Participatory Diagnostic Analysis and Yield Optimization in Rice-Wheat System of a Canal Command Area

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This study was undertaken based on the hypothesis that by narrowing the gap between the potential productivity (based on the agro-ecological constraints) and actual productivity of land and water, the livelihoods of poor people can be improved. Improved and scientific management of land and water resources for sustainable agricultural production to increase the income of the resource poor farmers is one of the means for poverty alleviation. In this study, constraints associated with land and water management were analyzed by adopting a livelihood approach. We had conducted resource mapping, group discussions with farmers, and house hold interviews. Information on institutions, farmers associations involved in land and water management, infrastructure and key services were collected. Based on the information collected, important removable constraints and interventions for land and water management were identified. The major focus of the study was on capacity building of resource poor farmers and communities rather than provision of resources required for land and water management. The team after rigorous discussion, recognized the critical production constraints to rice-wheat production system as delay in seedling raising and transplanting of rice, and late sowing of wheat due to non-availability of canal water in time and its inequitable distribution, inadequate number of shallow tube-wells, ineffective use of rain-water, and lack of conjunctive use of water. The focus of this paper is to increase the agricultural production through scientific and sustainable management of water resources and better crop husbandry practices to increase the farmer's income in rice-wheat system of Sone Command in Patna, Bihar.

Methodology

There are a number of ways and means for participatory diagnostic analysis, to identify key agricultural production constraints in relation to land and water management. In this study snowball sampling technique has been employed for identifying and subsequently ranking of key constraints perceived by key informants. Constraints of various farmer groups in the project area were studied by directly interviewing these farmer groups. The farmers were grouped as farmers at panchayat level, non-agricultural women group, share croppers, farmers belonging to water user association (WUA), progressive farmers, women group based on agriculture, small farmers and landless/agricultural labourers. Periodic meeting and discussion with key informants on identification of key constraints were held in which 119 members of different groups participated and expressed their views and experience on key constraints. The identified constraints were compiled and ranked by the key informations and farmers based on percent RBQ value. It is interesting to note that water management is the most important problem of the project area, which needs to be addressed effectively. A team of scientists from ICAR-RCER conducted farmers' training camps in the command area of RPC-5, to emphasize on advancing the date of transplanting by 15-20 days by raising nursery in the last week of May to first week of June using tube-well water, and transplanting it in the last week of June to middle of July for maximum utilization of rain water. Such a practice could save about 2-3 irrigation usually required by the late transplanted rice during its last growth phase, and would also help in timely sowing of rabi crops

The team also advised the farmers to use improved cultivars like Pusa 44 and Pusa Basmati for short duration, and MTU 7029 and MTU 1001 for long duration cultivations. In order to grow healthy nursery for transplanting 1.0 ha area, the farmers were advised to sow 25 kg of good quality rice seeds in 1000 m2 bed as against their normal practice of sowing 60-70 kg seed from 25th May to first week of June. A balanced basal doze of 5 kg urea, 11 kg single supper phosphate, 1.5 kg muriate of potash, and 2.0 kg zinc sulphate was applied in nursery bed. The farmers were told to apply 104 kg urea, 360 kg SSP, 60 kg MOP and 20 kg zinc sulphate as basal dose in one ha area at the time of puddling. The farmers were advised to transplant 2-3 seedlings per hill, and each seedling containing 2-3 tillers at a distance of 15cm x 20 cm for long duration varieties, and at a distance of 15 cm x 15 cm for short duration varieties, between last week of June to middle of July. On their own, the farmers were transplanting 8-12 seedlings per hill and were using only urea as fertilizer. The farmers were advised to apply 17 kg urea per acre after seven days of transplanting. To control weed growth, they were advised to apply 2.5 litre of Machete (Butachlor 50% EC) in 15 kg of sand and broadcast in one hectare rice field between fourth to seventh days after transplanting. The team also suggested three top dressings of rice fields by urea at the rate of 104 kg urea in two splits

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at tillering and flowering as top dressing, besides plant protection measures.

