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Productivity and Water Usage of Rice as Influenced by Different Cultivation Systems

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Field experiments were conducted during summer and *kuruvai* 2008 to study the performance of different rice cultivation methods on productivity and water usage using hybrid CORH-3 as test crop with treatments consisted of different rice cultivation methods *viz.,* transplanted rice (conventional), direct sown rice (wet seeded), alternate wetting and drying method (AWD) (irrigation at two days after disappearance of ponded water), system of rice intensification (SRI) and aerobic rice cultivation. Results revealed that maximum number of tillers/m^2, higher shoot and root length at maturity were recorded under system of rice intensification (SRI) followed by transplanted rice, while, aerobic rice produced lower growth parameters in both the seasons. SPAD values at flowering was higher under system of rice cultivation in two seasons studied (42.74 and 39.48 respectively during summer and *kuruvai* seasons) and transplanted rice compared to aerobic rice and alternate wetting and drying method. In both summer and *kuruvai* seasons, system of rice intensification (SRI) produced higher grain yield (6014 and 6682 kg/ha), followed by transplanted rice (5732 and 6262 kg/ha) while, the lowest grain yield (3582 and 3933 kg/ha) was recorded under aerobic rice cultivation. Under SRI, 5 and 6.7 % increase in grain yield and 12.6 and 14.8 % water saving were noticed compared to transplanted rice respectively during summer and *kuruvai* seasons. With respect to water productivity, SRI method of rice cultivation registered the highest water productivity (0.43 and 0.47 kg/m^3), followed by AWD and aerobic rice cultivation. The conventional rice cultivation and direct sown rice produced lower grain yield per unit quantity of water used.

Key words: Transplanted rice, SRI, wet seeded rice, aerobic rice, water productivity

Rice (*Oryza sativa* (L.)) is one of the most important stable food crops in the world. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. In India, rice occupies an area of 44 million hectare with an average production of 90 million tonnes with productivity of 2.0 tonnes per hectare. Demand for rice is growing every year and it is estimated that in 2010 and 2025 AD the requirement would be 100 and 140 million tones respectively. To sustain present food self-sufficiency and to meet future food requirements, India has to increase its rice productivity by 3 per cent per annum (Thiyagarajan and Selvaraju, 2001). Rice cultivation requires large quantity of water and for producing one kg rice, about 3000-5000 litres of water is required depending on the different rice cultivation methods such as transplanted rice, direct sown rice (wet seeded), alternate wetting and drying method (AWD), system of rice intensification (SRI) and aerobic rice. Owing to increasing water scarcity, a shifting trend towards less water demanding crops against rice is noticed in most part of the India and this warrants alternate methods of rice cultivation that aims at higher water and crop productivity. There are evidences that cultivation of rice through system of rice intensification (SRI) can increase rice yields by two to three fold compared to current yield levels (Abu Yamah, 2002; Uphoff *et al.*, 2005). Aerobic rice cultivation where fields remain unsaturated throughout the season like an upland crop offers an opportunity to produce rice with less water (Bouman *et al.,* 2002). In this context, a study was conducted at wetland farm of Tamil Nadu Agricultural University, Coimbatore to evaluate the performance of different systems of rice cultivation in terms of its water use efficiency and grain productivity.

Materials and Methods

Field experiments were carried out during summer and *kuruvai* 2008 at Wetland Farm of Tamil Nadu Agricultural University, Coimbatore, to evaluate the performance of different systems of rice cultivation. Treatments consisted of different rice cultivation methods *viz.,* transplanted rice (conventional), direct sown rice (wet seeded), alternate wetting and drying method (AWD) (irrigation at two days after disappearance of ponded water),

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system of rice intensification (SRI) and aerobic rice cultivation with four replications. Rice hybrid CORH -3 was studied as test crop. Fourteen days old seedlings were transplanted with a spacing of 22.5 X 22.5 cm in SRI. In Conventional and AWD methods, 24 days old seedlings were used with a spacing of 20 X 15 cm. In aerobic rice, the pre germinated seeds were sown in rows of 20 cm apart and 10 cm within rows by using TNAU aerobic rice drum seeder in thoroughly prepared dry soil. Direct sown wet seeded rice was sown by using eight row paddy drum seeder in a puddled soil. Recommended dose of fertilizer for hybrid at 175:60:60 kg NPK/ha was applied. Hand weeding twice at 20 and 35 days after transplanting was done in conventional and AWD methods. Weeding was done thrice using cono weeder at 10 days interval from 10th day after transplanting for SRI plots. Hand weeding at 15, 30 and 45 days after sowing was given in aerobic and wet seeded rice. Water management varied in different treatments as per the recommended practices. Irrigation at 5 cm depth of water was maintained in transplanted rice. In wet seeded rice, initially a week after sowing 2 cm depth of water was applied and drained immediately. Later, it was irrigated with 2.5 cm depth of water for another two weeks and then 5 cm depth of water was maintained. Application of 2.5 cm depth of water after the formation of hairline crack was followed in SRI. The field under alternate wetting and drying method was irrigated with 5 cm depth of water at two days after disappearance of ponded water. Aerobic rice field was irrigated once in 3-4 days interval depending on weather condition. In all the systems, the total water used was quantified by using water meter. Water productivity was worked out by dividing the grain yield with total water used. Observations on growth parameters such as shoot and root length during maturity, tillers at maximum tillering stage, SPAD meter reading at flowering and yield attributes like productive tillers, panicle length and filled grains per panicle and grain yield were recorded during harvesting stage.

