RESEARCH ARTICLE https://doi.org/10.58297/FTHR4599

Evaluation of Rice Varieties Under Different Crop Management Options in Rainfed and Drought Prone Ecology of Jharkhand

Verma BC, Saha S*, Singh CV, Srivastava AK, Prasad SM, Roy S, Banerjee A, Priyamedha, Bhagat S and Mandal NP

Central Rainfed Upland Rice Research Station (ICAR-NRRI), Hazaribag, Jharkhand, India

*Corresponding author Email: saha.soumya5@gmail.com

Received: 18th April, 2023; Accepted: 16th June, 2023

Abstract

Rice is the life and livelihood of Indians and the fact is more appropriate to the eastern part of the country. Rainfed and drought prone upland rice contributes a significant part of the total rice cultivation not only in India but also at the global level. However, the productivity is very low as compared to other rice-ecosystems. Hybrids were released from many institutions having several advantages and limitations. Comparative evaluation of rice hybrids and high yielding varieties (HYVs) under transplanting and direct seeding conditions is necessary to obtain a comparative picture. A field trial was conducted for three consecutive years to compare HYVs and popular hybrids under integrated crop management in drought prone rainfed ecology. Results of the experiment revealed that higher number of tillers were noted under wet-direct seeding, whereas increased application of fertilizer dose did not influence tillering under both direct seeding (DSR) and transplanting methods of crop establishment. Number of panicles per unit area also showed similar trend as tiller number and it was found that number of panicles were more in DSR as compared to transplanted rice. Grain yield between the transplanted and DSR is comparable, however, reduction in yield was higher in case of hybrids when switched from transplanted to DSR as compared to HYVs. Hence, it can be concluded that, in the drought prone rainfed areas HYVs should be preferred for cultivation over hybrids under DSR as there is diminishing scope of transplanted rice cultivation.

Keywords*:* Rainfed upland rice, drought prone, wet-direct seeding, transplanting, crop management, HYVs and hybrid

Introduction

Achieving higher productivity and increasing input use efficiency remain the major challenges experienced by researchers and farmers worldwide and it is the crucial option for increasing productivity and profitability in a sustainable manner for meeting food demand and alleviation of poverty. Rice is the staple food of about half of the world's population mainly in southeast, east, and south Asia and in some countries of Africa and tropical South America. In India, rice covers about 44 million hectares of area with an average production of 120 million tonnes and a productivity of 2.7 tonnes per hectare. (GoI, 2022). Considering the increasing population and the demand for rice, it is estimated that in 2030 and 2050 the requirement would be 137 and 197 million tonnes, to feed around 1.51 and 1.65 billion people, respectively (Pathak *et al.,* 2020). India must have to increase its rice productivity by 3% per annum to sustain the present food self-sufficiency and to fulfil future food demand (Thiyagarajan and Selvaraju, 2001). Rice is grown in diverse ecologies from submerged lowland in Assam to the drought prone upland conditions of Chotanagpur plateau and from hilly regions of Himalaya to the coastal saline regions of Kerala. Rainfed upland rice accounts for 11% of total rice area in India (4.8 Mha), located mainly in Eastern part of the country *i.e.,* Bihar, Chhattisgarh, Jharkhand, Odisha, UP and West Bengal (Pathak *et al*., 2020) and it is the prime contributor of livelihood security of the people in this region. In a suitable eco-region mapping for different crops, it was also found that eastern and northeastern states of the country come under suitable to very suitable category for growing rice (Pathak *et al.,* 2020).

