

Effect of deep ploughing and land leveling on rice productivity in canal commands of Western Orissa

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ABSTRACT

Experiments were conducted in farmers' fields during wet (2001 and 2002) and dry (2001-02, 2002-03) seasons in three different irrigation commands (Hirakud, Hariharajore and Pitamahal) in Western Orissa to study the effect of land leveling with and without deep ploughing on productivity of rice. Data revealed that deep ploughing followed by puddling and proper land leveling resulted in significant increase in rice grain yield (ranging from 38.0 to 45.6 q ha⁻¹ in wet season and 42.0 to 44.0 q ha⁻¹ in dry season) in all the locations during both the seasons but it was at par with ploughing with country plough followed by puddling and proper land leveling in Hirakud and Hariharajore locations during kharif. Economic analysis also revealed that net return (Rs. 6127 ha⁻¹ in wet season and Rs.7039 in dry season) and net return rupee⁻¹ invested (0.51 in wet season and 0.64 in dry season) were also the highest in deep ploughing followed by puddling and proper land leveling irrespective of locations. This practice proved more beneficial at Pitamahal where problem of iron toxicity of soil got decreased. However, usual ploughing with country plough followed by puddling along with proper leveling was adjudged to be most cost effective treatment across locations and seasons with a figure of more than Rs.4.00 of additional return per every additional rupee invested.

Key words: Land preparation, deep ploughing, rice yield, Orissa

The command area of irrigation projects in Orissa consist of canal net works, a major portion of which is unlined causing continuous seepage during operation period. In addition, field to field irrigation without adequate control over water also leads to excessive water use. Farmers, therefore, have adopted continuous rice cropping in *berna* (medium land) and *bahal* (low land) lands. As fields do not come to workable condition after the wet season rice, the farmer is left with no other option than direct puddling and transplanting the rice crop in dry season. Use of cage wheel for puddling in such intensively rice cropped canal commands brings about formation of hard pan in the plough sole layer preventing drainage by percolation. Deep ploughing helps to break the hard pan, promotes drainage through percolation and brings improvement in crop productivity. Profile studies in canal irrigated (Village-Kujapalli) and unirrigated (Village-Kendupalli) areas in this agroclimatic zone have indicated that the soils of irrigated villages have become angular and sub angular blocky and have shown presence of a compact layer at sub surface depths due to migration of finer

particles down the profile (Gulati, 1995). Naphade and Ghildayal (1971) and Ghildayal (1985) working on laterite sandy clay loam soil have reported that puddling reduces non capillary pore space, disintegrates soil aggregates and results in a closer packing of soil particles leading to a decreased percolation of water. Kumar (2000) also found lower value of bulk density under conventional tillage with wheat-rice cropping system. Improper land leveling is observed to be responsible for accumulation of uneven depth of irrigation water leading to non uniform crop stand in the fields and excessive weed growth. These factors have adverse effect on rice productivity and yield plateauing has been observed in many canal command areas in spite of high input use. Singh *et al.* (1988) reported that, irrigation water to the tune of 50 per cent can be saved if applied in leveled plots as compared to undulating plots. The practice of leveling helped in proper distribution of water in the field and thereby brought about uniformity in crop stand. Keeping this in view, the present study was undertaken to investigate

the effect of land preparation on growth and yield of rice in farmers' fields in different irrigation commands of Western Orissa.

MATERIALS AND METHODS

Experiments were conducted in farmers' fields during wet (2001 and 2002) and dry (2001-02 and 2002-03) seasons in three different irrigation commands, such as Hirakud (District: Sambalpur), Hariharajore (District: Sonepur) and Pitamahal (District: Sundargarh). The mean annual rainfall of these commands was 1428, 1525 and 1602 mm, respectively. The soil texture in the surface ranged from sandy loam to sandy clay loam. The treatments consisted of ploughing with country (wooden) plough followed by puddling and proper land leveling using bullock drawn wooden plank (T_1), deep ploughing with the help of bullock drawn mould board plough to a depth of about 20 cm followed by puddling and proper leveling with bullock drawn plank (T_2) and farmers' practice as control (T_3). Usually farmers resort to shallow depth of ploughing with country wooden plough followed by puddling and improper leveling with wooden plank. The treatments were tried in a randomized block design with seven replications.

The details of the experiment with respect to location, area covered, rice varieties grown and planting dates are presented in Table 1. A uniform dose of N, P, and K was applied at the rate of 80, 17.8, and 33.2 kg ha⁻¹ in the form of urea, single superphosphate and muriate of potash, respectively. Data on grain yield of rice were collected and analyzed separately for each command in different seasons by standard procedure (Panse and Sukhatame, 1985). Economics of different

treatments and net return rupee⁻¹ invested was worked out. Farmer's opinion during the course of investigation was also collected.

