On-farm Performance Evaluation of Aerobic Rice Technologies and Its Impact[1]

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Abstract :

The On-farm Performance Evaluations of Aerobic Rice Technologies were conducted at Triveni in Bara and Sibarwa in Parsa district during kharif seasons, 2003/04, 2004/05, and 2005/06. The experiments consisted of three treatments e.g. (T_1)= Direct Seeded Rice (DSR) by Power Tiller Drill (PTD), (T_2)=Direct Seeded Rice by Zero-till Drill (ZTD), and (T_3)= Farmer's Practice (F.P.). Rice variety Hardinath-1 was drilled with PTD and ZTD @ 40 kg/ha on June 11, 2004, June 21-22, 2005, and May 30- June 3, 2006 on pre-ploughed but unpuddled fields. The treatments were nourished with 100:60:40::N:P_2O_5:K_2O kg/ha. Pre-emergence herbicide, Pretilachlor was applied @ 1250 ml/ha. For Farmer's Practice (F.P.), 25- day old seedlings were transplanted on puddled soil. Treatment T_1 produced the highest mean grain yield of 5287 kg/ha followed by T_2 (4642 kg/ha) and T_3 (4265 kg/ha). Similarly, the highest mean straw yield of 6383 kg/ha was observed with treatment T_1. Likewise, treatment T_1 was the most economical and showed the mean Net Return of 30263 Rs/ha followed by T_2 (20282 Rs/ha). Farmer's Practice showed the least Net Return of 18863 Rs/ha. With Farmer's management, T_2 produced the highest mean rice yield of 5872 kg/ha followed by T_1 (5617 kg/ha). The mean lowest grain yield of 5044 kg/ha was obtained by T_3, while, the mean rice establishment costs of T_1, T_2 and T_3 were 3162, 3928, and 6304 Rs/ha, respectively.

Introduction :

The rice – wheat system is a predominant cropping system of the Indo-Gangetic Plains (IGP), where rice is traditionally grown by transplanting 4 – 6 weeks old seedlings into puddled fields. Puddling is achieved by ploughing under ponded water conditions. Puddling is a soil management operation that reduces soil permeability, controls weeds, facilitates transplanting of rice seedlings, and reduces the deep percolation losses of water to maintain anaerobic conditions that increase the availability of the iron, zinc, and phosphorus required for the growth of rice. At the other hand, studies indicate that nearly 30% of the total water used (1400 -1600 mm.) in rice culture is consumed mainly in puddling and transplanting operations. Poor-quality irrigation systems and greater reliance on groundwater have led to water tables declining by 0.1 to 1.0 m per year, leading to higher costs of pumping from

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deep aquifers and aggravating the energy crisis in many parts of the Indo-Gangetic Plains. Similarly, continued puddling over decades has led to deterioration in soil physical properties through structural breakdown of soil aggregates and capillary pores and clay dispersion. As well as, puddling forms a compacted layer (plough pan) that restricts the percolation of water causing temporary water logging and restricted root penetration and growth for succeeding crops after rice.

Transplanting operations are usually performed by labor which has an element of seasonality and becoming a serious concern for the timely transplanting of rice and maintaining a sufficient plant population (33 and 44 hills/m^2 in timely and delayed transplanting, respectively).

Direct Seeded Rice (DSR) covers 26% and 28% of the total rice area in South Asia and India, respectively (Pandey and Velasco,1999). In Nepal about 10% rice area is under direct seeding. Minimum –tillage reduces costs in direct seeded and transplanted rice because of less labor cost for hand weeding and land preparation (Buchrein et.al., 2002).

Direct seeded rice avoids puddling and does not need continuous submergence thus reducing the overall water demand for rice culture. Directed Seeded Rice matures 2-3 weeks earlier with higher number of tillers and panicles/m^2 mainly due to higher seed rate.

Direct Seeding of rice as a means of crop establishment is now recognized as a viable alternative to transplanting. It requires less labor and is less costly. However, it is constrained by heavy weed infestation which reduces yield by 15-70%. The system can be sustained only if it is accompanied by effective and low cost weed control system that is free of phytotoxicity and pollution of the aquatic system (John and Mathew, 2001).

