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System of Rice Intensification and Integrated Crop Management under Integrated Nutrient Management Improves Growth and Productivity of Lowland Rice

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ABSTRACT

Appropriate rice culture contributes to efficient utilization of limited resources which may contribute to enhance growth and productivity of rice in north eastern hill region. A field study was conducted with three rice cultures *i.e.*, system of rice intensification (SRI), integrated crop management (ICM) and conventional rice culture (CRC) and five nutrient management practices *viz.*, recommended dose of nutrients (RDN) (80:60:40 kg NPK ha^{-1}), farmyard manure (FYM) 10 t ha^{-1}, RDF + FYM 5 t ha^{-1}, 50% RDN + FYM 10 t ha^{-1} and control in lowland Agronomy field of ICAR-Research Complex for NEH Region Umiam, Meghalaya, India. The results revealed that growth attributes of rice like plant height, tillers plant^{-1}, no of leaves plant^{-1} and root dry matter production were significantly higher under SRI at maturity which was at par with ICM but remained significantly superior to CRC. However, tillers per unit area were higher under CRC followed by ICM and SRI. The grain yield of rice was maximum under integrated application of RDN + FYM 5 t ha^{-1} under ICM which was at par with integrated application of 50% RDN + FYM 5 t ha^{-1} under ICM and integrated application of RDN + FYM 5 t ha^{-1} under SRI. Thus, the study indicated that adoption of younger seedlings with appropriate age and planting geometry can substantially enhance rice productivity under integrated application of organic and synthetic fertilizers in north eastern hill region.

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INTRODUCTION

Rice (*Oryza sativa* L.) is an important food crop for a large proportion of the world's population. In the North Eastern region particularly in Meghalaya, there prevails a favourable climatic condition for the cultivation of rice. Rice is the dominant food grain crop and production of rice is about 80% of the total food production in the state (Ghosh *et al.*, 2018). However, even with the favourable conditions and resources available, the production of rice in this part of the country is nearly stagnating; the only option for achieving self-sufficiency is vertical yield improvement. Production of rice could be improved by changing the way that rice plant are managed, their soil, their water, organic nutrients and other inputs. Rice plants can be managed by maintaining optimum plant population, by use of appropriate seedling age and number of seedlings.

Appropriate seedling age at transplanting is essential for satisfactory yield. Uphoff (2002) while emphasizing System of Rice Intensification (SRI) technique of Fr. Henri de Laulanie, opined that early transplanting of younger seedling preserves plant’s potential for much greater tillering, more root growth, and better yield. Old seedlings were found to mature later because of delayed formation of tillers and longer time to recover from transplanting shock resulting in poor yield (Makarim *et al.*, 2002). Number of seedlings that are transplanted also influences the yield of the crop. Planting of single seedling hill^{-1} gave more yields being comparable with that of two seedlings hill^{-1} (Rajarathinam and Balasubramaniyan, 1999).

Nutrient management practices play an important role in enhancing the production of rice. Proper utilization and combination of nutrients have a significant effect on the proper growth which in turn enhances its yield attributes and yield. The nutrients from the organic and inorganic sources differ in their relative availability for crop uptake. Synthetic fertilizers contain very high amount of nutrients and these are the quick source of nutrient supply and readily available as most of the fertilizers are water soluble. However, use of synthetic fertilizers had led to deterioration in soil health and fertilizer use efficiency. In contrast, organic manure are nearly complete source of most of the nutrients but due to their low nutrient content and bulky in nature, they would become available for crop uptake gradually but would be available for longer duration due to slow decomposition and gradual release of the nutrients into the labile pool. Further, organic sources release nutrients very slowly and cannot provide nutrients during the early stages of crop growth. Therefore, an integrated approach with the use of organic and inorganic inputs that nourishes the soil in many ways and supplies all the essential nutrients to the crops in sufficient amounts and makes the nutrients readily available during crop growth is required.

The SRI system comprised of package of agronomic components like use of younger seedlings (12 to 15 days old), transplanting single seedling per hill, use of wider spacing (25 × 25 cm), intermittent irrigation, uprooting of seedlings by scooping and careful transplanting, weed control by passing a conoweeder, use of organic manures (Satyanarayana, 2004). Even though, SRI was gaining wider acceptance in many countries, there are some limitations especially in the high rainfall areas in which the production of rice is not promising as it should be. To overcome the limitations of SRI and to begin with one can go for Integrated Crop Management (ICM) as suggested by IRRI scientists in which 15-20 days old seedlings are planted in spacing of 20 × 20 cm and two seedlings hill^{-1} are transplanted, organic manures and fertilizers are used in integration.