RESULTS AND DISCUSSION

Grain yield of rice (Table 2) ranged from 3.35 to 4.11 t ha⁻¹ in wet season and 3.73 to 3.88 t ha⁻¹ in dry season across the locations and varieties under farmers' practice (T_3). Ploughing with country plough followed by puddling and proper land leveling (T_1) increased the grain yield significantly over the farmers' practice in both the seasons irrespective of varieties in most of the locations with yield ranging from 3.60 to 4.38 t ha⁻¹ in wet and 3.97 to 4.15 t ha⁻¹ in dry seasons. The yield improvement under this treatment however, was in the range of 6.6 to 8.8 per cent in wet and 4.0 to 7.0 per cent in dry seasons which is in line with the observation of Mathankar *et al* (2003) who reported that 20 per cent increase in yield could be achieved in precisely leveled fields. The practice of leveling helped in proper distribution of water in the field and thereby brought about uniformity in crop stand. Walker *et al* (2003) observed that soil with precision land leveling showed more desirable flooding and drainage characteristics, favoured in maintenance of optimum flood depth, helped to increase nutrient availability and reduced weed menace which ultimately increased the rice yield. Deep ploughing followed by puddling and proper leveling (T_2) showed further increase in grain yield at all the locations irrespective of seasons and varieties grown (Table 2). The increase in grain yield, however, was significant in both the seasons in most of the locations. The yield improvement with deep

Table 1. Experimental details in different locations of Western Orissa

	Canal command						
	Hirakud		Hariharajore			Pitamahal	
Season	Wet season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season
Year	2001	2001	2001-02	2002	2001-02	2002	2002-03
Village	Malgund	Redom	Redom	Redom	Balanda	Balanda, Kalunga	Balanda, Kalunga
Block	Maneswar	Ulunda	Ulunda	Ulunda	Lathikata	Lathikata	Lathikata
Area (ha)	2.5	1.0	1.0	1.0	2.72	2.72	1.56
Rice variety	Lalat	Swarna	Lalat	Utkal Prava	Khandagiri	Lalat	Khandagiri
Duration (days)	120	135	120	155	105	120	105
Date of planting	25.07.01	9.8.01	20.2.02	14.8.02	5.2.02	28.7.02	15.1.03

Table 2. Effect of different treatments on grain yield of rice (t ha⁻¹)

	Hirakud		Hariharajore		Pitamahal	Hariharajore		Pitamahal	
	Wet season	Wet season	Wet season	Mean	Wet season	Dry season	Dry season	Dry season	Mean
Treatments	2001	2001	2002		2002	2001-02	2001-02	2002-03	
T ₁	43.79 (6.6)	35.98 (7.34)	36.68 (8.75)	36.33 (7.58)	41.80 (7.46)	41.50 (6.96)	38.80 (4.02)	39.65 (5.17)	39.22 (4.58)
T ₂	44.73 (8.90)	38.28 (14.20)	37.64 (11.59)	37.96 (12.88)	45.60 (17.22)	43.90 (13.14)	41.40 (10.99)	42.35 (12.33)	41.88 (11.68)
T ₃	41.07	33.52	33.73	33.63	38.90	38.80	37.30	37.70	37.50
CD (P=0.05)	1.94	1.26	N.S	1.44	0.70	1.47	1.04	1.24	0.64

N.B.: Values in parenthesis indicate per cent increase over T₃

T₁ = Ploughing with *desi* plough followed by puddling and proper land leveling using bullock drawn wooden plank

T₂ = Deep ploughing with bullock drawn M.B. plough up to a depth of 20 cm followed by puddling and proper land leveling

T₃ = Farmers' practice (Shallow ploughing with *desi* plough followed by puddling and improper land leveling)

ploughing over ploughing with country plough and land leveling, irrespective of locations was from 2.3 to 9.8 per cent and 6.2 to 7.2 per cent during wet and dry seasons, respectively. Effect of deep ploughing followed by puddling and proper leveling became conspicuous in terms of improvement in grain yield in some locations where drainage might have been impeded. Deep ploughing might have facilitated drainage by percolation due to breaking of hard pan in the sub-surface zone. Effect of deep ploughing and leveling was significant in Pitamahal and the farmers observed a decrease in reddish tinge on soil surface (a symptom of Iron toxicity) in this treatment. They opined that crop performance and yield improvement were better with deep ploughing followed by puddling and leveling. Data

pertaining to yield of rice in different locations (Table 3) indicated that mean yield irrespective of treatments imposed was 4.32, 3.60 (pooled over 2 seasons) and 4.21 t ha⁻¹ at Hirakud, Hariharajore and Pitamahal, respectively during wet season. The higher yield obtained under Hirakud and Pitamahal is largely attributed to planting in the month of July which is the recommended planting period for the region. In Hariharajore command, the low yield was perhaps due to delayed planting of the rice variety 'Swarna' which is more susceptible to incidence of pests and diseases particularly under late planting conditions compared to the variety 'Lalat' grown in Hirakud and Pitamahal commands. During dry season, the mean grain yield of rice was 4.14 and 3.95 t ha⁻¹ (average of two years) at

Table 3. Grain yield (t ha⁻¹) of rice over locations and seasons.

