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Standardization of Cultivars and Plant Geometry to Achieve Higher Productivity in Rice (*Oryza sativa* L.)

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ABSTRACT

The present investigation was carried out with three rice cultivars (AU1 GSR, ADT 46 and BPT 5204) in main plots and five establishment methods (Broadcasting, line sowing, recommended spacing, wider spacing and SRI planting) in sub-plots in split-plot design. Results showed that SRI method produced higher plant height, number of tillers and dry matter accumulation than recommended spacing. SRI produced higher grain yield than recommended spacing and wider spacing, respectively. Among varieties, maximum growth attributes viz., plant height, number of tillers and dry matter accumulation. And Yield parameters like number of productive tillers m-2, filled grains panicle-1, grain yield, straw yield and harvest index was observed with AU1 GSR.

Key words: *AU1 GSR, SRI, Growth and Yield Parameters.*

Introduction

Rice is the staple cereal crop of India (Meena *et al.*, 2019). Its production must be increased by 70% by 2050 to meet the growing demand for food accompanying population growth and economic development (Godfray *et al.*, 2010). Sustainable crop yield can only be achieved by adopting viable crop management technologies that optimize the use of limited resources such as space, nutrients, irrigation, water, and labour. Over the years, crop genetic improvements and technological innovations have significantly contributed to increased crop production (Gregory and George, 2011). It is imperative to develop crop management that is less dependent on heavy agronomic input but still achieves the potential of high-yielding rice cultivars.

Growing demand of rice can be met by selection of high yielding varieties suitable even for adverse environments. Rice scientists in Philippines proposed the concept of green super rice to breed and produce a new type of rice, that requires fewer pesticides, fewer fertilizers, and reduced irrigation while exhibiting greater stress resilience without compromising grain yield and quality. AU1 GSR is one such variety released in Tamilnadu from the stress tolerant lines obtained from IRRI, Phillpines which should be tested for its superiority with ruling cultivars like ADT 46 and BPT 5204.

Another important trait was methods of establishment were each methods have unique advantages. The different alternate establishment methods such as broadcasting, line sowing, recommended spacing, and wider spacing are also important as they save water with yield penalty. In broadcasting, seeds are either broadcasted, line sowing - seeds

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sown in line using drum seeder. Transplanting method for rice cultivation in recommended spacing reduce the amount of irrigation water during the growing period, costs of weed control and facilitate early weed management in rice fields while rice plants are in the nursery. Wider spacing as the wide distance between plants leads to maximum roots growth, shoot branching and more appropriate plant canopy which allows highest plant's performance based on its genetic traits (Al-Mashhadani 2010). Recently, system of Rice Intensification (SRI) transplanting is the most adopted rice establishment method among farmers. using less production inputs such as seed, organic/inorganic fertilizer, water and pumping cost (Uphoff *et al*., 2011). Other advantages are decrease in amount of irrigation water by 25% to 50% (Satyanarayana *et al*., 2007), less investment capital, which favours small holder farmers, and higher returns at the end of the season (Nyamai *et al*., 2012). Keeping these facts in view, the present investigation was carried out to study the behaviour of various cultivars under different establishment methods for achieving higher productivity in rice.