Scientific data on the performance of rice under various establishment methods are meager. The nutrient requirement of rice for various establishment methods may also vary. Thus the present study was conducted with the objectives to assess impact of different rice culture and integrated application of organic and inorganic fertilizer on growth and yield of rice in mid-altitudes of the north eastern hill region of India.

MATERIALS AND METHODS

A field experiment was conducted at the low-land Agronomy Farm, ICAR-Research Complex for North Eastern Hill Region, Umiam (25°30′ N latitude and 91°51′ E longitude with an elevation of 950 m above mean sea level), Meghalaya, India during four consecutive rainy seasons under rainfed condition. The soil of the experimental field was low in available phosphorous (6.95 kg P ha^{-1}), medium in nitrogen (277 kg N ha^{-1}) and high in potassium (258 kg K ha^{-1}). The pH and organic carbon content of the soil was 5.1 and 2.56%, respectively. The experimental soil was sandy clay loam in texture. The average monthly minimum and maximum temperature during the rice growing seasons ranged from 12.4 to 21.2 °C and from 23.9 to 29.1 °C, respectively. The average annual rainfall of the study site is about 2450 mm.

Three rice cultures *viz*., SRI, ICM and conventional rice culture (CRC) and five nutrient management practices *viz*., recommended dose of nutrients (RDN) (80:60:40 kg NPK ha^{-1}), farmyard manure (FYM) 10 t ha^{-1}, RDF + FYM 5 t ha^{-1}, 50% RDN + FYM 10 t ha^{-1} and control (no manure or fertilizer) were followed in factorial randomized block design and replicated thrice. The gross and net plot sizes were 5.0 m × 4.0 m and 4.0 m × 3.0 m, respectively and the treatments were superimposed in the same plot every year to study the cumulative treatment effects. The nurseries for all the three establishment methods were sown on the same day but transplanting date varied as per the requirement of different establishment methods. For SRI 10 days old seedling at 1 seedling hill^{-1} was used with 25 cm × 25 cm spacing while for ICM, it was 20 days old seedlings at 2 seedlings hill^{-1} with a spacing of 20 cm × 20 cm and for CRC, 30 days old seedlings at 3 seedlings hill^{-1} with a spacing of 20 cm × 15 cm was followed. High yielding and medium duration rice variety 'Shahsarang 1' was used as test crop in the experiment. The details of nursery management practices and establishment practices of SRI and ICM rice cultures have been described by Wahlang *et al.* (2001).

The FYM was applied 20 days ahead of transplanting to the main field and incorporated during ploughing. The supply of N, P and K was ensured through urea, single super phosphate (SSP) and muriate of potash (MOP) fertilizer. Two handweedings (HW) in CRC [20 and 45 days after transplanting (DAT)] and two HW (15 and 45 DAT) and one weeding with cono-weeder (30 DAT) were done in SRI and ICM methods. The field was given conditions of alternate wetting and drying and only a thin film of water was maintained by closing and opening of bund around the plots as necessary for SRI and ICM rice culture. A continuous flooded water level of about 5±2 cm was maintained in CRC plots. For easy irrigation and drainage of water, a channel of 30 cm width and 20 cm depth was provided around each individual plots.

Plant height, tillers hill^{-1}, leaves hill^{-1} and root dry matter production and volume (cc) were recorded at 15 days interval and at harvest from randomly selected five hills in each plot. The data on grain and straw yields were obtained at harvest after proper sun drying and expressed as tones ha^{-1}. The plant and soil data were statistically analyzed using the F-test as per the procedure given by Gomez and Gomez (1984). The differences between treatments means were compared with the critical difference (CD) at 5% level of probability (P=0.05).