Transplanting is the common method of crop establishment in rice and 77% of rice crop in the world is established through this method (Rao *et al*., 2007). In India also barring rainfed upland and some deep-water areas, rice is mostly transplanted in all other ecosystems. But this method of crop establishment consumes huge quantity of water either through rain or irrigation and is highly labour intensive and requires about 30 persons/ha/day (IRRI 2007). In the recent years, there is a trend of labour migration from low-income rural areas to high income urban/ industrial areas that led to huge shortage of labour in agricultural sector and as a result, labour-intensive work like transplanting of rice is adversely affected. Among different agricultural operations, transplanted rice is one of the major sources of greenhouse gas emission contributing 11% of the global total anthropogenic methane emission leading to global warming effect (Stocker *et al*., 2013). With the increasing problem of transplanting operations in rice cultivation and to reduce the cost of cultivation in an environment friendly manner there is a growing interest to replace it with other suitable methods. Different alternative crop establishment methods such as dry-direct sowing of rice (D-DSR), wet direct sowing (Wet DSR), aerobic rice etc have emerged to address several issues related to rice production *viz.* water and labour scarcity, improving the economic gain from rice cultivation etc. Aerobic rice is growing rice like any other upland crop under non-puddled, non-flooded and non-saturated soil conditions that require considerably less water than conventional puddled (transplanted) rice. Direct seeded rice (DSR) in wet (puddled) condition results in reduced use of labour, less consumption of water and early crop maturation of 1 to 2 weeks earlier when compare to the conventional transplanted rice (Weerakoon *et al*., 2011; Mishra *et al*., 2017; Saha *et al*., 2020). However, DSR has several limitations such as inconsistent plant population, injudicious use of fertilizer, water stress and presence of weeds in the field that often restrict realization of crop yield (Shultana *et al*., 2016). To improve the productivity and production in rainfed drought prone systems, a combination of improved varieties as well as integrated crop management practices are necessary. It was observed that, many farmers practice injudicious application of fertilizers which promotes higher losses in soil or environment that leads to low nutrient use efficiency. Fertilizers use efficiency (especially N) is very low in rice (approx. <40%) due to several losses (Cassman *et al*., 2002). Beside this, performance of different crop establishment methods also varies throughout the agroecological regions with different crop management options. Hence, there is scope for comparative evaluation of different establishment methods and crop management options together (Alam *et al*., 2020). Current situation demands an economically viable crop establishment method while growing different varieties to enhance the productivity as well as net return. Limited information is available on fertilizer management options under wet-DSR system. Moreover, DSR is an emerging production system which is less labour intensive that may reduce the cost of production. Hence, information on effect of fertilizer and different rice varieties in DSR may be helpful to identify suitable crop management options to achieve higher production and to reduce cost of cultivation. Therefore, the present study was undertaken to evaluate suitable varieties and fertilizer management options to obtain higher grain yield under wet DSR and to compare its relative advantage over transplanted rice.

Materials and Methods

Experimental details

To achieve the objectives, a field trial was initiated in *kharif* (wet season) of 2016 and continued for three consecutive years to compare high yielding varieties (HYVs) and popular hybrids under integrated crop management (fertilizer application rates and crop establishment methods) at research farm of CRURRS (ICAR-NRRI), Hazaribag. Combination of two crop establishment methods *viz.,* 1) Transplanting and 2) Wet direct Seeding (DSR); and two fertilizer management schedule *viz.,* 1) N_{80}:P_{40}:K_{30} and 2) N_{120}:P_{60}:K_{30} comprised the main plot treatments while four high yielding varieties (Hazaridhan, Sadabahar, Sahbhagidhan and DRR Dhan 44) and two hybrids (PAC 801 and PA 6444 Gold) formed the subplot treatments. The experiment was carried out under shallow lowland field having clay loam soil texture. The weather condition during the crop growth period is shown in **Figure 1.**

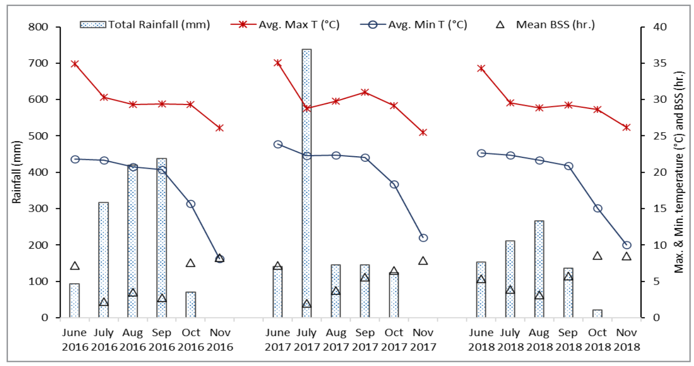

Figure 1: Weather condition during crop growth period

Table 1: Duration and special features of the rice varieties used in the study

Varieties	Duration (days)	Special Feature
Hazaridhan	115-120	Long slender grain, resistant to blast, moderately resistant to bacterial leaf blight, stem borer
Sadabahar	105	Long bold grain, moderately resistant to sheath blight
Sahbhagidhan	105-110	Long-bold grains; resistant to blast, and moderately resistant to brown spot, sheath rot, stem borer and leaf folder
DRR Dhan 44	115-120	Long slender grains, resistant to blast, moderate resistant to bacterial leaf blight and plant hoppers
PAC 801	120-125	Hybrid, long slender grains
PA 6444 Gold	135	Hybrid, resistant to bacterial leaf blight