Results and Discussion

a. Participatory Diagnostic Analysis

Periodic meeting and discussion with key informants on identification of key constraints were held in which 119 members of different groups viz. farmers at panchayat level, non-agricultural women group, sharecroppers, farmers belonging to water user association (WUA), progressive farmers, women group based on agriculture, small farmers and landless/agricultural labourers participated and expressed their views and experience on key constraints. The identified constraints were compiled and ranked by the key informations and farmers based on percent RBQ value. Several formal meetings were held amongst the identified groups and it has been observed that the most common constraints of all the eight groups were lack of capital, lack of transportation & storage facilities, lack of timely supply of electricity, lack of water management practices due to unlined canals and untimely supply of canal water, no arrangement for cleaning of ahar, water-logging of agricultural land, lack of plant protection measures, lack of quality of farm inputs like seeds, fertilizers and pesticides, non availability of modern agricultural implements, non availability of tube well, low crop yield results into low income encouraging money lender to exploit farmers, lack of allied activities, viz. dairy, poultry etc owing to capital constraints, lack of timely agricultural credit facility, lack of agricultural training, inadequate milk procurement agency, lack of basic need of health and education, social problem in the village viz. casteism, factionalism, untouchability, etc., lack of agro-industry in the area, no credit card to farmers risk in adoption of new technologies, lack of agril. technology extension, lack of veterinary doctors and training on livestock keeping and dairying, lack of proper health and education facilities, , lack of farmers organization/unity, lack of market of agril. Produce, fragmentation of land holding and less price of agricultural produce lack of latest training regarding modern agricultural practices, lack of dissemination of agricultural technologies, lack of training regarding keeping of livestock on commercial basis and lack of agro-industries and allied activities. Key informants and farmers ranked the identified constraints based on percent RBQ value.

A Two-way Frequency Table Along with RBQ Value (%) is Done. Based on percent RBQ Value Top Five Ranked Constrains are Presented Below:

Rank	Constraints/Problem
I	Water management
II	Lack of quality seed, fertilizer and pesticides
III	Non-availability of modern agril. Implements
IV	Non-availability of tube well
V	Allied activity-dairy

It was interesting to note that water management is the most important problem of the project area, which needs to be addressed effectively. This ranking was based on the perception of key informants.

b. Yield Optimization of Rice and Wheat Crop

Adoption of Rice Production Technology

The rice production technology was tested in two village namely Badauli and Saharampur in the commands of RP Channel-5 distributary during Kharif season of 2001. The improved production technology resulted in bumper paddy yields of 6 to 7 t/ha (based on crop cutting experiment in 3m x 3m area) as against the traditional yields of 1.6 to 3 t/ha. The results are in the conformity with the results of Singh *et al.* (2002). The farmers adopted the recommended practices in 111.2 ha. Saharampur village and harvested almost the same yields. As the farmers harvested unprecedented high yields, the improved rice production technology became an important issue for discussion among the farmers. Consequently, the farmers from the adjoining commands of five distributaries namely Kurkuri, Rewa, Narayanpur, Fatehpur, and Khajuri of Sone canal approached us to adopt their villages.

i. Nursery Raising

It is evident form the Table 1 that 87 per cent nurseries were raised during 3rd and 4th week of June in head, and middle reach, whereas in tail end maximum nursery was raised during 2nd and 3rd week of June. Nursery raising in all 20 villages of RP Channel-5 during 2002 in head, middle and tail end was completed by 27th standard week.

TABLE 1—RICE NURSERY RAISING IN HEAD, MIDDLE AND TAIL END IN R.P. CHANNEL-5.