Non-puddled transplanted or directed seeded rice is grown with zero-till or reduced till and are potentially important for many areas across the Indo-Gangetic Plains. Zero-till reduces cost of plow, increases yields, reduces weed population, avoids soil cracking, and saves irrigation water by 20%. Reduced till is useful where weeds carryover to the next wheat crop. Zero and reduced till reduce soil erosion and other forms of soil degradation. In direct seeded rice, the crops are able to utilize the nitrates lost when soils are puddled (Hobbs, 2003).

Materials and Methods :

The On-farm Performance Evaluations on Aerobic Rice Technologies were conducted at Triveni, Bara district and Sibarwa in Parsa district, during Kharif Seasons 2003/04, 2004/05, and 2005/06. The studies consisted of three treatments e.g. T_1=Direct Seeded Rice by Power Tiller Drill (DSR by PTD), T_2= Direct Seeded Rice by Zero-till Drill (DSR by ZTD), and T_3= Farmer's Practice (F.P.). For all the treatments, fields were ploughed two times (dry), first after wheat harvest and second at the start of monsoon, double passes each time with 9tine cultivator. For T_3, fields were further puddled with 9-tine cultivator and were leveled by planking.

Direct Seed (dry) drillings, on unpuddled soil, were done for T_1 and T_2, while, 25 day-old seedlings were transplanted on puddled fields for T_3. Adopted seed rate for T_1 and T_2 was 30 kg/ha, while, it was 60 kg/ha for T_3 (Table 1). Rice variety Hardinath-1 was chosen for the studies. Seed drillings were accomplished on June 11, 2004, June 21-25, 2005 and May 30- June 3, 2006. The crops were nourished with 100:30:30::N:P_2O_5:K_2O kg/ha (2003/04) and 100:60:40::N:P_2O_5:K_2O kg/ha (2004/05 & 2005/06) in the form of DAP+ Urea+ M/P (Table 1). Out of them, 50% N+ full doze of Phosphorus+ full doze of Potash were applied at sowing/transplanting time. Remaining N were applied in two equal dozes as top dressings. First and second top-dressings were done on 25 DAS and 50 DAS, respectively. For treatment T_2, DAP was drilled with the ZTD, while, Urea and M/P were broadcasted. For T_1 and T_3, DAP+ Urea + M/P were all broadcasted. Seed drillings were done at sufficient soil-moisture. After seeding, Pre-emergence Herbicide, Pretilachlor was sprayed @1250 ml/ha within 72 hrs of sowing. At maturity, samples were harvested.

Table 1: Rice Variety, Seed Rate and Seeding Date for DSR during 2003/04, 2004/05, & 2005/06.

Particular		Year		
		2003/04	2004/05	2005/06
Variety		Hardinath-1	Hardinath-1	Hardinath-1
Seed Rate (kg/ha)	T_1	40	40	40
	T_2	40	40	-
	T_3	60	60	60
Seeding Date		June11, 2004	June21-22, 2005	May30-June1,2006
Total Fertilizers Used ($N:P_2O_5:K_2O$ kg/ha)		100:30:30	100:60:40	100:60:40
Herbicide Used (1250 ml /ha)		Pretilachlor	Pretilachlor	Pretilachlor

Results and Discussions:

Grain Yields:

During 2003/04, the grain yields were significant at 5% level. The highest grain yield of 5541 kg/ha was received with Direct Seeded Rice by Power Tiller Drill (T_1) followed by Farmer's Practice (T_3) i.e. transplanted rice (4461 kg/ha). Direct Seeded Rice by Zero-till Drill (T_2) produced the lowest grain yield of 4210 kg/ha (Table 2). During 2004/05, the grain yields were significant at 1% level. The highest grain yield of 5255 kg/ha was obtained with DSR by PTD (T_1) followed by DSR by ZTD (T_2) of 5074 kg/ha. The lowest grain yield of 4200 kg/ha was obtained by Farmer's Practice/Transplanted rice (T_3). During 2005/06, the grain yields were significant at 1% level. The highest grain yield of 5065 kg/ha was obtained with DSR by PTD (T_1), while, it was the lowest with the Farmer's Practice (T_3), 4133 kg/ha (Table 2).

The highest mean grain yield of 5287 kg/ha was obtained with DSR by PTD (T_1) followed by DSR by ZTD (T_2) (4642 kg/ha). The Farmer's Practice (T_3) was the lowest grain yielder of 4265 kg/ha, over the years (Table 2). The mean grain yields with T_1, T_2 and T_3 are supported by Effective Tillers/m^2 and Thousand Grain Weights (Table 3).