RESULTS AND DISCUSSION

Plant Height

The different rice cultures exerted significant influence on plant height (Table 1). The rice plants were taller under SRI as compared to ICM and CRC cultures. CRC produced shorter plant and at 15, 30 and 45 DAT and similar trends in plant height were observed with ICM. Less competition among the plants for resources like moisture and nutrients due to less plant population might have attributed to enhanced availability of nutrient and other resources leading to an increase in plant height (Das *et al.*, 2013). However, in Himachal Pradesh during the rabi season it was observed that the maximum plant height was observed under CRC in comparison to SRI and ICM (Mankotia *et al.*, 2006). The best response of nutrient management practices on plant height from 15 to 45 DAT was recorded with application of RDN + FYM @ 5 t ha^{-1} where taller plants were produced over the other nutrient management practices but plants of similar height were produced with 50% RDN + FYM 10 t ha^{-1}. From 60 DAT, plants were taller with 50% RDN + FYM 10 t ha^{-1} than others. Plants of similar height were produced with RDN + FYM 5 t ha^{-1}. Control treatment produced the least plant height at all the growth stages. At 15 and 30 DAT, application of RDN alone produced more plant height over FYM 10 t ha^{-1}. However, from 45 DAT onwards similar plant height was observed among the nutrient management practices.

Table 1: Effect of stand establishment methods and nutrient management practices on plant height (cm) of lowland rice

Rice cultures	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
SRI	22.8	43.0	60.0	76.6	87.3	89.8	89.8
ICM	21.9	40.9	56.9	74.5	83.7	84.5	84.5
CRC	21.2	39.9	55.3	72.2	80.7	82.2	82.2
SE (d)	0.29	0.69	0.71	0.66	0.73	0.76	0.76
CD (P=0.05)	0.81	1.92	1.97	1.83	2.03	2.11	2.11
Nutrient management							
RDN	22.6	41.6	57.7	74.3	82.4	84.5	84.5
FYM 10 t ha^{-1}	21.4	39.5	57.8	74.6	84.7	86.1	86.1
50% RDN + FYM 10 t ha^{-1}	23.2	43.8	59.2	77.7	87.2	89.0	89.0
RDN + FYM 5 t ha^{-1}	23.7	44.2	59.4	77.2	86.0	87.4	87.4
Control	19.0	37.4	52.8	68.5	79.0	80.7	80.7
SE (d)	0.41	0.98	1.12	1.08	1.12	1.08	1.08
CD (P=0.05)	0.85	2.02	2.31	2.23	2.31	2.23	2.23
A × B							
SE (d)	0.71	1.67	1.88	1.80	1.89	1.84	1.84
CD (P=0.05)	1.55	3.64	4.06	3.89	4.10	4.01	4.01

Number of Tillers Hill^{-1}

The CRC rice culture produced higher number of tillers over SRI and ICM (Table 2). From 45 till 105 DAT, more number of tillers hill^{-1} was observed under SRI culture and during this period the lowest number of tillers hill^{-1} was observed with CRC.

Table 2: Effect of stand establishment methods and nutrient management practices on number of tillers hill^{-1} of lowland rice

Rice cultures	**15 DAT**	**30 DAT**	**45 DAT**	**60 DAT**	**75 DAT**	**90 DAT**	**105 DAT**
SRI	2.73	6.92	14.42	15.54	14.46	14.08	13.67
ICM	3.16	8.12	12.45	13.03	12.01	10.98	10.61
CRC	4.8	8.41	10.01	10.42	9.17	8.37	7.99
SE (d)	0.14	0.14	0.31	0.32	0.32	0.26	0.22
CD (P=0.05)	0.39	0.39	0.86	0.89	0.89	0.72	0.61
Nutrient management practices							
RDN	3.89	8.26	12.00	12.50	11.66	11.06	10.69
FYM 10 t ha^{-1}	3.43	7.58	12.09	12.57	11.93	11.06	10.73
50% RDN + FYM 10 t ha^{-1}	3.52	7.92	13.20	13.96	12.24	11.55	11.13
RDN + FYM 5 t ha^{-1}	3.93	8.48	13.36	14.19	12.31	11.66	11.22
Control	3.03	6.84	10.80	11.78	11.13	10.42	10.01
SE (d)	0.13	0.21	0.35	0.38	0.27	0.29	0.26
CD (P=0.05)	0.27	0.43	0.72	0.78	0.56	0.60	0.59
A × B							
SE (d)	0.25	0.35	0.62	0.68	0.52	0.52	0.46
CD (P=0.05)	0.57	0.76	1.39	1.51	1.21	1.16	1.02

Tillers production reached its peak at 60 DAT and started decreasing from 75 DAT in all rice cultures. At 105 DAT, the number of tillers (13.67) under SRI was 28.84% and 41.55% higher over CRC (7.99) and ICM culture (10.61). Maximum numbers of tillers hill^{-1} at 15 to 60 DAT were observed under RDN + FYM 5 t ha^{-1}. From 75 to 105 DAT, the number of tillers hill^{-1} was maximum under 50% RDN + FYM 10 t ha^{-1} which was at par with RDN + FYM 5 t ha^{-1}. However, from 45 DAT onwards, the number of tillers hill^{-1} was higher under FYM 10 t ha^{-1} alone and remained at par with RDN alone. Minimum number of tillers was noted under control.

