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RESEARCH ARTICLE

Effect of system rice intensification on root characteristics and dry matter production of rice

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SUMMARY

Field experiments were carried out during *Rabi* seasons of 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 had significantly higher root characteristics *viz*., root length, root volume, root dry weight and more crop dry matter production.

Key Words : SRI, Root length, Root volume, Root dry weight, DMP

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Rice (*Oryza sativa* L.) is the major source of food for nearly half of the world's population. The slogan rice is life1 comes from the understanding that rice-based cropping systems are essential to everyone directly or indirectly for food security, livelihood improvement, cultural heritage and sustainable development for global peace (FAO, 2001).

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Rice plays a major role in the national economy of many developing countries. 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. The world entered the 21st century facing many challenges, often in an agricultural front. According to FAO, the global rice requirement in 2025 will be of the order of 800 million tonnes. At the moment, the production is less than 600 million tonnes and hence the additional 200 million tonnes of rice have to be produced by increasing productivity per unit area (Malik *et al*., 2006). Transplanting is a common practice in rice cultivation. Improper planting technique is one of the important factors limiting rice yield. The traditional rice planting

system comprises conventional planting with too many numbers of seedlings per hill and dumping of nitrogenous fertilizer. Closer spacing is also one of the main constraints in obtaining high yield under conventional planting. Hence, a new method of rice cultivation must be tried aiming at higher crop productivity. System of rice intensification (SRI) is a new approach, now gaining popularity as it is found to increase the productivity and reduce the cost of cultivation. Due to wider spacing of 25 x 25 cm, there are more weeds with SRI than conventional cultivation (Zheng *et al*., 2004). Weeding operations using mechanical weeder permit greater root growth through better soil aeration and organic matter addition (Anonymous, 2002). But early and frequent weeding is essential otherwise the weed growth will become a problem (Vijayakumar *et al*., 2005). 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 enhanced root activity as evidence from lengthier roots and root volume subsequently increased nutrient uptake and total DMP (Uphoff, 2006). Hence, keeping all the above aspects in view the present investigation was carried out under system rice intensification.

MATERIAL AND METHODS

Field experiments were carried out at Agricultural College and Research Institute, Madurai during *Rabi* seasons of 2007-08 and 2008-09. The experimental soil was sandy clay loam with pH of 7.5, which was medium is 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 upto control pest and diseases. Root samples and plant samples were collected for root characters studies as per standard procedures followed. The data were analyzed as per the statistical procedures given by Gomez and Gomez (1984). As 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 root system :

It is generally considered that a thorough knowledge of the root system of crop is a pre requisite for understanding many problems connected with the crop production. Root studies especially root volume and depth of distribution helps in understanding water use, nutrient uptake and placement of fertilizers. The root characteristics *viz*., root length, root volume and root dry weight gradually increased and attained maximum at flowering stage. Afterwards the parameters were found

7to decrease due to root degeneration. Transplanting young seedlings preserve the potential for tillering and root growth while they also exploit the benefits from other favourable condition. Transplanting of 14 days old seedlings resulted in improved root characteristics like root length (25.3, 31.1 and 29.0 cm at panicle initiation, flowering and harvest, respectively) and root volume (34.6, 37.8 and 32.2 cm^3 at panicle initiation, flowering and harvest, respectively) (Table 1). This was mainly due to reduced intra plant competition for nutrients and sunlight etc. The root dry weight (560.7, 941.1 and 692.2 kg ha^{-1} at panicle initiation, flowering and harvest, respectively) of the individual plant was more under 14 days old seedlings because of increased root length and root volume (Table 2). This led to higher root dry weight per unit area (Sridevi, 2006). Root characters increased from transplanting to the flowering stage and declined later. At initial crop growth stage root length, root volume and root dry weight significantly increased. SRI method recorded higher root volume at all stages of crop growth .Better root characteristics, such as root length, root volume and root dry weight were obtained by planting of seedlings through SRI method Wider spacing and less plant population per unit area resulted in increased root volume, root length and root dry weight due to abundant availability of nutrients, light intensity and water availability and enabled the plant to extract nutrient efficiently from wider spacing. Similar findings were reported by Vijayakumar (2003).

All the root characteristics *viz.*, root length (28.0,34.0 and 30.8 cm), root volume (36.8,40.2 and 34.3 cm^3) and root dry weight (609.1,1001.6 and 737.0 kg ha^{-1}) were maximum at panicle initiation, flowering and harvest, respectively) with pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT due to higher WCE and reduced weed competition. This was followed by mechanical weeding three times at 10, 25 and 45 DAT. Mechanical weeding resulted in increased soil aeration by increasing pore space leading to increased root growth (Randriamiharison, 2002). Pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT resulted in formation of larger amount of newer roots due to root pruning and enhanced root aeration, ultimately leading to higher root activity.