	Wet season				Dry season				
	Hirakud	Hariharajore		Pitamahal	Mean	Hariharajore	Pitamahal		Mean
Treatments	2001	2001	2002	2002		2001-02	2001-02	2002-03	
T ₁	43.79	35.98	36.68	41.80	39.56 (7.50)	41.50	38.80	39.65	39.98 (5.40)
T ₂	44.73	38.28	37.64	45.60	41.56 (12.93)	43.90	41.40	42.35	42.55 (12.18)
T ₃	41.07	33.52	33.73	38.90	36.80	38.80	37.3	37.70	37.93
Average	43.2		35.97*	42.1		41.4		39.53*	

N.B.: Values in the parenthesis indicate per cent increase over T₃; * Values indicate average of two years

T₁ = Ploughing with *desi* plough followed by puddling and proper land leveling using bullock drawn wooden plank

T₂ = Deep ploughing with bullock drawn M.B. plough up to a depth of 20 cm followed by puddling and proper land leveling

T₃ = Farmers' practice (Shallow ploughing with *desi* plough followed by puddling and improper land leveling)

Hariharajore and Pitamahal, respectively. This marginal variation in yield under Hariharajore to the tune of 4.8 per cent was mainly due to growing of variety 'Lalat' which has higher yield potential than the variety 'Khandagiri' owing to latter's shorter duration.

Mean grain yield (Table 3) over locations was 3.68 and 3.79 t ha⁻¹ during wet and dry seasons, respectively under farmers' practice of ploughing with country plough followed by puddling and improper leveling. The comparative yield advantage in dry seasons can be attributed to better environmental conditions which are in conformity with the normal trends. An appreciable improvement in yield over farmers' practice was observed due to imposition of proper leveling after ploughing with country plough and puddling and deep ploughing followed by puddling with proper leveling. However, the increase in yield due to deep ploughing and proper levelling treatment was more conspicuous with an increase of 12.9 per cent in wet season and 12.2 per cent in dry season as against the increase of 7.5 and 5.4 per cent under ploughing with country plough and proper levelling, respectively under similar situations.

Cost of cultivation under farmers' practice across the locations in wet season was Rs.11023 ha⁻¹ (Table 4) which was 6.14 per cent higher than that of dry season (Table 5). It was mainly due to greater infestation of pest and diseases in wet season causing more expenditure towards plant protection measures. The cost of cultivation under deep ploughing with proper levelling and farmer's practice was also higher in wet season than in dry season due to similar reasons. The expenditure incurred under deep ploughing followed by proper land levelling was the highest obviously because of engagement of more animal power for bringing the land under proper puddled and leveled condition.

The highest expenditure of Rs.11850 ha⁻¹ in Hiraakud and the lowest of Rs.10520 ha⁻¹ at Hariharajore command area were recorded under farmers' practice during wet season. The difference was mainly due to engagement of more animal and man power towards land preparation and transplanting operations. Similar trend was also observed in other two treatments. During dry season, however, Hariharajore recorded marginally more expenditure (Rs.10520 ha⁻¹) on cultivation as compared to Rs.10250 ha⁻¹ in Pitamahal command area under farmers' practice due to variations in local labour wages.

Table 4. Economics of different treatments on rice cultivation during wet season at different locations of Western Orissa

Treatments	Cost of cultivation (Rs. ha ⁻¹)			Cost of produce (Rs. ha ⁻¹)			Net return (Rs.)					
	Hirakud	Hariharajore	Pitamahal	Mean	Hirakud	Hariharajore	Pitamahal	Mean	Hirakud	Hariharajore	Pitamahal	Mean
T ₁	12100	10900	10950	11316	18392	15258	17556	17068	6292	4358	6606	5752
									(0.52)	(0.40)	(0.60)	(0.50)
T ₂	12600	11200	11700	11833	18787	15943	19152	17960	6187	4743	7452	6127
									(0.49)	(0.42)	(0.64)	(0.51)
T ₃	11850	10520	10700	11023	17250	14125	16338	15904	5400	3605	5638	4881
									(0.45)	(0.34)	(0.53)	(0.44)

N.B.: Values in the parenthesis indicate net return rupee⁻¹ invested; Cost of rice grain = Rs.420.00 q⁻¹

T₁ = Ploughing with *desi* plough followed by puddling and proper land leveling using bullock drawn wooden plank

T₂ = Deep ploughing with bullock drawn M.B. plough up to a depth of 20 cm followed by puddling and proper land leveling