Number of Leaves Hill^{-1}

The higher number of leaves plant^{-1} were observed with CRC culture at 15 DAT; whereas, at 30 DAT, the number of leaves was comparable with ICM (Table 3). The number of leaves hill^{-1} was significantly higher with SRI culture from 45 to 105 DAT and the lowest number of leaves was observed with CRC during these stages. The number of leaves increased in the subsequent stages upto 60 DAT, and thereafter there was a reduction in the number of leaves in all the establishment methods up to 105 DAT. Higher number of leaves hill^{-1} at 15 and 30 DAT was observed with RDN alone which was comparable with RDN + FYM 5 t ha^{-1} but significantly superior over FYM 10 t ha^{-1} alone. From 45 to 105 DAT, the number of leaves hill^{-1} were found to be maximum with RDN + FYM 5 t ha^{-1} and similar number of leaves was observed when 50% RDN + FYM 10 t ha^{-1} was applied. Control treatment produced the minimum number of leaves during the vegetative growth stages but at 75, 90 and 105 DAT the leaf number was comparable with the application of RDN alone. The use of younger seedlings in SRI at one seedling hill^{-1} avoided transplanting shock and might have enhanced root activity thus enhancing crop growth through significant increase in the leaf number hill^{-1} (Thiyagarajan *et al.*, 2002). The number of leaves decreased during the later stages and the reason behind this might be the shedding of leaves.

Table 3: Effect of stand establishment methods and nutrient management practices on the number of leaves hill^{-1} of lowland rice

Rice cultures	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
SRI	11.85	27.20	57.46	59.83	55.41	50.00	49.09
ICM	13.59	35.78	46.68	48.44	42.63	37.98	37.72
CRC	15.92	37.20	44.34	45.21	33.38	28.09	25.12
SE (d)	0.42	0.58	0.88	0.64	1.23	0.57	2.12
CD (P=0.05)	1.17	1.61	2.44	1.78	3.41	1.58	5.89
Nutrient management practices							
RDN	15.35	36.07	48.93	50.69	42.93	37.18	36.10
FYM 10 t ha^{-1}	12.96	33.03	49.03	51.04	43.83	38.87	37.56
50% RDN + FYM 10 t ha^{-1}	13.56	33.4	51.03	53.54	45.98	40.87	39.11
RDN + FYM 5 t ha^{-1}	15.32	35.47	52.49	54.10	46.07	41.53	39.75
Control	10.96	29.02	45.98	46.60	40.04	35.00	33.83
SE (d)	0.74	1.01	1.16	1.56	1.83	1.51	1.74
CD (P=0.05)	1.53	2.08	2.39	3.22	3.78	3.12	3.59
A × B							
SE (d)	1.22	1.66	2.00	2.50	3.09	2.41	3.43
CD (P=0.05)	2.62	3.57	4.40	5.28	6.74	5.06	8.03

Root Growth

The root volume and root dry weights were higher under SRI culture when compared to the other rice cultures (Figure 1). The reason that roots grow large under SRI method of establishment was because young seedlings are transplanted at shallow depth

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and wider spacing, soil was kept well aerated and rich with diverse microorganisms. Continuous mechanical disturbance to the soil loosened the soil and supply oxygen directly to the growing roots to result into more active and long functioning sturdy root system and root degeneration was avoided (Patel *et al.*, 2008).