Results and Discussion

Growth attributes

Growth parameters of rice as influenced by different methods of rice cultivation is presented in Table 1. Significantly higher shoot (85.2 and 86.6 cm) and root lengths (29.2 and 29.5 cm) at maturity were recorded under system of rice intensification (SRI) in both the seasons. However, this was comparable with transplanted rice and wet seeded rice. Aerobic rice produced lesser shoot and root length in both the season experiments. Rice under

Table 1. Growth parameters and SPAD meter reading at flowering of rice as influenced by different systems of rice cultivation

Systems of rice cultivation	Summer 2008				*Kuruvai* 2008			
	Shoot length (cm)	Root length (cm)	Tillers m^{-2}	SPAD values	Shoot length (cm)	Root length (cm)	Tillers m^{-2}	SPAD values
Transplanted Rice	86.4	29.0	391	41.4	85.8	27.6	410	38.3
System of Rice Intensification	85.2	29.2	414	42.7	86.6	29.5	448	39.5
Alternate Wetting and Drying	79.7	27.4	362	40.1	74.3	28.1	408	39.5
Wet seeded rice	82.7	28.4	387	42.0	81.2	28.5	438	40.5
Aerobic rice	67.2	22.6	326	39.6	71.2	24.3	375	36.2
CD (0.05)	4.8	1.5	24.8	2.1	4.7	1.4	31.4	1.9

SRI produced significantly more number of tillers/ m^2 (414 and 448) than other systems of rice production. This was closely followed by transplanted rice and direct sown rice. Optimum plant population and geometry under SRI led to availability of more resources to the plants that resulted in increased plant height and more number of tillers (Koma and Sinv, 2003). Minimum number of tillers/m^2 was recorded under aerobic rice cultivation in both the seasons which might be due to lack of adequate soil moisture and method of land preparation. SPAD values recorded by chlorophyll meter (SPAD 502) indicated that significantly higher SPAD values at flowering were noticed with SRI (42.74 and 39.48 respectively), wet seeded rice and transplanted rice as compared to aerobic rice and alternate wetting and drying method.

Yield attributes and grain yield

The influence of different rice cultivation methods on the yield attributes and grain yield are presented in Table 2. System of rice intensification (SRI) registered significantly more number of productive tillers/m^2 (383 and 416) than other rice cultivation methods in both the seasons. Transplanted rice and wet seeded rice were comparable to each other in recording number of productive tillers/m^2 . Significantly lower number of productive tillers/m^2 was observed under aerobic rice cultivation. With

Table 2. Yield parameters and grain yield of rice as influenced by different systems of rice cultivation

Systems of rice cultivation	Summer 2008				*Kuruvai* 2008			
	Produtive tillers (m^2)	Panicle length (cm)	Filled grains (No./ panicle)	Grain yield (kg/ha)	Produtive tillers (m^2)	Panicle length (cm)	Filled grains (No./ panicle)	Grain yield (kg/ha)
Transplanted rice	354	23.2	110.8	5732	374	23.3	121.9	6262
System of Rice Intensification	383	23.7	117.8	6014	416	23.3	130.8	6682
Alternate Wetting and Drying	336	22.9	106.5	5376	381	23.3	126.4	5796
Wet seeded rice	361	23.1	102.5	5175	402	23.8	94.8	5500
Aerobic rice	302	20.9	85.2	3582	347	21.6	86.7	3933
CD (0.05)	21.1	1.1	7.3	276	26.7	1.3	8.9	311

regard to panicle length, all the systems of rice cultivation were comparable except aerobic rice. Higher number of filled grains per panicle was observed with system of rice intensification (117.8 and 130.8), followed by transplanted rice and alternate wetting and drying method. Grain yield of rice was significantly influenced by different methods of rice cultivation. Among the different rice production methods, system of rice cultivation (SRI) produced significantly higher grain yield (6014 and 6682 kg/ ha), followed by transplanted rice (5732 and 6262 kg/ha). Under SRI, 5 and 6.7 % increase in grain yield was noticed compared to transplanted rice. Increased grain yield under SRI is mainly due to the synergistic effects of modification in the cultivation practices such as use of young and single seedlings per hill, limited irrigation, and frequent loosening of the top soil to stimulate aerobic soil conditions (Stoop *et al.,* 2002). Transplanting of very young seedlings usually 8-12 days old, preserves its potential for tillering and rooting which was reduced if transplanted after the occurrence of fourth phyllochron. Further, combination of plant, soil, water and nutrient management practices followed

Table 3. Water usage and water productivity of rice as influenced by different systems of rice cultivation