Effect on dry matter production :

There was a significant difference in DMP with

Table 1 : Effect of age of seedlings, planting methods and weed management practices on root length and root volume (pooled mean of two years)

Treatments	Root length(cm)				Root volume(cm^3)			
	Initial tillering	Panicle initiation	Flowering	Harvest	Initial tillering	Panicle initiation	Flowering	Harvest
Age of seedlings								
A_1 – 14 DAS	20.4	25.3	31.1	29.0	14.0	34.6	37.8	32.2
A_2 – 18 DAS	21.5	24.3	28.0	25.5	15.2	30.5	33.3	28.4
A_3 – 22 DAS	23.0	22.1	27.2	23.7	17.9	28.3	30.9	26.4
S.E.±	0.4	0.5	0.6	0.5	0.3	0.6	0.7	0.6
C.D. (P=0.05)	1.0	1.1	1.3	1.2	0.7	1.4	1.5	1.3
Planting methods								
P_1 – Machine planting	21.4	22.9	27.2	24.7	15.5	29.5	32.2	27.5
P_2–SRI planting (manual)	21.9	24.9	30.3	27.5	15.9	32.8	35.8	30.5
S.E.±	0.4	0.4	0.5	0.4	0.3	0.5	0.6	0.5
C.D. (P=0.05)	0.8	0.9	1.1	1.0	0.6	1.1	1.3	1.1
Weed management practices								
W_1 – HW (twice)	19.7	22.0	26.2	24.2	13.7	28.9	31.6	26.9
W_2 – MW (thrice)	23.1	25.8	31.4	28.4	17.5	34.0	37.1	31.6
W_3 – Pre. + MW (twice)	25.1	28.0	34.0	30.8	18.0	36.8	40.2	34.3
W_4 – unweeded check	18.7	19.8	23.5	20.8	13.5	24.8	27.1	23.1
S.E.±	0.6	0.7	0.8	0.7	0.4	0.9	0.9	0.8
C.D. (P=0.05)	1.2	1.3	1.6	1.5	0.9	1.8	1.9	1.6
Interaction effects	NS	NS	NS	NS	NS	NS	NS	NS

NS= Non-significant

age of seedlings. Twenty two days old seedlings produced higher DMP at early tillering. This was attributed to more root characters like root length, root volume and root dry weight. This result is in concurrence with Ancy Francis (2007). But at later stages, DMP was found to be more in 14 days old seedlings and increase (5032, 7511 and 16751 kg ha^{-1} at panicle initiation, flowering and harvest, respectively) over 22 days old seedlings (Table 2). This should be attributed to more tiller production, number of leaves, increased LAI and improved root characteristics $hill^{-1}$. In the presence of adequate nutrient availability and larger photosynthesizing surface, the dry matter accumulation preceded at a rapid rate leading to its greater accumulation. This result is in conformity with the findings of Rajesh and Thanunathan (2003).

There was a significant difference in DMP with different transplanting methods. SRI method produced higher dry matter 4429, 6403 and 13080 kg ha^{-1} at panicle initiation, flowering and harvest, respectively. This is attributed to more LAI and root characters like root length, root volume and root biomass in SRI method. Dry matter production was found to be more under SRI method of transplanting at tillering and panicle initiation stage which can be attributed due to more accumulation of photosynthates. Wider spacing in SRI method gave better root growth leading to robust growth and high tillering. This result is in accordance with findings of Sathyanarayana (2006). Significant differences were noticed in crop dry matter production among weed management practices. The crop dry matter production was higher with pre-emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT (W_3) produced more dry matter production 4341,6276 and14020 kg ha^{-1} at panicle initiation, flowering and harvest, respectively. This is line with findings of Pradhan and Chatterji (1987).The increased dry matter production in the above-said weed management practice was mainly due to weed free condition prevailed at critical crop growth stages, which in turn, favoured availability of plant nutrients with less competition for water, space and light. Hence, increased plant nutrients availability led to higher nutrient uptake, which ultimately resulted in higher plant dry matter production due to increased plant height, more number of tillers and better development of leaves. The plant

Table 2 : Effect of age of seedlings, planting methods and weed management practices on root dry weight and crop dry matter production (pooled mean of two years)

	Root dry weight (kg ha^{-1})				Crop dry matter production(kg ha^{-1})			
Treatments	Initial tillering	Panicle initiation	Flowering	Harvest	Initial tillering	Panicle initiation	Flowering	Harvest
Age of seedlings								
A_1 – 14 DAS	289.7	560.7	941.1	692.2	1945	5032	7511	16751
A_2 – 18 DAS	313.3	502.5	829.3	610.2	2079	4578	6619	14495
A_3 – 22 DAS	348.4	482.5	770.7	567.1	2330	4420	6151	12245
S.E.±	6.1	10.4	17.1	12.6	42	94	137	137
C.D. (P=0.05)	13.7	23.2	38.1	28.0	94	211	304	304
Planting methods								
P_1 – Machine planting	313.5	488.0	802.3	590.3	2094	4429	6403	13080
P_2–SRI planting (manual)	320.7	542.4	891.8	656.1	2143	4924	7117	15914
S.E.±	5.0	8.5	14.0	10.3	35	77	112	112
C.D. (P=0.05)	11.2	18.9	31.1	22.9	77	172	248	248
Weed management practices								
W_1 – HW (twice)	294.7	478.3	781.3	578.3	1930	4341	6276	14020
W_2 – MW (thrice)	352.2	557.1	924.2	679.7	2423	5102	7376	15396
W_3 – Pre. + MW (twice)	364.5	609.1	1001.6	737.0	2463	5527	7994	17620
W_4 – unweeded check	257.1	416.3	681.1	497.7	1657	3731	5395	10952
S.E.±	8.5	14.3	23.5	17.2	58	130	188	188
C.D. (P=0.05)	17.1	28.9	47.6	35.0	117	263	380	380
Interaction effects	NS	NS	NS	NS	NS	NS	NS	S •

NS=Non-significant

dry matter was lower in unweeded check and this might be due to reduction in plant height, number of leaves and number of tillers by severe competition from weeds on all sources at all stages of crop growth.

Conclusion :

The results obtained in 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 higher rate of root characters and more dry matter production.

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