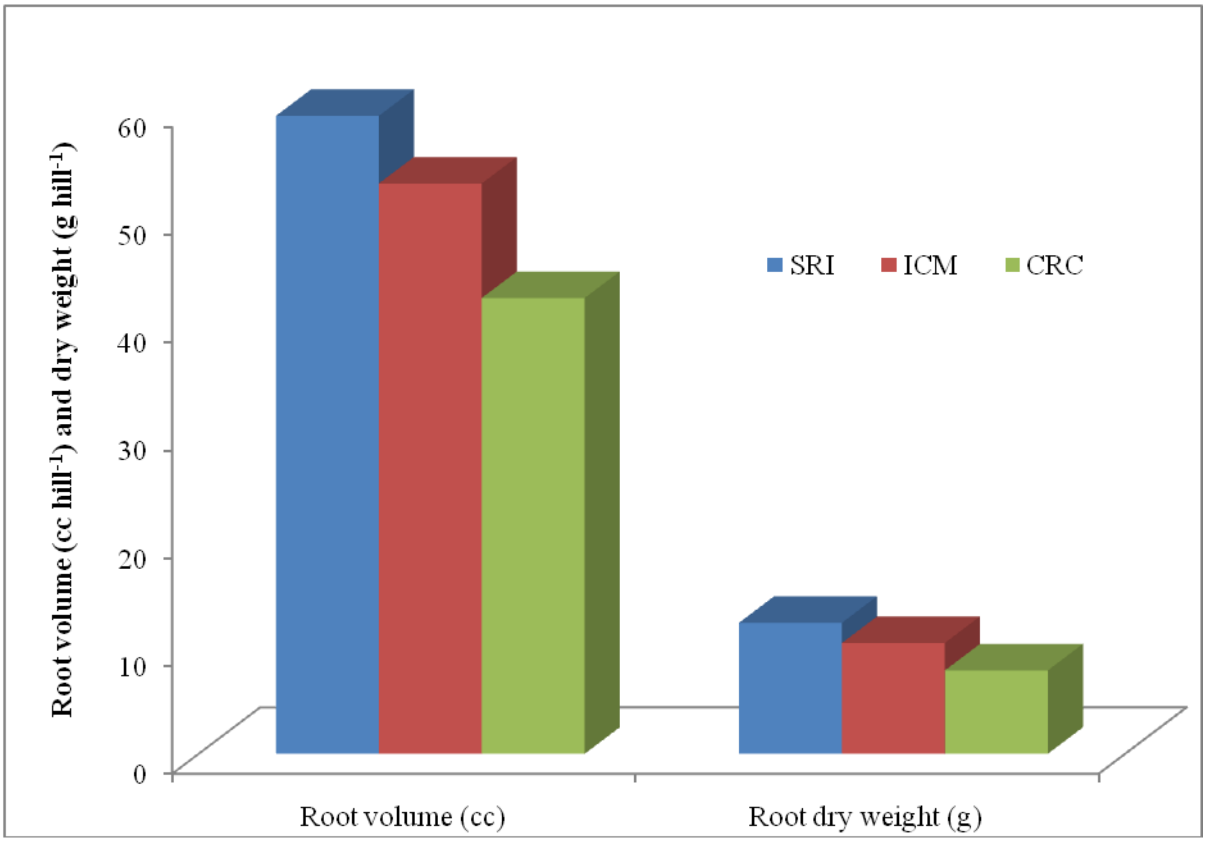

Figure 1: Root volume and dry weight under different rice cultures

Yields

There was a significant interaction effect between rice culture and nutrient management practices on grain yield, stover yield and the Harvest Index (Table 4). RDN + FYM 5 t ha^{-1} produced the highest rice yields under ICM which was at par with 50% RDN + FYM 10 t ha^{-1} ICM. These two integrated nutrient management options under SRI also produced grain yield at par with the best combinations. More number of tillers per unit area against higher tiller hill^{-1} under ICM might have contributed to higher yields (Das *et al.*, 2013).

Table 4: Interaction table between stand establishment methods and nutrient management practices on yield of lowland rice

Treatment	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})			Harvest Index		
	SRI	ICM	CRC	SRI	ICM	CRC	SRI	ICM	CRC
RDN	5.22	5.33	4.92	6.98	7.134	6.31	42.76	42.75	42.98
FYM 10 t ha^{-1}	5.34	5.48	5.03	7.03	7.19	6.90	43.15	43.26	43.25
50% RDN + FYM 10 t ha^{-1}	5.54	5.78	5.27	7.11	7.35	6.52	43.54	44.06	43.85
RDN + FYM 5 t ha^{-1}	5.741	5.88	5.33	7.24	7.37	6.90	44.38	44.35	44.27
Control	4.63	4.78	4.43	6.48	6.65	6.97	41.69	41.84	41.73
SE (d)		0.16			0.14			0.82	
CD (P=0.05)		0.34			0.33			1.79	

Combined application of nutrient sources recorded significantly higher stover yields and Harvest Index in all the establishment methods which were at par with recommended NPK or FYM 10 t ha^{-1} alone and the maximum being achieved in ICM cultures. This may due to higher nutrient uptake under integrated application of synthetic and organic manure which resulted greater economic yield. Minimum Harvest Index was observed in control treatment of CRC method of establishment under control.