Std. Week	Head			Middle			Tail end		
	Total area (ha)	Week Wise (%)	Cumu-lative (%)	Total area (ha)	Week Wise (%)	Cumu-lative (%)	Total area (ha)	Week Wise (%)	Cumu-lative (%)
22. (28May-3June)	0.25	1.16	1.16	0.52	1.46	1.46	0.20	0.88	0.88
23(4-10 June)	0.375	1:74	2.90	NIL	NIL	NIL	3.90	17.26	18.14
24(11-17June)	1.904	8.83	11.73	3.40	9.57	11.03	7.98	35.32	53.46
25(18-24) June	11.19	52.04	63.77	13.19	37.15	48.18	6.00	26.56	80.02
26(25June-1July)	7.705	35.81	99.58	18.39	51.82	100.00	4.19	18.54	98.56
27(2-8July)	0.08	0.42	100.00	NIL	NIL		0.31	1.44	100.00
Total area in villages	21.504	100%		35.50	100%		22.59		

ii. Timely Rice Transplanting

One of the key interventions of improved rice production technology is to educate the farmers about the advantages of early nursery raising and transplanting. Table 2 gives the percentage of farmers fields transplanted in different weeks during kharif 2001. The sample has been drawn from 135 ha area in 2 villages. It is revealed from Table 2 that the bulk of the transplanting to the tune of about 45.09 per cent took place during 16—29th July corresponding to 29th and 30th weeks. Only about 10.74 per cent area was transplanted on 2nd to 15th July (27th and 28th week). But more than 50 per cent of transplanting was done after 30th week and continued upto 35th week due to dry spell in the beginning of July, 2001 whereas the percentage decreased to 16.84 per cent during kharif 2002 due to dry spell and unavailability of rain and canal water.

TABLE 2—RICE AREA TRANSPLANTED IN DIFFERENT STANDARD WEEKS DURING KHARIF 2001 & 2002 BY THE FARMERS ADOPTING IMPROVED TECHNOLOGY

Standard weeks of transplanting	Area trans-planted (ha) (2001)	Percentage of farmer's field trans-planted (2001)	Cumul-ative Per cent age (2001)	Area trans-planted (ha) (2002)	Percentage of Farmer's field transplanted (2002)	Cumulative Percent age (2002)
26 (25 June-01 July)	—	—	—	0.41	0.04	0.04
27 (02 July-08 July)	5.64	4.17	4.17	11.76	1.43	1.47
28 (09 July-15 July)	9.01	6.67	10.74	32.76	3.98	5.45
29 (16 July-22 July)	30.68	22.70	33.44	44.81	5.46	10.90
30 (23 July-29 July)	17.10	12.65	45.09	48.83	5.95	16.84
31 (30 July-05 Aug.)	13.13	9.71	54.80	128.54	15.65	32.48
32 (06 Aug.- 12 Aug.)	14.54	10.71	65.51	164.17	19.98	52.46
33 (13 Aug.-19 Aug.)	29.15	21.57	87.08	203.67	24.78	77.46
34 (20 Aug.-26 Aug.)	13.46	9.96	97.04	140.98	17.15	94.42
35 (27 Aug.-02 Sept.)	2.45	1.81	100.00	45.93	5.58	100.00
Total	**135.16**	**100.00**	—	**820.86**	**100.00**	—

It is evident from the Table 3 that maximum transplanting was done using canal water (63 Per cent followed by rainfall (26 Per cent) and tube well (10 Per cent). The farmers of head, middle and tail end have used canal water whereas only tail end farmers for transplanting have used tube well water.

TABLE 3—PERCENTAGE DISTRIBUTION OF SOURCES OF IRRIGATION IN FIELD DURING TRANSPLANTING R. P. CHANNEL-5

Standard Week	Rainfall	Tube well	Canal
26 (25 June-01 July)	0.12	NIL	NIL
27 (02 July-08 July)	1.32	NIL	1.66
28 (09 July-15 July)	8.24	0.27	NIL
29 (16 July-22 July)	2.79	5.0	NIL
30 (23 July 29 July)	2.09	4.55	NIL
31 (30 July-05 Aug.)	2.26	0.33	10.57
32 (06 Aug,.-12 Aug.)	0.98	NIL	15.18
33 (13 Aug.-19 Aug.)	5.04	NIL	18.51
34 (20 Aug.-26 Aug.)	2.72	NIL	12.65
35 (27 Aug.-05 Sept.)	0.78	NIL	4.27
Total	**26.34**	**10.15**	**62.84**

Data presented in Table 4 indicates percentage distribution of farmers field dependent on different sources of irrigation in head, middle and tail end in RPC-5. It is evident from the data that 97 and 88 per cent farmers of head and middle reach were dependent on canal irrigations whereas in tail end only 5.0 per cent farmers were dependent on canal irrigation. Farmers of tail end had used 28 per cent tube well water for transplanting.

