Ann. Agric. Res. New Series Vol. 39 (2) : 135-140 (2018)

Effect of establishment methods and varieties on yield attributes, yield and economics of rice in submergence prone lowland of Eastern India

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Received : December 2017 ; Revised Accepted: May 2018

ABSTRACT

A field study was undertaken to evaluate the establishment methods, and varieties on yield and economics in submergence prone rainfed lowland situation at agriculture farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India during *kharif* seasons of 2014. The experiment was laid out in split plot design and replicated thrice with four crop establishment methods in main plot along with two rice varieties (swarna-sub1 and samba mahsuri-sub1)in sub plot. Remarkable effects were noted under establishment methods and rice verities in terms of yield attributes, yield and economics. The highest yield attributes [panicle / m^2 (282), panicle length (23.2 cm), panicle weight (3.4g), grain / panicle (135) and test weight (19.8g)], grain yield (5.1t / ha), biological yield (11.7 t / ha), net returns (₹ 57.4×10^3 / ha) and B:C (1.47) were recorded with DSR-ZT drill seeding with Sesbania co-culture (brown manuring). Similarly, Swarna-sub1 reported superior to Samba mahsuri-sub1in terms of yield and economics.

Key words: Submergence prone rainfed lowland, growth, yield, establishment methods, economics, rice.

Rice, "Crop of the Millennium" fulfils about 21% of the global energy and protein requirements of the human population and feeds more than half of the world population (McLean *et al.*, 2002). Rainfed lowlands constitute almost 40% of total rice area in India, out of which 84% situated in Eastern India (Reddy *et al.*, 2013). Environmental stresses such as flash floods, drought severely deduct the output in almost every year in rainy and post rainy seasons. Flash flood submergence is the major constraint of rainfed lowland rice in kharif season and excess moisture conditions during post rainy season make the fields unfit for cultivation in these areas. Nearly 10 million hectares of lowlands in Bihar, Orissa and West Bengal are affected with flash flood and water logging (Prasad *et al.*, 1986). It was estimated that the actual yield of rainfed rice in eastern India is 86 per cent lower than its potential farm yield (Dey and Upadhyaya, 1996). The maintenance of optimum plant population is the key to get higher productivity of rice and maintaining optimum plant population is only possible by using appropriate planting techniques (Ghosh and Sharma, 1997). Suitable

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varieties for tolerating flash flood conditions have been introduced in India to replace the local varieties. The most suitable establishment method needs to be evaluated extensively to obtain the maximum grain yield. Suitable varieties for specific location need to be evaluated in order to maximize the return. Therefore this study was planned and executed in search of best establishment method with suitable variety for submergence prone rainfed lowland rice ecosystem of Eastern India.

Materials and Methods

A field experiment was carried out during *kharif* season of 2014-15 at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (India) situated North East plain zone of the country to find out the best rice establishment method with suitable variety for submergence prone rainfed lowland areas. The soil of the experimental site was moderately fertile, low in organic carbon (0.44%), available nitrogen (210.12 kg/ha), and high in available phosphorus (26.2 kg/ha) and medium in potash (208.6 kg/ha). The experiment was laid out in split plot design and replicated thrice using rice varieties Swarna-Sub1 (V_1) and Samba Mahsuri-Sub1 (V_2) as sub-plot treatments and assigning four establishment methods in the main plot (CE_1: puddled transplanted; CE_2: un-puddled transplanted rice; CE_3: direct-seeded rice (DSR-ZT seed drill); and CE_4: DSR (DSR-ZT seed drill) with Sesbania co-culture (brown manuring). A uniform dose of 120 kg N/ha, 60 kg P_2O_5/ha, 60 kg K_2O/ha were applied in all the plots of rice along with zinc sulphate heptahydrate @ 25 kg/ ha. All the N, P_2O_5 and K_2O were applied in the form of Urea, Diammonium phosphate (DAP), Muriate of potash (MOP) respectively. Rice field was subjected to complete submergence with water depth of 1 m after 50 days after direct seeding/15 days after transplanting. The submergence was terminated when the sensitive check Swarna starts showing 70-80% symptoms of damage (severe stress after 17 days of submergence). The effect of establishment methods and varieties were measured in terms of yield attributes, yield and economics of rice. Observations were calculated on yield attributes, grain yield, straw yield and harvest index of rice. The data collected during the course of experimentation were subjected to statistical analysis to draw valid conclusions.

Results and Discussion

Yield attributes

Yield attributes *viz.* panicles/m^2, panicle

Table 1. Effect of establishment methods and varieties on yield attributes and maturity duration of rice in rainfed submergence prone lowland ecosystem.