Systems of rice cultivation	Summer 2008				*Kuruvai* 2008			
	No. of irrigations	Total water used (m^3/ha)	% water saving over transplanted rice	WP (kg/ m^3)	No. of irrigations	Total water used (m^3/ha)	% water saving over transplanted rice	WP (kg/ m^3)
Transplanted Rice	32	16120	-	0.36	33	16802	-	0.37
System of Rice Intensification	29	14085	12.6	0.43	27	14322	14.8	0.47
Alternate Wetting and Drying	24	13636	15.4	0.39	23	13773	18.0	0.42
Wet seeded rice	37	15763	2.2	0.33	39	15683	6.7	0.35
Aerobic rice	26	9687	39.9	0.37	24	9425	43.9	0.42

Data statistically not analysed ; WP- Water productivity

in SRI increased the root growth, along with increase in productive tillers, grain filling and higher grain weight that ultimately resulted in maximum grain yield (Uphoff, 2001). The lowest grain yield of 3582 and 3933 kg/ha was recorded under aerobic rice cultivation. Competition from weeds during early stage of growth and less soil moisture under aerobic rice might have been the reasons for poor yield.

Water usage and water productivity

Variation in water usage, water saving and water productivity of rice under different cultivation systems are presented in Table 3. In summer and *kuruvai* seasons, wet seeded rice required more number of irrigations (37 and 39), followed by transplanted rice (32 and 33). Under SRI, there is a saving of 3 and 6 irrigations respectively during summer and *kuruvai* seasons compared to transplanted rice. Minimum number of irrigations were recorded under alternate wetting and drying method of rice cultivation (24 and 23), followed by aerobic rice (26 and 24) in both the seasons. Conventional rice cultivation used higher amount of water (16120 and 16802 m^3), followed by wet seeded rice and SRI. Aerobic rice used minimum quantity of water (9687 and 9425 m^3 respectively) during both the seasons compared to other methods. Maximum water saving was recorded with aerobic rice (39.9 and 43.9 %), followed by alternate wetting and drying method (15.4 and 18.0 % respectively) over transplanted

rice in both the experiments. Water saving under SRI was 12.6 and 14.8 % respectively during summer and *kuruvai* seasons. Impounding of 2.5 cm of irrigation water, irrigation after formation of hairline cracks have shown considerable water saving besides better root environment in SRI. Similar findings were reported by Thiagarajan *et al.* (2002). With respect to water productivity, SRI method of rice cultivation registered the highest water productivity (0.43 and 0.47 kg/m^3), followed by AWD and aerobic rice cultivation during both the seasons. The conventional rice cultivation (0.36 and 0.37kg/m^3 in summer and *kuruvai* respectively), and direct sown rice produced lower grain yield per unit quantity of water used.

Thus, system of rice intensification increased the grain yield by 5 to 7 % besides saving of water by 12 to 15 % over conventional method of rice cultivation under wetland ecosystem.

References

Abu Yamah. 2002. The practice of system of rice intensification in Sierraleone. In: Proceedings of the International Conference on System of Rice Intensification (SRI). April 1-4, 2002. Chinese National Hybrid Research and Development Centre, Sanya, China.

Bouman, B.A.M., Xiaoguang, Y., Huaqui, W., Zhiming, W., Junfang, Z., Changgui, W., Bin, C. 2002. Aerobic rice (Han Dao): A new way growing rice in water short areas. **In**: Proceedings of the 12th International Soil Conservation Organization Conference, May 26-31. Beijing, China. Tsinghua University, p. 175-181.

Koma, Y.S. and Sinv, S. 2003. An assessment of ecological system of rice intensification (SRI) in Combodian wet season. CEDAC field document, Pheom Penti, CEDAC Mimeo.

Stoop, W.A., Uphoff, N. and Kassam, A. 2002. A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource poor farmers. *Agric. Systems.* **71**: 249-274.

Thiyagarajan, T.M., and Selvaraju, R. 2001. Water saving in rice cultivation in India. In: Proceedings of an International Workshop on Water Saving Rice Production Systems. April 2-4, 2001. Nanjing University, China, p.15-45.

Thiyagarajan, T.M., Velu., V., Ramasamy, S., Durgadevi, D., Govindarajan, K., Priyadarshini, R., Sudhalakshmi, C., Senthilkumar, K., Nisha, P.T., Gayathry, G., Hengsdijk, H., Bindraban, P.S. 2002. Effect of SRI practices on hybrid rice performance in Tamil Nadu, India. **In**: Bouman, B.A.S, Hengsdijk, H, Hardy, B, Bindraban, P.S, Tuong, T.P, Ladha, J.K. Editors. Water -wise rice production. IRRI and Plant research International (PRI), P 119-127.

Uphoff, N. 2001. Scientific issue raised by the system of rice intensification: A less-water rice cultivation system. **In**: Proceedings of an International Workshop on Water Saving Rice Production Systems. Nanjing University, China. April 2-4, 2001.

Uphoff, N., Saryanarayana, A. and Thiyagarajan, T.M. 2005. Prospects for rice sector improvement with the System of Rice Intensification, considering evidence from India. In: Proceedings of the 16th International Rice Conference, September 10-14, 2005. Bali, Indonesia.

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