Straw Yields:

During all the years, the straw yields were significant at 1% level. The highest mean straw yield of 6363 kg/ha was observed with Direct Seeded Rice by Power Tiller Drill (T_1) followed by Farmer's Practice (T_3) of 5889 kg/ha. The lowest mean straw yield of 5680 kg/ha was found with Direct Seeded Rice by Zero-till Drill (T_2) (Table 2). The straw yields by T_1, T_2 and T_3 are supported with No. of Effective Tillers/m^2 (Table 3).

No. of Effective Tillers/m^2:

During 2003/04 and 2004/05, the No. of Effective Tillers/m^2 were significant at 1% level, while, during 2005/06, they were at par, statistically. In all the years, Direct Seeded Rice by Power Tiller Drill and Zero-till Drill were higher compared to Farmer's Practice. Over the years, DSR by PTD (T_1) showed the highest mean No. of Effective Tillers/m^2 of 290 followed by DSR by ZTD (T_2) of 270, while, F.P. (T_3) had the lowest value of 238. The higher the effective tillers/m^2, the higher was the yield observed.

Thousand Grain Weight :

During first and second year, the thousand grain weights (TGW) were significant at 1% level, while, they were at par during the last year. The highest mean TGW of 22.17gm was found with DSR by PTD (T_1) followed by DSR by ZTD (T_2) 21.96 gm. The lowest mean TGW of 21.87 gm was found with F.P. (T_3) (Table 3). The TGW had positive responses on the mean grain yields (Table 2).

No. of Grains/Panicle:

During first year, the No. of Grains/Panicle were significant at 1% level. While, they were significant at 5% level during second year and were at par during the third year. The highest mean grains/panicle of 128.3 was found with Farmer's Practice (T_3) followed by DSR by ZTD (T_2) of 113.5 . The lowest Grains/Panicle of 103.3 was observed with DSR by PTD (T_1) (Table3).

Unfilled Grains/Panicle :

Over the years, the mean unfilled grains per panicle with T_2, T_1 and T_3 were 24.5, 19.5 and 13.0, respectively (Table 3).

Table 2: Influence of Direct Seeded Rice Technologies on Grain and Straw Yields at Farmer's Field

Treatment	Grain Yield at 14% m.c. (kg/ha)				Straw Yield (kg/ha)			
	2003/04	**2004/05**	**2005/06**	**Mean**	**2003/04**	**2004/05**	**2005/06**	**Mean**
Direct Seeded Rice by Power Tiller Drill (T_1)	5541	5255	5065	5287	5809	6502	6839	6383
Direct Seeded Rice by Zero-till Drill (T_2)	4210	5074	-	4642	4344	7016	-	5680
Farmer's Practice (T_3)	4461	4200	4133	4265	7496	4986	5186	5889
F- test (Tr.)	0.0202 (S)	0.0008 (HS)	0.002 (HS)	-	0.00 (HS)	0.0005 (HS)	0.001 (HS)	-
CV (%)	10.45	13	13.9	-	9.28	18.0	9	-
LSD 0.05	789.7	561.9	1279	-	1012.9	981.9	683.8	-

S= Significant at 5% level
HS= Significant at 1 % level
NS= Not Signific

Table 3 : Influence of Direct Seeded Rice Technologies on Yield Attributes at Farmer's Fields

Treatment	No. of Effective Tillers/m^2				1000 Grain Weight (gm)				No. of grains/Panicle				No. of unfilled Grains/Panicle			
	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean
Direct Seeded Rice by PTD (T_1)	248	313	309	290	23.3	21.5	21.7	22.17	102	95	113	103.3	18	21	-	19.5
Direct Seeded Rice by ZTD (T_2)	214	326	-	270	22.45	21.48	-	21.96	124	103	-	113.5	19	30	-	24.5
Farmer's Practice (T_3)	174	247	293	238	21.5	22.37	21.75	21.87	155	113	117	128.3	14	12	-	13
F- test (Tr.)	0.0001 (HS)	0.0012 (HS)	0.339 (NS)	-	0.0002 (HS)	0.0061 (HS)	(NS)	-	0.0001 (HS)	0.0156 (S)	(NS)	-	0.3065 (NS)	0.0001 (HS)	-	-
C.V. (%)	6.14	14	11.6	-	2.2	4.02	4.02	-	7.7	10.96	17.5	-	34	33.4	-	-
LSD 0.05	20.19	39	-	-	0.8	0.8	-	-	16.5	11	-	-	10.1	7	-	-

S= Significant at 5% level
HS= Significant at 1 % level
NS= Not Significant.