TABLE 4—PERCENTAGE DISTRIBUTION OF FARMER'S FIELDS DEPENDENT ON DIFFERENT SOURCES OF IRRIGATION IN HEAD MIDDLE, AND TAIL REACHES IN R.P. CHANNEL-5

Std. Weeks	I. Head			II. Middle			III. Tail		
	Rain fall	Tube-well	Canal	Rain fall	Tube-well	Canal	Rain fall	Tube-well	Canal
26 (25 June-01 July)	NIL	NIL	NIL	NIL	NIL	NIL	0.37	NIL	NIL
27 (02 July-08 July)	0.10	NIL	NIL	0.76	NIL	NIL	3.12	NIL	5.0
28 (09 July-15 July)	0.13	NIL	NIL	1.50	0.83	NIL	23.09	NIL	NIL
29 (16 July-22 July)	0.56	NIL	NIL	1.43	NIL	NIL	6.40	15.0	NIL
30(23 July-29 July)	1.90	NIL	NIL	4.37	1.0	NIL	NIL	12.67	NIL
31 (30 July-05 Aug.)	NIL	NIL	25.20	1.0	1.0	6.51	5.78	NIL	NIL
32 (06 Aug.-12 Aug.)	NIL	NIL	35.34	NIL	NIL	10.21	2.96	NIL	NIL
33 (13 Aug.-19 Aug.)	NIL	NIL	15.5	NIL	NIL	40.05	15.13	NIL	NIL
34 (20 Aug.-26 Aug.)	NIL	NIL	16.80	1.0	NIL	21.17	7.18	NIL	NIL
35 (27 Aug.-05 Sept.)	NIL	NIL	4.47	NIL	NIL	8.36	2.34	NIL	NIL
Total	**2.69**	—	**97.31**	**9.00**	**2.83**	**88.17**	**64.37**	**27.67**	**5.0**

iii. Effect of Transplanting Dates on Rainwater Utilization in Rice Production

Kharif rice is normally transplanted and harvested during 11th June to 2nd December, coinciding with standard 24th to 48th weeks. The nursery for such rice is raised about 24 to 30 days prior to transplanting. Consequently, the rainfall during the 24th to 48th weeks has been taken as seasonal rain. The rain water utilization by rice crop transplanted on June 25 to July 1, July 23 to 29, and August 20 to 26th corresponding to 26th, 30th, and 34th weeks during the Kharif season 2001 was 721.8 mm (66.1 Per cent, 599.4 mm (54.9 Per cent) and 471.4 mm (43.2 Per cent), respectively (Table 5). The corresponding figures for the Kharif 2002 are 87.5 , 59.5 per cent, and 21.1 Per cent. The 40 years (1960-1999) average rainwater utilization is also reported in Table 5. It may be noted that only a part of the rainwater is utilized in meeting the requirements of evapotranspiration, degree of submergence, and deep percolation in rice production system (Anonymous, 1994).

TABLE 5—EFFECT OF DATE OF TRANSPLANTING RICE ON RAINWATER UTILIZATION DURING 2001- 2002.