Field and crop management

The field was prepared with two passes by a power tiller followed by two ladderings before sowing or transplanting. Twenty-four to thirty days old seedlings were transplanted in the main field at a spacing of 20 cm ×10 cm; maintaining two to three seedlings at each hill in conventional transplanting. In direct seeding, 2-3 sprouted seeds were dibbled manually at 20 cm × 10 cm spacing in puddled field with negligible or no standing water on surface. The nursery for transplanting and main field sowing in direct sowing was done at the same time for providing uniform growth. Fertilizers were applied as per the treatments through urea, DAP (di-ammmonium phosphate) and MOP (muriate of potash) in both transplanting and DSR. Alternate wetting and drying were followed for managing water requirement of the crop. Others management practices were followed throughout the experiment as per requirement.

Data collection and analysis

After harvesting rice plants were separated into straw (including rachis) and spikelets by hand threshing and then the grain yield, straw yield, panicle weight, grains per panicle and 1000-grain weight (test weight) were recorded. The data pertaining to treatment effects on different parameters were tested by two-way analysis of variance (ANOVA), and treatment means were compared using least significant difference (LSD) tests at 0.05 level of significance ($p \leq 0.05$).

Results and Discussion

During the three consecutive years of study, it was observed that the number of days required for 50% flowering varied significantly due to interaction between varieties, methods of crop establishment as well as fertilizer application rates. On an average it was observed that, varieties took 7-10 days more to flower (50% flowering) under TPR compared to wet-DSR. Varieties also showed substantial variations among themselves in number of days taken to 50% flowering as illustrated in **Figure 2.**

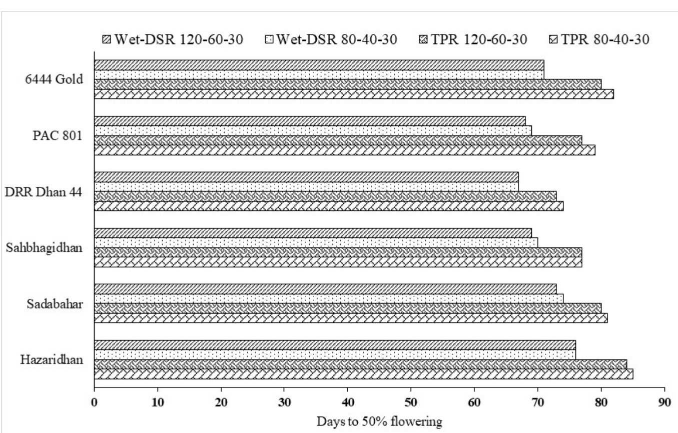

Figure 2: Effect of crop establishment, fertilizer application and varieties on 50% flowering

Effects of crop management options and varieties are found to be significant on different growth and yield attributes as shown in **Table 2.** Higher number of tillers was noted under DSR method, whereas increased application of fertilizer dose did not influence tillering under both DSR and TPR methods of crop establishment. Number of panicles per unit area also showed similar trend as tiller number and it was found that number of panicles were more in DSR as compared to transplanting. Higher tiller number in DSR compared to transplanted rice was also observed in other studies (Mai *et al*., 2021). Xu *et al*., (2019) also reported positive response to direct rice seeding in terms of panicle number. In contrast to tiller and panicle number, it was found that, under TPR, panicles were heavier and number of spikelets per panicle was also more as compared to DSR method and increased rate of fertilizer also resulted in heavier panicles with more grains per panicle. Among the varieties, hybrids were found with heavier panicles and more spikelets per panicle as compared to HYVs. Crop establishment method and fertilizer application (integrated crop management options) failed to influence test weight; however, varieties are found to be significantly differed in their test weights.