Table 4: Economic Returns of Direct Seeded Rice Technologies in Farmer's Fields

Particulars	Direct Seeded Rice by PTD				Direct Seeded Rice by ZTD				Farmer's Practice			
	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean
Gross Return from Grain and Straw (Rs./ha)	51323	43662	47301	47429	38975	42348	-	40661	42027	34847	38498	38457
Land Preparation Cost (Rs./ha)	2646	2250	2250	2382	2646	2250	-	2448	3850	4125	4125	4033
Seeding/Transplanting Cost (Rs./ha)	717	769	853	780	1481	1579	-	1530	2271	2271	2271	2271
Total Production Cost (Rs./ha)	18067	18478	14950	17165	21651	19108	-	20380	20071	21080	17632	19594
Net Return (Rs./ha)	33255	25184	32351	30263	17323	23240	-	20282	21956	13767	20867	18863
Change in Net Return over F.P. (%)	51	15	55	60	21 (-)	59	-	7	-	-	-	-

Table 5: Area Coverage Direct Seeded Rice Adoption on Grain and Straw Yields

Particulars	Direct Seeded Rice by PTD				Direct Seeded Rice by ZTD				Farmer's Practice			
	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean
No. of Beneficiary	3	7	13		2	1	9		-	-	-	-
District	Parsa Bara Rautahat	Parsa Dhanusha	Parsa Bara		Parsa	Parsa	Parsa Bara		Parsa Bara Rautahat	Parsa Dhanusha	Parsa Bara	
Seeding Date	May31-June5, 2004	June 21-22, 2005	May28 - June 3, 2006		May 31, 2004	June 21-22, 2005	May 29-June 2, 2006				-	
Area Covered (ha)	6	6.5	13		4	3.5	10.4				-	
Variety	Hardi nath-1	Hardi nath-1	Hardi nath-1		Sona Masuli	Sona Masuli	Sona Masuli		Sona Masuli Hardi nath-1	Sona Masuli	-	
Seed Rate (kg/ha)	40	45	40	41.7	37	45	33	38.3	60	60	-	60
N:P_2O_5: K_2O (kg/ha)	46:21:0	100:60:40	100:60 :40	82:47: 27	101:48: 24	52:48:2 4	100:60:40	84:52 :29	101:48: 24** 60:30:0 *	52:48:24**	-	76:48:24** 80:39:12 *

*= Hardinath-1 (BG1442)

**= Sona Masuli

Table 7: Establishment Cost of Direct Seeded Rice Technology Adoption

Particulars	Direct Seeded Rice by PTD				Direct Seeded Rice by ZTD				Farmer's Practice			
	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean
Land Preparation Cost (Rs./ha)	2646	2250	2250	2250	2646	2250	2250	2382	2646	2250	2250	2382
Puddling Cost (Rs/ha)	-	-	-	-	-	-	-	-	1200	1875	1875	1651
Seeding/Transplanting Cost (Rs./ha)	717	769	853	780	1481	1579	1579	1546	2271	2271	2271	2271
Total Establishment Cost (Rs./ha)	3363	3019	3103	3162	4127	3829	3829	3928	6121	6396	6396	6304

Economics :

Direct Seeded Rice by Power Tiller Drill (T_1) was the most profitable among the treatments. In all the years, the Net Returns by (T_1) were higher compared to Farmer's Practice (T_3) and Direct Seeded Rice by Zero-till Drill (T_2). As the establishment costs were lower and productions were higher, the Net Returns were higher with (T_1) compared to DSR by ZTD (T_2), and Farmer's Practice (T_3). Over the years, the mean establishment cost of 3162 Rs/ha, 3978 Rs/ha and 6304 Rs/ha were found with treatments T_1, T_2 , and T_3 , respectively. Similarly, the mean total production costs of 17165 Rs/ha, 20380 Rs/ha and 19594 Rs/ha were observed with T_1, T_2, and T_3, respectively, over the years. Therefore, the mean Net Returns of 30263 Rs/ha, 20282 Rs/ha, and 18863 Rs/ha were observed with T_1, T_2 and T_3, respectively (Table 4).