T₃ = Farmers' practice (Shallow ploughing with *desi* plough followed by puddling and improper land leveling)

Table 5. Economics of different treatments on rice cultivation during dry season at different locations of Western Orissa

Treatments	Cost of cultivation(Rs. ha ⁻¹)			Cost of produce(Rs. ha ⁻¹)			Net return (Rs.)		
	Hariharajore	Pitamahal	Mean	Hariharajore	Pitamahal	Mean	Hariharajore	Pitamahal	Mean
T ₁	10900	1,425	10662	17430	16472	16951	6530(0.60)	6047(0.58)	6289(0.59)
T ₂	11200	10750	10975	18438	17590	18014	7238(0.64)	6840(0.63)	7039(0.64)
T ₃	10520	10250	10385	16296	15750	16023	5776(0.55)	5500(0.53)	5638(0.54)

N.B.: Values in the parenthesis indicate net return rupee⁻¹ invested; Cost of rice grain = Rs. 420.00 q⁻¹.

T₁ = Ploughing with *desi* plough followed by puddling and proper land leveling using bullock drawn wooden plank

T₂ = Deep ploughing with bullock drawn M.B. plough up to a depth of 20 cm followed by puddling and proper land leveling

T₃ = Farmers' practice (Shallow ploughing with *desi* plough followed by puddling and improper land leveling)

On an average, the practice of deep ploughing followed by puddling along with proper leveling emerged as the costliest practice with an average cost of cultivation of Rs.11833 and Rs.10975 ha⁻¹ in wet and dry seasons, respectively (Table 4 and Table 5). It was 7.34 and 5.68 per cent higher over farmer's practice, respectively. It was mainly because of increased bullock power engaged to attain the desired ploughing depth of 20 cm followed by puddling and proper leveling.

During wet season the net returns of Rs.4743 ha⁻¹ against an investment of Rs.11200 ha⁻¹ and Rs.7452 ha⁻¹ against the investment of Rs.11700 ha⁻¹ were obtained at Hariharajore and Pitamahal, respectively in deep ploughing followed by puddling and proper leveling treatment (Table 4). Ploughing with country plough followed by puddling and proper leveling produced the highest net profit of Rs.6292 ha⁻¹ at Hirakud with an investment of Rs.12100 ha⁻¹. Net return per rupee invested was 0.42 and 0.64 under deep ploughing followed by levelling at Hariharajore and Pitamahal, respectively.

During dry season, similar trend was observed at Hariharajore and Pitamahal and a net profit of

Rs.7238 and Rs.6840 ha⁻¹ against an investment of Rs.11200 and Rs.10750 ha⁻¹, respectively was obtained with corresponding net return rupee⁻¹ investment of 0.64 and 0.63 (Table 5).

In general the additional cost involved in deep ploughing followed by puddling and proper levelling ranged from Rs.500 to Rs.1000 ha⁻¹ (Table 6) across seasons and locations. Deep ploughing followed by puddling and proper land levelling (T₂) resulted in higher additional return in all the locations across the seasons. But the additional returns per additional rupee invested narrowed down uniformly in T₂ compared to T₁. The benefits of deep ploughing followed by puddling and proper leveling however, was conspicuous as per observations of farmers of Pitamahal. According to them the additional cost involved in T₂ was more than compensated due to higher yields and there was a reduction of iron accumulation.

From this study it can be inferred that proper leveling should not be ignored. This practice is useful and cost effective. Proper ploughing even with country plough for puddling along with proper leveling was found to be advantageous and cost effective. This technology

Table 6. Additional return per additional rupee invested as influenced by different treatments on rice cultivation

Treatments	Wet season						Dry Season								
	Hirakud			Hariharajore			Pitamahal			Hariharajore			Pitamahal		
	C	P	R	C	P	R	C	P	R	C	P	R	C	P	R
T ₁	250	1142	4.56	280	1134	4.05	250	1218	4.87	280	1134	4.05	175	772	4.13
T ₂	750	1537	2.50	680	1818	2.67	1000	2814	2.81	680	2142	3.15	500	1840	3.68

C = Additional cost of treatment imposition over T₃ (Rs ha⁻¹); P = Additional return of treatment imposition over T₃ (Rs ha⁻¹); R = Additional return per additional rupee invested (Rs.)

T₁ = Ploughing with *desi* plough followed by puddling and proper land leveling using bullock drawn wooden plank

T₂ = Deep ploughing with bullock drawn M.B. plough up to a depth of 20 cm followed by puddling and proper land leveling

T₃ = Farmers' practice (Shallow ploughing with *desi* plough followed by puddling and improper land leveling)

is worth recommending to farmers for wide scale adoption. However, it was further inferred that deep ploughing followed by puddling with proper leveling is more beneficial in the locations having the problem of impeded internal drainage or iron toxicity.

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