Materials and Methods

The field experiment was carried out during samba season of 2020 - 2021 in Garden land block at experimental farm, Annamalai University, Annamalai Nagar, Tamilnadu, India. The soil of the experimental field was clay loam in texture, neutral reaction (pH 7.3), low in organic carbon (0.35%) and low in available nitrogen (239.7 kg ha^{-1}), medium in available phosphorus (21.5 kg ha^{-1}) and high in available potassium (325.3 kg ha^{-1}). The experiment was laid out in spilt-plot design with three cultivars such as AU1 GSR, ADT 46 and BPT 5204 in main plots and five establishment method namely direct sowing - broadcasting, direct sowing - line sowing, Transplanting - recommended spacing, Transplanting - wider spacing and SRI transplanting in sub plots taking three replications. In broadcasting, seeds were sown directly and there was no spacing and in line sowing, seeds were sown directly with the help of drum seeder at a distance of 20 cm X 10 cm between rows and plants. How ever, for recommended and wider spacing 21 days old seedlings were transplanted in puddled soil keeping two seedling hill^{-1} at a spacing of 20 cm X 10 cm and 30 cm X 15 cm respectively. In SRI method 12 days old seedlings were transplanted in puddled field keeping two seedling hill^{-1} at a spacing of 22.5 cm X 22.5 cm. The recommended dose of fertilizer *i.e.,* 150-50-50 kg ha^{-1} of N-P_2O_5-K_2O was used to raise the experimental crop. For broadcasting, line sowing, recommended spacing and wider spacing 25% N and K plus full dose of P was applied before sowing / transplanting through urea (37.5 kg N), SSP (16 kg P). Rest 75% N and K was applied in two splits at active tillering and panicle initiation stage. For SRI, half of the recommended dose of nitrogen and potassium was applied basally, and the remaining half was applied in two equal splits, each at active tillering and panicle initiation stage, Full dose of phosphorus was applied as basal. Flooding of irrigation was followed and pre sowing irrigation was given for seed bed preparation and soil moisture was maintained near saturation at sowing to milking stage in broadcasting, line sowing, recommended spacing and wider spacing. Transplanting, up to seedling establishment, a thin film of water (2-3 cm) was maintained and then plots were continuously flooded to maintain a ponded layer of 5-6 cm depth during vegetative and after panicle initiation, 2-3 cm depth of water was maintained, and plots were drained 15 days before harvest. While in SRI, wetting and drying is the common method of irrigation. Grain yield from net plot area was adjusted to 14% moisture. Biometric observation on plant height, number of tillers m^{-2}, dry matter accumulation, number of productive tillers m^{-2}, filled grains panicle^{-1}, grain yield, straw yield, harvest index and economics. Recommended agronomic practices were followed to raise the experimental crop.

Results and Discussion

Growth attributes

Among various rice cultivars screened, the values on plant height, number tillers m^{-2}, and dry matter accumulation significantly varied. Maximum growth attributes were noticed with variety AU1GSR which was followed by BPT 5204 and ADT 46.

Variation in plant height and number of tillers m^{-2} might be due to their ability to effectively utilize natural resources viz. photoperiod, solar radiations, as well as absorb more nitrogen from soil through roots for the synthesis of protoplasm which is responsible for rapid cell division which may increase plant shape and size or due to genetic character of the variety (Gautam *et al*., 2008). Higher dry matter accumulation in AU1GSR might be due to the increased cytokinin content in their roots at later growth stages (Singh *et al*., 2013).

Plant height, number tillers m^{-2}, and dry matter accumulation were influenced significantly due to different establishment methods (Table 1). Plant height vary with establishment methods and highest plant height was recorded under SRI establishment method. Number of tillers m^{-2} was estimated during maturity stage of rice growth. The results shown that there was significant difference in number of tillers m^{-2} in different treatments. The maximum number of tillers was registered in SRI method when compared to other methods. SRI method accumulated highest dry matter which was followed by recommended spacing and wider spacing which was at par with line sowing but was significantly superior over direct broadcasting method.

Maximum increment in plant height, no. of tillers and dry matter accumulation in SRI method might be due to increased amount of photosynthate accumulation, nutrient availability, and soil moisture than closely spaced rice plants under rest of the establishment methods. The results are in close conformity with (Kumar *et al.*, 2021) all growth parameters were highest in the SRI compare other establishment methods.

Among interaction, highest growth attributes were obtained in AU1GSR variety under SRI which was significantly superior over all other combinations of cultivars and establishment methods.

Yield attributes

Among the cultivars AU1GSR gave highest number of productive tillers m^{-2}, filled grains $panicle^{-1}$, grain yield, straw yield and harvest index which was sig-

Table 1. Effect of cultivars and establishment methods on growth attributes at harvest of rice.