Thus, Direct Seeded Rice by Power Tiller Drill (T_1) showed 60% and 49% higher Net Return compared to F.P. (T_3) and Direct Seeded Rice by Zero-till Drill (T_2), respectively. Though, not much, Direct Seeded Rice by ZTD (T_2) showed 7% higher Net Return than Farmer's Practice (T_3) (Table 4).

Impacts among farming community:

Influenced by the on-farm Evaluations of the Aerobic Rice at the sites, three farmers in Parsa, Bara, and Rautahat districts adopted Direct Seeded Rice by Power Tiller Drill (T_1) on an area of 6 ha and Direct Seeded Rice by Zero-till Drill (T_2) by two farmers on an area of 4 ha in Parsa district, during 2003/04. During 2004/05, DSR by PTD (T_1) and DSR by ZTD (T_2) were adopted on 6.5 ha and 3.5 ha by 7 farmers and 1 farmer, respectively. Similarly, during 2005/06, DSR by PTD (T_1) and DSR by ZTD (T_2) were adopted by 13 farmers and 9 farmers on an area of 13 ha and 10.4 ha, respectively. Over the years, varieties adopted for DSR by PTD (T_1) and DSR by ZTD (T_2) were Hardinath-1 and Sona Masuli. Seed rate of 41.7 kg/ha and 38.3 kg/ha were chosen for (T_1) and (T_2), respectively. While, for Farmer's Practice/Transplanting, it was 60 kg/ha. The mean total fertilizers applied for (T_1),(T_2), and (T_3) were 82:47:27, 84:52:29, and 76:48:24 :: $N:P_2O_5:K_2O$ kg/ha, respectively (Table 5).

Over the years, the mean grain yield with DSR by PTD (T_1) was 5617 kg/ha compared to Farmer's Practice (T_3) of 4303 kg/ha (with Hardinath-1). Similarly, the mean grain yield with DSR by ZTD

(T_2) was observed to be 5872 kg/ha compared to F.P. (T_3) of 5532 kg/ha (with Sona Masuli) (Table 6). While, the mean crop establishment costs of (T_1), (T_2), and (T_3) were 3162 Rs/ha, 3928 Rs/ha, and 6304 Rs/ha, respectively (Table 7).

Table 6: Effect of Direct Seeded Rice Technology Adoption on Grain and Straw Yields (2003/04 to 2005/06)

Treatment	Grain Yield (kg/ha)				Straw Yield (kg/ha)			
	2003/04	2004/05	2005/06	Mean	2003/04	2004/05	2005/06	Mean
Direct Seeded Rice by PTD (T_1)	5113* (3)	5837* (5)	5902* (7)	5617*	4276*	8875*	7833*	6995*
Direct Seeded Rice by ZTD (T_2)	5785** (2)	6000** (1)	5831** (4)	5872**	5715**	5750**	7598**	6354**
Farmer's Practice (T_3)	3542* 5537**	- 5528**	5065* -	4303* 5532**	3549* 6337**	- 7094**	7184* -	5366* 6715**

*= Hardinath-1 (BG1442)
**= Sona Masuli

Conclusion:

It is obvious from the above results that Direct Seeded Rice Technologies were more beneficial than the traditional rice transplanting method. Direct Seeded Rice by PTD (T_1) produced 24% higher grain yield (5287 kg/ha) compared to transplanted rice/ Farmer's Practice (T_3) of 4265 kg/ha. Similarly, rice establishment cost of 3162 Rs/ha was observed with DSR by PTD (T_1) compared to 6304 Rs/ha with F.P. (T_3). Thus, 60% higher Net Return of 30263 Rs/ha was found with T_1 over F.P. T_3. Likewise, Direct Seeded Rice by Zero-till Drill (T_2) showed 9% higher grain yield (4642 kg/ha) compared to F.P. (4265 kg/ha). It was found that the Net Return was 7% higher with (T_2) compared to (T_3). Seed saving of 20 kg/ha was the additional benefit by DSR.. In farmer's managed condition, (T_1) and (T_2) produced higher rice yields than (T_3) by 30% (Hardinath-1) and 6% (Sona Masuli), respectively.

It was also found that Direct Seeded Rice (DSR) matured 3 weeks earlier than transplanted rice enabling the farmers for early planting of succeeding crops i.e. vegetables or winter crops.

It had positive impacts among farming community and some farmers adopted DSR Technologies. Farmers were benefited with higher yields, less costs and lowered drudgery of transplanting. Therefore, scaling-up of DSR should be highly focused with proper weed and water management.

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THANK YOU