Effect of crop management options and varieties are significant on the grain yield, and it was found that, wet-DSR method produced numerically less yield (not significant in most of the cases) as compared to transplanted condition. The yield under wet DSR is comparable to transplanted method as there was very less change (mean change of approx. 0.5 t/ha) due to switching from DSR to TPR over three years of experimentation **(Table 2).** Other researchers also reported comparable result in rice grain yield under wet and dry direct sowing in comparison to transplanted rice (Kukal and Aggarwal, 2002; Saha *et al*, 2020). Among the varieties, hybrids produced more yield as compared to HYVs in some instances, however, the trend is not similar throughout the year and establishment methods and yield are comparable in most of the cases **(Table 3).**

Interactive effect of integrative crop management options and varieties are also significant, and on an average, it was found that grain yield reduction of 17.7 per cent in hybrids and 5.0 per cent in the HYVs

Table 2: Effect of crop management (crop establishment methods and fertilizer application) and varieties on yield and yield attributes of rice

Treatments	Tillers/m^2 (no.)			Panicles/m^2 (no.)			Panicle wt. (g)			Spikelets/panicle (no.)			1000- grain wt. (g)			Grain yield (t/ha)		
	2016	2017	2018	**2016**	**2017**	**2018**	2016	2017	2018	**2016**	**2017**	**2018**	2016	2017	2018	**2016**	**2017**	**2018**
Establishment method × Fertilizer																		
TPR 80-40-30	167	236	201	153	208	178	4.67	4.30	4.02	209	137	145	24.9	24.9	24.4	5.69	5.27	4.77
TPR 120-60-30	155	227	205	142	203	184	5.00	4.27	4.16	215	139	152	25.1	25.3	25.4	5.61	5.54	4.89
Wet-DSR 80-40-30	250	266	255	234	229	227	3.25	4.14	3.25	127	129	103	25.7	26.1	24.2	4.99	4.79	4.22
Wet-DSR 120-60-30	231	246	257	209	215	232	3.68	4.18	3.45	135	127	112	25.3	25.9	24.8	5.60	5.15	3.98
CD (0.05)	*42*	*30*	*36*	*39*	*16*	*28*	*0.58*	*ns*	*0.32*	*31*	*ns*	*25*	*ns*	*ns*	*0.4*	*0.69*	*0.57*	*0.62*
Varieties																		
Hazaridhan	207	238	228	195	213	200	4.28	4.20	3.78	147	116	113	28.1	27.8	27.3	5.52	5.32	4.57
Sadabahar	256	275	274	236	250	248	3.28	3.97	3.15	117	109	106	24.9	25.6	24.6	4.83	4.67	3.88
Sahbhagidhan	218	235	236	188	211	210	3.65	4.29	3.49	156	129	117	24.3	25.8	24.3	5.53	5.32	4.55
DRR Dhan 44	184	228	214	161	198	188	4.32	4.37	3.87	202	148	140	24.9	26.4	25.0	5.42	5.04	4.31
PAC 801	178	237	214	166	207	196	4.69	4.40	4.07	192	150	136	25.7	25.3	24.8	5.83	5.43	4.77
PA 6444 Gold	177	253	212	163	220	186	4.69	4.17	3.95	231	144	153	23.3	23.2	22.6	5.72	5.35	4.71
CD (0.05)	*25*	*18*	*28*	*24*	*20*	*18*	*0.61*	*0.27*	*0.42*	*25*	*14*	*16*	*1.5*	*0.8*	*1.1*	*0.65*	*0.42*	*0.58*

Table 3: Interaction effect of crop management and varieties on grain yield of rice

Rice variety	2016				2017				2018			
	T1	T2	T3	T4	**T1**	**T2**	**T3**	**T4**	T1	T2	T3	T4
Hazaridhan	5.91	5.92	4.60	5.64	5.53	5.69	4.79	5.26	5.07	5.12	4.02	4.08
Sadabahar	4.48	4.73	4.78	5.32	4.40	4.85	4.54	4.90	3.58	4.18	4.01	3.76
Sahbhagidhan	5.18	5.37	5.74	5.83	5.47	5.66	4.91	5.22	4.64	4.78	4.66	4.10
DRR Dhan 44	5.34	5.61	5.05	5.69	5.06	5.19	4.82	5.10	4.50	4.64	4.19	3.89
PAC 801	6.86	6.02	4.87	5.57	5.60	5.91	4.90	5.30	5.45	5.28	4.24	4.12
PA 6444 Gold	6.39	6.03	4.91	5.53	5.55	5.96	4.79	5.10	5.39	5.34	4.20	3.92
CD 5%	*1.59*				*0.94*				*0.86*			

Note- T1: *TPR 80-40-30, T2: TPR 120-60-30, T3: Wet-DSR 80-40-30, T4: Wet-DSR 120-60-30*

was noted because of switching of crop establishment method from TPR to DSR. However, between the two fertilizer doses, remarkable response of HYVs was noted under DSR at high dose of fertilizer application. Hybrids used in this study were originally bred for conventional transplanting that might be a reason for less response of hybrids in wet-direct seeding. A higher number of panicles in DSR compared to TPR might have compensated for less test weight and number of grains per panicle (Yadav *et al*., 2021).