Treatments	Plant height (cm)				Number of tillers m^{-2}				Dry matter production (kg ha^{-1})			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	81.23	72.06	65.69	72.99	234	206	220	220	9870	8528	8894	9097
S_2	94.58	83.57	75.01	84.39	302	254	272	276	10436	10017	10478	10310
S_3	108.47	95.54	84.33	96.11	354	302	322	326	12531	11351	11824	11902
S_4	95.19	85.02	76.08	85.43	313	265	285	288	11053	9888	10371	10437
S_5	121.33	104.12	93.89	106.45	393	338	359	363	13609	12761	13200	13190
Mean	100.16	88.06	79.00		319	273	292		11500	10509	10953	
	M	S	MxS	SxM	M	S	MxS	SxM	M	S	MxS	SxM
SEd	0.60	2.39	3.71	4.12	2.09	7.88	12.37	13.65	77.92	325.72	510.30	564.85
CD (p=0.05)	1.21	4.78	7.50	8.28	4.18	15.76	24.75	27.30	155.27	651.62	1020.6	1128.65

M_1 - AU 1 GSR, M_2 - ADT46 and M_3 - BPT 5204
S_1 – Broadcasting, S_2 – Line Sowing (20cm x 10cm), S_3 – Recommended Spacing (20 cm x 10 cm), S_4 – Wider Spacing (30 cm x 15cm) and S_5 – SRI planting (22.5 cm x 22.5 cm)

Table 2. Effect of cultivars and establishment methods on yield attributes at harvest of rice.

Treatments	Number of productive tillers m^{-2}					Number of filled grains $panicle^{-1}$			
	M_1	M_2	M_3	Mean		M_1	M_2	M_3	Mean
S_1	185.11	110.37	151.27	148.92	134	97	115	115	185.11
S_2	212.98	137.51	177.38	175.96	139	104	121	121	212.98
S_3	252.74	168.16	214.11	211.67	142	108	125	125	252.74
S_4	218.31	142.32	186.05	182.23	140	105	122	122	218.31
S_5	277.16	201.39	244.29	240.95	144	112	129	128	277.16
Mean	229.26	151.95	194.62	140	105	123		229.26	
	M	S	MxS	SxM	M	S	MxS	SxM	M
SEd	2.07	7.50	11.71	12.99	0.77	1.50	1.74	1.98	2.07
CD (p=0.05)	4.14	15.48	24.32	26.82	1.54	2.08	NS	NS	4.14

M_1 - AU 1 GSR, M_2 - ADT46 and M_3 - BPT 5204
S_1 – Broadcasting, S_2 – Line Sowing (20 cm x 10 cm), S_3 – Recommended Spacing (20 cm x 10 cm), S_4 – Wider Spacing (30 cm x 15cm) and S_5 – SRI planting (22.5 cm x 22.5 cm)

nificantly greater than rest of the varieties. Yield attributes was significantly influenced due to different establishment methods and cultivars (Table 2). SRI transplanting produced significantly more number of productive tillers m^{-2} (240.95), filled grains panicle^{-1} (128), grain yield (5111 kg ha^{-1}), straw yield (7037 kg ha^{-1}) and harvest index (40.60%) which was significantly higher than direct broadcasting method and other methods of establishment. This confirms the finding of a study in which SRI rice gave higher yield attributes than direct seeded rice (Chauhan *et al*., 2015). This is because at higher spacing, there is no competition of nutrients, air and light thus creating a better environment for crop growth. Better performance of hybrid and high yielding varieties might be due to better growth and partitioning of photosynthates to reproductive parts (Singh *et al*., 2017). Among interaction, highest yield attributes were obtained in AU1GSR variety under SRI which was significantly superior over all other combinations of establishment methods and cultivars. The Least yield, yield attributes was observed in ADT 46 variety under broadcasting method.