Treatments	Panicles /m^2	Panicle length (cm)	Panicle weight (g)	Test weight (g)	Grains/ panicle	Fertility (%)	Days to 50% flower	Days to maturity
Crop establishment methods								
CE_1	240.3	21.2	2.7	17.2	123.0	62.0	134.3	169.5
CE_2	278.5	21.8	2.9	16.8	118.9	65.0	134.0	168.5
CE_3	266.8	22.8	3.1	18.6	133.2	83.0	115.7	155.7
CE_4	282.2	23.2	3.4	19.8	135.2	85.7	116.0	158.0
SEm±	6.83	0.54	0.25	0.38	5.50	2.01	0.62	0.93
CD(P=0.05)	23.6	1.9	NS	1.3	NS	7.0	2.2	3.2
Variety								
V_1	272.2	22.8	3.1	19.5	133.2	76.7	128.5	165.8
V_2	261.8	21.6	2.9	16.8	121.9	71.2	121.5	160.1
SEm±	6.84	0.36	0.18	0.18	4.61	0.88	0.37	0.75
CD(P=0.05)	NS	NS	NS	0.6	NS	2.9	1.2	2.4

CE_1- Puddled transplanted rice; CE_2-un-puddled transplanted rice; CE_3- DSR-ZT seed drill; CE_4-DSR-ZT seed drill with co-culture *Sesbania* (brown manuring);V_1-Swarna-Sub1; V_2- Samba Mahsuri-Sub1.

length (cm), grains / panicle, panicle weight (g) and test weight (g) were significantly influenced by different crop establishment methods (Table 1). The highest number of panicles (282 / m^2) was recorded with DSR-ZT drill seeding with co-culture Sesbania (brown manuring) *i.e.* CE_4 which was significantly higher than CE_1. However CE_2 (278.5) and CE_3 (266.8) were recorded at par with CE_4. While among varieties there is non-significant difference were found for all yield attributes except test weight. It is due to low mortality rate and synchronized tillering in DSR than transplanted rice. Singh *et al.* (2005); Jat *et al.* (2014) also showed similar results with more panicles / m^2 in DSR than transplanted rice. Panicle length of the establishment methods did not differ significantly, although CE_4 produced longest panicles (23.2 cm), while it was found statistically at par with both varieties. Gill *et al.* (2006); Shekhar and Singh (1991) also found that the panicle length did not differ significantly on account of method of establishment methods. Whereas, panicle weight was significantly heaviest (3.4g) recorded with CE_4 which was at par with CE_3 (3.1g) but differed significantly with CE_2 (2.9g) and CE_1 (2.7g). This result is in conformity with Gangwar *et al.* (2005).The maximum 1000 grain weight was also recorded with CE_4 (19.8 g), however it was at par with CE_3 (18.6g). Low vigour and less nutrition to panicles of transplanted rice might result in reduced grain weight. Gangwar *et al.* (2005) also showed maximum test weight with drill seeding. Among the both varieties Swarna-sub1 recorded significantly maximum test weight (19.5g) than Samba Mahsuri-sub1 (16.8 g). Number of grains / panicle recorded non-significant variations among the establishment methods, however CE_4 had the highest number (135.2) of grains / panicle which was followed by CE_3 (133.2), CE_2 (118.9) CE_1 (123). Among the verities Swarna-sub1 had 133.2 grains / panicle, which was statistically at par with Samba Mahsuri-sub1 which attained 121.9 grains / panicle. CE_4 had maximum fertility per cent (85.7%). Longer crop growth duration in transplanted crop rendered more infertile spikelets. CE_3 and CE_4 took at least fifteen days less to flower and matured at least 10 days earlier than transplanted methods. This was due to better root establishment from the day of germination and lack of transplanting shock leads to 12 days early maturity than transplanted rice. The rate of tillering, leaf area expansion, N uptake and dry matter accumulation during the vegetative stage were considerably more rapid in DSR than in transplanted rice. Here in lowland condition initial submergence shock along with transplanting shock further lengthened the

Table 2. Effect of establishment methods and varieties on yields of rice in rainfed submergence prone lowland.