Date of transplanting, standard week	Seasonal rain water utilization in rice production, mm		
	2001	2002	Forty years average
26 (25 June-01 July)	721.8	894.5	965.2
27 (02 July-08 July)	686.4	673.0	905.3
28 (09 July-15 July)	647.2	630.5	834.4
29 (16 July-22 July)	638.1	614.5	741.3
30 (23 July 29 July)	599.4	608.3	664.2
31 (30 July-05 August)	574.5	431.9	589.3
32 (06 Aug,.-12 Aug.)	567.2	257.9	524.3
33 (13 Aug.-19 Aug.)	524.6	224.4	471.0
34 (20 Aug.-26 Aug.)	471.4	215.5	432.0
35 (27 Aug.-05 Sept.)	356.8	213.3	

Rainfall between June-11 to December-02
For the year 2001 & 2002 = **1092 mm & 1022 mm**, Forty years average = **1024 mm**

iv. Effect of Transplanting Dates on Rice Yield

The effect of dates of transplanting on rice yield, as observed in farmers fields during kharif 2001 and 2002, is reported in Table 6. The yields were recorded by unit crop cutting survey in 3 m x 3 m area in farmers' fields of different villages. Most of the farmers had adopted the full package of rice production technology. The crop harvest data of 2001 and 2002, were obtained with the help of the farmers in the commands of RP Channel-5. Each data point of 2001 and 2002 are average of 2 to 5 harvests.

Rice transplanting was started in RP Channel-5 from 26th standard weeks (9-15 July) and continued up to 35th weeks (27 Aug- 3 Sep). Majority of the farmers completed their transplanting in between 29th to 31st weeks. It has been observed that maximum grain yield was recorded, when rice was transplanted in 26th standard week (25th June—1st July) followed by succeeding weeks. It has been also observed that as the transplanting was delayed by a week, there was reduction in grain yield of rice. The reductions in grain yield from 27th week to 35th week were to the tune of 1.5, 6.1, 9.1, 15.2, 16.7, 19.7, 24.2, 34.8 and 51.5 per cent, respectively during 2001 and 2002 (Table 6). It indicates that the transplanting of rice should be done in between 27th—29th week, to increase the grain yield of rice 2 folds on the present situation. The yields of rice transplanted in subsequent weeks were lower than the planting done in 26th week. Hence, the value of yield was divided by the highest yield and the relative yields were obtained.

The relative yield is a major of the fraction of maximum yield that has been achieved by transplanting rice crops in different weeks. As the data have been collected from the farmers' field spread overall several villages, it may be taken as the representative for the area. The yield collected from 3m x 3m sampled-area contains sampling errors. However, the relative yield is expected to eliminate some of the errors (Singh et. al. 2002).

TABLE 6—EFFECT OF DATE OF TRANSPLANTING ON YIELD OF RICE DURING 2001 AND 2002.

Date of transplanting rice, standard week	Rice yield during the year, t/ha			Percent reduction in yield in succeeding weeks	Relative yield	
	2001	2002	Pooled		2001	2002
26 (25 June-01 July)	6.9	6.3	6.6	—	1.0	1.0
27 (02 July-08 July)	6.7	6.4	6.5	1.5	0.971	1.015
28 (09 July-15 July)	6.5	5.8	6.1	6.1	0.942	0.921
29 (16 July-22 July)	6.2	5.6	5.9	9.1	0.898	0.888
30 (23 July-29 July)	5.9	5.4	5.6	15.2	0.855	0.857
31 (30 July-05 Aug.)	5.7	5.3	5.5	16.7	0.826	0.841
32 (06 Aug.- 12 Aug.)	5.6	5.1	5.3	19.2	0.812	0.809
33 (13 Aug.-19 Aug.)	5.2	4.8	5.0	24.2	0.754	0.762
34 (20 Aug.-26 Aug.)	4.4	4.3	4.3	34.8	0.638	0.683
35 (27 Aug.-05 Sept.)	3.1	3.2	3.2	51.5	0.449	0.507

v. Effect of Date of Sowing of Wheat on Crop Yield

Wheat is highly sensitive to soil and ambient thermal regimes. Its optimum sowing time has been considered to be the middle of November when winter has just started. In order to study the effect of date of sowing of wheat on crop yield, crop harvest data of wheat sown in the standard weeks of November 19—25, November 26 to December 2, December 3—9, Dec. 10—16, Dec. 17—23, and Dec. 24—31 during 2001—2002 and 2002—2003 were collected from the farmers' fields located in several villages and distributary commands. Even though the soils in all the villages are alluvial, they have variable textural distributions. The methods of sowing and other crop production inputs were variable as per practices adopted by different farmers. The data were scientifically collected from 3 m × 3 m area by randomly locating it in the farmer's field. The observed crop yield data has been corrected at standard moisture content of 12 per cent.