Economics

It is evident from the data that economics of the crop significantly influenced by the highest gross return (₹1,10,376 ha^{-1}), net return (₹74,060 ha^{-1}) and B:C ratio (2.04) over other establishment methods. was recorded in treatment combination with AU 1 GSR and SRI transplanting (M_1S_5). This might be due to the fact that, higher spacing between rice hill produce many grains per panicle and tillers (Reuben *et al*., 2016). Which reflects on gross return and net returns. The lowest gross return (₹65,499 ha^{-1}), net return (₹30,463 ha^{-1}) and B:C ratio (0.87) was recorded in ADT 46 and broadcasting (M_2S_1).

Conclusion

The experimental study titled "Standardization of Cultivars and Plant Geometry to Achieve Higher

Table 3. Effect of cultivars and establishment methods on yield of rice

Treatments	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})				Harvest index			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	3443	3119	3292	3285	5169	4845	5018	5011	39.99	39.46	39.71	39.72
S_2	3994	3742	3837	3858	5720	5468	5563	5584	40.06	39.57	39.76	39.80
S_3	4610	4336	4458	4468	6436	6162	6284	6294	40.73	40.30	40.50	40.51
S_4	4162	3778	3910	3950	5888	5504	5636	5676	40.41	39.70	39.96	40.02
S_5	5256	4972	5104	5111	7182	6898	7030	7037	40.89	40.35	40.55	40.60
Mean	4293	3989	4120	6079	5775	5906	40.42	39.88	40.10			
	M	S	MxS	SxM	M	S	MxS	SxM	M	S	MxS	SxM
SEd	23.84	136.14	212.25	235.8	34.81	200.44	312.46	347.17	0.38	0.48	1.59	1.75
CD (p=0.05)	66.21	280.98	439.98	486.67	96.65	413.69	647.66	716.53	0.78	0.97	NS	NS

M_1 - AU 1 GSR, M_2 - ADT46 and M_3 - BPT 5204
S_1 – Broadcasting, S_2 – Line Sowing (20 cm × 10 cm), S_3 – Recommended Spacing (20 cm x 10 cm), S_4 – Wider Spacing (30 cm × 15 cm) and S_5 – SRI planting (22.5 cm × 22.5 cm)

Table 4. Effect of cultivars and establishment methods on economics of rice.

Treat-ments	Gross Returns (Rs ha^{-1})				Net Returns (Rs ha^{-1})				B:C Ratio (Rs ha^{-1})			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S1	72303	65499	69132	68978	37267	30463	34096	33942	1.06	0.87	0.97	0.97
S2	83874	78582	80577	81011	49298	44006	46001	46435	1.43	1.27	1.33	1.34
S3	96810	91056	93618	93828	59354	53600	56162	56372	1.58	1.43	1.50	1.51
S4	87402	79338	82110	82950	50475	42411	45183	46023	1.37	1.15	1.22	1.25
S5	110376	104412	107184	107324	74060	68096	70868	71008	2.04	1.88	1.95	1.96
Mean	90153	83777.4	86524.2		54090.8	47715.2	50462.0		1.5	1.3	1.4	

M_1 - AU 1 GSR, M_2 - ADT46 and M_3 - BPT 5204
S_1 – Broadcasting, S_2 – Line Sowing (20 cm x 10 cm), S_3 – Recommended Spacing (20 cm × 10 cm), S_4 – Wider Spacing (30 cm x 15cm) and S_5 – SRI planting (22.5 cm x 22.5 cm)

Productivity in Rice" has revealed that the AU1 GSR cultivar has shown significant growth, yield and economic benefits as compared to other cultivars. Additionally, the use of SRI practice in rice transplanting has also shown higher growth, yield and economic benefits when compared to other establishment methods.

It has been concluded that in AU1GSR, the use of SRI practice in rice transplanting has shown the highest growth, yield and economic benefits when compared to other treatments. This is due to the fact that higher spacing between rice hills create a favorable environment for plant growth.

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