Treatments	Yields			
	Grain yield (t / ha)	Straw yield (t / ha)	Biological yield (t / ha)	Harvest Index (%)
Crop establishment method				
CE_1	3.1	3.1	6.2	49.7
CE_2	3.4	3.9	7.3	46.8
CE_3	4.9	5.8	10.7	45.8
CE_4	5.1	6.6	11.7	43.9
SEm±	0.10	0.11	1.50	0.39
CD(P=0.05)	0.3	0.4	0.20	1.4
Variety				
V_1	4.3	5.0	9.3	46.3
V_2	4.0	4.6	8.6	46.6
SEm±	0.08	0.05	0.11	0.48
CD(P=0.05)	0.3	0.2	0.3	1.6

CE_1- Puddled transplanted rice; CE_2-un-puddled transplanted rice; CE_3- DSR-ZT seed drill; CE_4-DSR-ZT seed drill with co-culture *Sesbania* (brown manuring); V_1-Swarna-Sub1; V_2- Samba Mahsuri-Sub1.

duration of the crop. Budhar and Tamilselvan (2002); Wang and Sun, 1990; Sharma *et al.* (2005) also found similar results. Gill (2008) and Peng *et al.* (2001) also concluded that direct seeding of rice results in early maturity and short the crop duration than transplanted rice.

Yield and harvest index

Perusal of data (Table 2) showed that DSR-ZT drill seeding with co-culture Sesbania (brown manuring) *i.e.* CE_4 records the productivity in terms of grain, straw and biological yield and found significantly superior over CE_2 and CE_1. It might be due to yield attributes like panicle/m^2, panicle length, panicle weight, 1000 grain weight were superior with direct sowing of rice which resulted better yield. Both varieties were statistically at par with grain yield but Swarna sub 1 recorded significantly higher straw and biological yield over Samba mahsuri sub1 (V_2). Higher grain yield in V_1 than V_2 might be due to its early stand and better submergence tolerance. Robust growth and optimum plant stand due adequate slow released nutrients from decomposing Sesbania in CE_4 treatment helped the plants to grow luxuriantly which resulted in maximum biological as well as economic yield. CE_1 recorded significantly highest per cent harvest index (49.7%) followed by CE_2 (46.8%), CE (45.8%) and CE_4 (43.9%). It might be due to very poor vegetative growth all through the period and repeated stresses made it unable to produce sufficient vegetative growth, but ambient environment after flowering helped the plants to transform more flowers fertile. Gathala *et al.* (2010); Singh and Singh (1993) reported similar results.There was no significant variation between the varieties in terms of harvest index per cent was found.

Economics

Among the establishment methods, CE_1 recorded the highest cost of cultivation (₹ 50.2 × 10^3/ha) which was due to more labor required for transplanting in CE_1. The highest gross income (₹ 96.3×10^3/ha), net return (₹ 57.7×10^3/ha) and B:C (1.47) was obtained with CE_4 which was significantly higher than all other establishment methods. The next highest gross return, net return and B:C ratio was recorded with CE_3 and also found significantly superior over CE_1 & CE_2. The least gross, net return and B:C ratios was recorded with both transplanted rice CE_1 & CE_2. The variation in cost of cultivation was recorded to different establishment methods. Transplanting methods required higher costs due to extra

Table 3. Effects of establishment methods and varieties on economics of rice in rainfed submergence prone lowland.

Treatments	Economics			
	Cost of cultivation (₹ ×10^3/ha)	Gross return (₹ ×10^3/ha)	Net return (₹ × 10^3/ha)	B:C ratio
Crop establishment method				
CE_1	50.2	54.1	3.9	0.08
CE_2	46.6	62.1	15.5	0.33
CE_3	38.9	89.1	50.1	1.29
CE_4	39.9	96.3	56.9	1.42
SEm±		1.6	1.6	0.04
CD(P=0.05)		5.7	5.7	0.13
Variety				
V_1	43.5	76.4	32.9	0.82
V_2	43.7	74.4	30.6	0.77
SEm±		1.10	1.10	0.02
CD(P=0.05)		3.60	3.60	0.08

CE_1- Puddled transplanted rice; CE_2-un-puddled transplanted rice; CE_3- DSR-ZT seed drill; CE_4-DSR-ZT seed drill with co-culture *Sesbania* (brown manuring); V_1-Swarna-Sub1; V_2- Samba Mahsuri-Sub1.

nursery raising, puddling operation and costly labour inputs for transplanting the seedlings than DSR. Higher crop yield from DSR fetched higher gross return than transplanting. There was non-significant difference between the varieties in terms of economic traits. However, Swarna-sub1 had produced higher gross-return, net return and B:C ratio than Samba mahsuri-sub1.

Conclusion

Based on the results obtained from the above experiment, the establishment method, consisting of DSR-ZT seed drill with co-culture Sesbania (brown manuring), and ZT-DSR with Sub-mergence tolerance variety are recommended for enhancing productivity and profitability of rice in Eastern India.

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