The data presented in Table 7 reveals the effect of date of sowing of different wheat cultivars on crop yield during the rabi season of 2001-2002 and 2002-2003. Wheat sown during the period November 19—25 has yielded maximum grain during both the years. Likewise, the wheat sown during the week Dec. 24—31 has yielded the minimum. As evident from Table 7, the yield has drastically declined between these two periods. Similar trend was observed by Singh *et al.* (2002).

TABLE 7—EFFECT OF DATE OF SOWING OF WHEAT (ALL VARIETIES) ON CROP YIELD DURING 2001-2002

St. Week	Yield (t/ha)		Relative yield		Total crop season yield (q)	Actual relative average yield
	2001	2002	2001	2002		
Nov. 19-25	4.9	5.1	1.0	1.0	5.0	1.0
Nov. 26-2 Dec.	4.1	4.0	0.84	0.78	4.1	0.81
Dec. 3-9	3.6	3.3	0.73	0.65	3.5	0.69
Dee 10-16	3.2	3.2	0.66	0.63	3.2	0.65
Dec. 17-23	3.2	3.1	0.65	0.61	3.2	0.63
Dec. 24-31	2.5	2.5	0.50	0.51	2.5	0.51

Ry = Relative yield of wheat

$$= \frac{\text{Average yield of wheat sown during a week}}{\text{Maximum observed average yield of wheat sown in any week (5)}}$$

CONCLUSION

- The process of accelerating adoption of optimization of rice transplanting basically involved knowledge sharing through various means of communication such as training, strategic demonstration, distribution leaflets on "*Samay per ropai* se *adhik dhan ka utpadan*" *and "Samay per boai* se *gahuan ki adhikatam paidawar*" and motivation of farmers. The scientists from the ICAR Research Complex for Eastern Region, Patna organized 44 training camps in the commands of RPC- V, to educate them about the timeliness of seeding and planting, improved rice-wheat production technology and other aspects of agricultural production system. In these trainings, more than 1000 farmers participated.
- Trainings helped the farmers in adoption of improved rice and wheat production technologies. During kharif 2001, the farmers of 2 villages in the commands of RP Channel-5 adopted timely sowing of rice nursery using tube-well water sufficient for transplanting 135.10 ha area. Consequently during kharif 2002, the farmers in the commands of RP Channel-5 followed the improved methods of rice production in 820.86 ha spread in 20 villages. Early nursery raising and transplanting of rice helped its early harvesting, thereby making the fields available for timely sowing of wheat.
- Rice transplanted during the week 25th June to 1st July in kharif 2001 & 2002 gave higher average yield of 6.6 t/ha. Late transplanting during last week of August resulted in reduction of yield up to 52 per cent.
- Maximum wheat yield (5.0 t/ha) was obtained, when wheat crop was sown in the weeks of November 19—25 but normally when wheat crop is sown in the last week of December, the yield is reduced by 50 per cent.
- The total production of rice and wheat has increased to the tune of 11-12 t/ha in the command of RP Channel-5. This will help the farmers to take care of their family members with regard to higher education, health care and discharging social liabilities. They can also plan for other allied activity to increase their income. This way livelihood of small, marginal and affluent farmers can be improved.
- For timely raising of nursery by using tubewell water during non-availability of canal water service providers (i.e. tubewell owning farmers) sold water for Rs., 42000/during 1999-2000, whereas during 2003-04, they have sold water for Rs. 104550 registering 2.5 times increase in ground wate market. The operating hours of tubewells an water selling in the command have increased b the number of tubewells in the canal command ha not increased significantly due to poor econon condition of the farmers and fragmented holdin Efficiency of rain water utilization was a enhanced significantly.

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