CONCLUSION

The study emphasized on the importance of transplanting younger seedlings. Less number of tillers hill^{-1} is providing adequate spacing for effective growth and development of rice. Integrated application of inorganic fertilizer along with organic manure like FYM was found effective against sole application of fertilizer or organic manure. Thus adoption of ICM rice culture with integrated application of inorganic and organic fertilizer is recommended for sustainable rice production in north eastern hill region of India.

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Conflict of Interest

The authors declare no conflict of interest.

REFERENCES

Das, A., Patel, D.P., Munda, G.C., Ramkrushna, G.I., Kumar, M., Ngachan, S.V., 2013. Improving productivity, water and energy use efficiency in lowland rice (*Oryza sativa*) through appropriate establishment methods and nutrient management practices in the mid altitudes of North-east India. *Experimental Agriculture* 50(3), 353-375. DOI: https://doi.org/10.1017/S0014479713000483.

Ghosh, P.K., Das, A., Pattanayak, A., Bhagwati, R., Tripathi, A.K., Ngachan, S.V., 2018. Managing soil health of crop fields in North-east India – Some potential module of indigenous resource conserving techniques. *Innovative Farming* 3(4), 167-173.

Gomez, K.A., Gomez, A.A., 1984. *Statistical Procedures for Agriculture Research*. 2nd Edition. John Wiley and Sons Publishers, New York. pp. 357-423.

Makarim, A.K., Balasubramaian, V., Zaini, Z., Syamsiah, I., Diratmadja, I.G.P.A., Handoko, Arafah, Wardana, I.P., Gani, A., 2002. System of Rice Intensification (SRI) Evaluation of seedling age and selected components in Indonesia. In: *Water-wise Rice Production*. (Eds.) Bouman, B.A.M., Hengsdijk, H., Hardy, B., Bindraban, P.S., Tuong, T.P. and Ladha, J.K. Proceedings of the International Workshop on Water-wise Rice Production. International Rice Research Institute, Los Baños, Philippines. pp. 129-142.

Mankotia, B.S., Shekhar, J., Negi, S.C., 2006. Performance of rice in SRI (system of rice intensification), ICM (integrated crop management) and conventional transplanting methods with common date of transplanting in the mid hills of HP. *Haryana Journal of Agronomy* 22(1), 68-70.

Patel, D.P., Das, A., Munda, G.C., Ghosh, P.K., Ngachan, S.V., Kumar, R., Saha, R., 2008. *SRI and ICM Rice Culture for Water Economy and Higher Productivity*. Research Bulletin No: 68. ICAR-Research Complex for NEH Region, Umiam, Meghalaya. pp. 1-28.

Rajarathinam, P., Balasubramaniyan, P., 1999. Effect of plant population and nitrogen on yield attributes and yield of hybrid rice (*Oryza sativa*). *Indian Journal of Agronomy* 44(4), 717-721. DOI: https://doi.org/10.59797/ija.v44i4.3576.

Satyanarayana, A., 2004. Rice, research and real life in the field. *Nature* 429, 803. DOI: https://doi.org/10.1038/429803a.

Thiyagarajan, T.M., Vellu, V., Ramaswamy, S., Durgadevi, D., Govindarajan, K., Priyadarshani, R., Sudhalakshmi, C., Senthilkumar, K., Nisha, P.T., Gayathry, G., Hensdijik, H., Bindrabanban, P.S., 2002. Effects of SRI practice on hybrid performance in Tamil Nadu, India. In: *Water-wise Rice Production*. (Eds.) Bouman, B.A.M., Hengsdijk, H., Hardy, B., Bindraban, P.S., Tuong, T.P. and Ladha, J.K. Proceedings of the International Workshop on Water-wise Rice Production. International Rice Research Institute, Los Baños, Philippines. pp. 119-127.

Uphoff, N., 2002. Changes and evaluation in SRI methods. In: *Assessments of the System of Rice Intensification (SRI)*. Proceedings of International Conference. 01-04 April, 2002. Sanya, China. pp. 8-14.

Wahlang, B., Das, A., Layek, J., Munda, G.C., Ramkrushna, G.I., Panwar, A.S., 2001. Effect of establishment methods and nutrient management on physiological attributes and water-use efficiency of rice (*Oryza sativa*) in a sub-tropical climate. *Indian Journal of Agronomy* 60(4), 534-540. DOI: https://doi.org/10.59797/ija.v60i4.4512.

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