47
Planting methods									
P_1 – Machine planting	32.5	14.3	35.4	126.1	31.6	132.6	244.6	15.5	274.4
P_2–SRI planting (manual)	36.1	15.9	39.3	140.6	35.2	145.2	216.1	13.6	242.2
S.E. ±	0.57	0.25	0.62	2.24	0.55	2.23	3.06	0.20	3.47
C.D. (P=0.05)	1.26	0.56	1.38	4.99	1.23	4.97	6.83	0.44	7.74
Weed management practices									
W_1 – Hand weeding (twice)	31.9	14.0	34.7	126.5	31.0	127.8	247.4	15.1	272.3
W_2 – Mechanical weeding (thrice)	37.4	16.5	40.8	148.1	36.5	155.8	212.5	13.6	252.0
W_3 – Butachlor @ 1.25 kg ai ha^{-1}+ MW (twice)	40.5	17.9	44.1	156.1	39.5	165.2	190.5	12.1	225.7
W_4 – unweeded check	27.4	12.1	29.8	102.8	26.6	106.8	271.0	17.4	283.3
S.E. ±	0.95	0.42	1.04	3.77	0.93	3.74	5.37	0.34	6.07
C.D. (P=0.05)	1.93	0.85	2.10	7.33	1.88	7.59	10.89	0.69	12.31
Interaction effects	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS= Non-significant

Effect on growth and yield of rice :

The age of seedlings, planting methods and weed management practices improved the growth parameters and yield by eliminating weed competition. The 14 days old seedlings recorded taller plants (96.1), and higher leaf area (Table 2). It was due to the fact that young seedlings had higher vigor and more root growth which stimulated cell divisions causing more stem elongation resulted in increased plant height (Prema, 2007). Fourteen days old seedlings recorded maximum LAI (5.9). This could be attributed to the higher tiller number which resulted in more leaf number leading to higher LAI value. The young seedlings recorded better root growth and facilitated increased cell division and cell enlargement due to increased photosynthetic rate subsequently increasing the LAI (Shrirame *et al*., 2000) ultimately resulted in higher economic yields. In the present investigation, 14 days old seedlings resulted in higher increase in grain and straw yield to the tune of 50.19 and 48.50 per cent increase over 22 days old seedlings. This might be attributed to increase in plant height, number of tillers m^{-2}, LAI, better rooting ability and finally the higher DMP. Transplanting of young seedlings provided sufficient nutrients for vegetative growth and also for reproductive phase due to better root growth. This might be due to efficient utilization of resources that ultimately lead to increased plant height and yield attributes thereby increased grain and straw yields (Kavitha *et al.*, 2010).

SRI method of planting had significant influence on growth parameters of rice. Plant height and LAI were increased. This is because of wider spacing which influenced the vegetative growth in a better way than closer spacing by increasing the nutrient absorption by plants and resulted in better growth of plants. There was increased growth of plants under wider spacing, maintaining the good plant exposure to the sun and air (Jiaguo Zeng *et al.*, 2002). The present study also revealed that SRI method with wider spacing 25 × 25 cm recorded maximum plant height (91.6) and leaf area index (5.6) (Table 2). The closer spacing in transplanting had decreased transmission of light in the canopy making the plant to grow taller for want of light (Anonymous, 1987). SRI produced more productive tillers $hill^{-1}$; higher panicle length (21.9), panicle weight, grains (123 $panicle^{-1}$) and thousand grain weights ultimately produced more yield (8971) which was due to due to the increased value of yield attributing characters like panicle number, panicle length, total grains per panicle resulting from vigorous young seedlings which was due to more tillers m^{-2} under wider intra and inter row spacing and better assimilation of photosynthates due to better utilization of incident solar radiation might have increased the size of sink and effective translocation of assimilates which led to improved panicle length, total grains $panicle^{-1}$. Similar

Table 2 : Effect of age of seedlings, planting methods and weed management practices on growth, yield attributes and yield of rice

(Pooled data of two years)

Treatments	Growth attributes		Yield attributes and yield			
	Plant height at harvest (cm)	LAI at harvest	Panicle length (cm)	Total grains $panicle^{-1}$	Yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Age of seedlings						
A_1 – 14 DAS	96.1	5.9	23.4	129	8037	9592
A_2 – 18 DAS	87.0	5.2	22.0	118	6598	7931
A_3 – 22 DAS	78.0	4.8	19.0	100	5351	6459
S.E. ±	1.8	0.1	0.4	2	168	170
C.D. (P=0.05)	3.9	0.2	0.9	5	374	379
Planting methods						
P_1 – Machine planting	82.4	5.0	21.0	108.	5899	7017
P_2–SRI planting (manual)	91.6	5.6	21.9	123	7424	8971
S.E. ±	1.4	0.1	0.3	1	138	139
C.D. (P=0.05)	3.2	0.2	0.8	4	306	310
Weed management practices						
W_1 – Hand weeding (twice)	81.7	4.9	20.3	109	6394	7347
W_2 – Mechanical weeding (thrice)	94.0	5.8	22.7	120	6949	8425
W_3 – Butachlor @ 1.25 kg ai ha^{-1}+ MW (twice)	103.5	6.3	23.7	134	8348	10059
W_4 – unweeded check	69.0	4.2	19.2	99	4956	6145
S.E. ±	2.4	0.1	0.6	3	222	232
C.D. (P=0.05)	4.9	0.3	1.2	6	451	471
Interaction effects	NS	NS	NS	NS	S*	S*

NS=Non-significant

finding was reported by Viraktamath (2006).

The increased plant height and higher LAI were recorded in the pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT at all crop growth stages was due to broad spectrum control of weeds cum reduced weed dry weight, which in turn increased the vigor and growth of rice by maximum root length with good crop establishment and lead to more nutrient uptake, exposure to sunlight and weed free condition at the early stages of crop growth onwards. The weed free condition at critical stages of crop favors increased plant height and leaf development with higher LAI due to increased availability of nutrients with less competition. This was supported by Subramanian *et al*. (2006). The increased grain and straw yields in pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT clearly indicated the influence of weed free environment on grain production. Due to weed free condition provided in rice ecosystem the competition for light, space and nutrient were reduced and resulted in better availability and uptake of the required nutrients by the crop. This favourable environment resulted in higher production of plant DMP with increased plant height, LAI, number of tillers $hill^{-1}$ and other yield attributes like number of productive tillers m^{-2}, number of filled grains $panicle^{-1}$ and test grain weight. All these improved the performance of the crop under the favorable weed free condition leading to higher grain and straw yields. This is in conformity with findings of Narayanaswamy *et al*. (2006).

Conclusion :

The results of the present study explained the potential of agronomic practices *viz*., age of seedlings, planting methods and weed management practices in rice under SRI techniques of 14 days old seedlings with manual planting and pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT significantly improved the growth parameters, yield attributes and yield of rice.

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