Conclusions

From the above finding it was observed that, though the number of grains per panicle was lower in DSR, the increased tiller number compensated the same which turned into comparable grain yield between the transplanted and direct seeding. However, reduction in yield is higher in case of hybrids when shifted from transplanted to DSR as compared to HYVs. Rice varieties/hybrids bred for transplanted condition should not be used for DSR without judging their potential to perform in direct seeded methods. Hence, it can be concluded that in the drought prone rainfed areas HYVs should be preferred for cultivation under DSR over hybrids as there is diminishing scope of transplanted rice.

References

Alam MK, Bell RW, Hasanuzzaman M, Salahin N, Rashid MH, Akter N, Akhter S, Islam MS, Islam S, Naznin S, Anik MFA, Apu MMRB, Saif HB, Alam MJ and Khatun MF. 2020. Rice (*Oryza sativa* L.) Establishment techniques and their implications for soil properties, global warming potential mitigation and crop yields. *Agronomy*, 10: 888.

Cassman KG, Dobermann A and Walters DT. 2002. Agro-ecosystems, nitrogen-use efficiency, and nitrogen management. *AMBIO: A Journal of the Human Environment*, 31: 132–140.

GoI. 2022. Annual report 2021-22; Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India. Pp 303.

IRRI. 2007. Plant establishment. Rice production Manual. International Rice Research Institute, Los Baños, Philippines. Pp 14.

Kukal SS and Aggarwal GC. 2002. Percolation losses of water in relation to puddling intensity and depth in a sandy loam rice (*Oryza sativa*) field. *Agricultural Water Management*, 57: 49-59.

Mai W, Abliz B and Xue X. 2021. Increased number of spikelets per panicle ss the main factor in higher yield of transplanted vs. direct-deeded rice. *Agronomy*, 11: 2479.

Mishra AK, Khanal AR and Pede VO. 2017. Is direct seeded rice a boon for economic performance empirical evidence from India. *Food Policy*, 73: 10-18.

Pathak H, Tripathi R, Jambhulkar NN, Bisen JP and Panda BB. 2020. Eco-regional rice farming for enhancing productivity, profitability, and sustainability. NRRI Research Bulletin No. 22, ICAR-National Rice Research Institute, Cuttack 753006, Odisha, India. pp 28.

Rao AN, Johnson DE, Sivaprasad B, Ladha JK and Mortimer AM. 2007. Weed management in direct-seeded rice. *Advances in Agronomy*, 93:153-255.

Saha S, Tuti MD, Kumar RM, Bandeppa and Singh TV. 2020. Suitability of elite genotypes for wet direct seeding in rice-rice system in Vertisol. *Oryza*, 57: 36-42.

Shultana R, Biswas JC, Mamun MAA and Nahar L. 2016. Fertilizer and weed management options for direct wet seeded rice in dry season. *Bangladesh Rice Journal*, 20: 65-75.

Stocker TF, Qin D, Plattner GK, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V and Midgley PM. 2013. Climate Change 2013: the Physical Science Basis, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.

Thiyagarajan TM and Selvaraju R. 2001. Water saving in rice cultivation in India. *In:* Proceedings of an international workshop on water saving rice production systems. Nanjing University, China, pp.15-45.

Weerakoon WMW, Mutunayake MMP, Bandara C, Rao AN, Bhandari DC and Ladha JK. 2011. Direct-seeded rice culture in Sri Lanka. *Field Crops Research*, 121: 53-63.

Xu L, Li X, Wang X, Xiong D and Wang F. 2019. Comparing the grain yields of direct-seeded and transplanted rice: A Meta-Analysis. *Agronomy*, 9: 767.

Yadav DB, Yadav A, Vats AK, Gill G and Malik RK. 2021. Direct seeded rice in sequence with zero-tillage wheat in north-western India: addressing system-based sustainability issues. *SN Applied Sciences*, 3: 844.