NATURAL RESOURCES SYSTEMS PROGRAMME

PROJECT REPORT[1]

DFID Project Number

R7830 and R7839

Report Title

Livelihood improvement through optimisation of rice transplanting and timely sowing of wheat in participatory mode in RP Channel V of Sone Command.

Annex Biv of the Final Technical Report of projects R7830 and R7839.

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Date

2005

NRSP Production System

High Potential

[1] This document is an output from projects funded by the UK Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID.

Content

Summary

This study was undertaken in the command area of RP Channel–V of Sone Command in Patna, Bihar 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, livelihoods of poor people can be improved. 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 Project Team after rigorous discussion with farmers, 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 was 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. Advancing the date of rice transplanting by 15-2□ days (by raising nursery in the last week of May to first week of June using tubewell water) to undertake transplanting of rice between 4th week of June to middle of July not only enables effective utilization of rainwater received during the season but also saves amount of irrigation and facilitates timely sowing of *rabi* crops. Rice transplanted during the week 25th June to 1st July in kharif 2□□1 & 2□□2 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.□ t/ha) was obtained, when wheat crop was sown in the weeks of November 1□-25, where as normally when wheat crop is sown in the last week of December, the yield is reduced by 5□per cent.

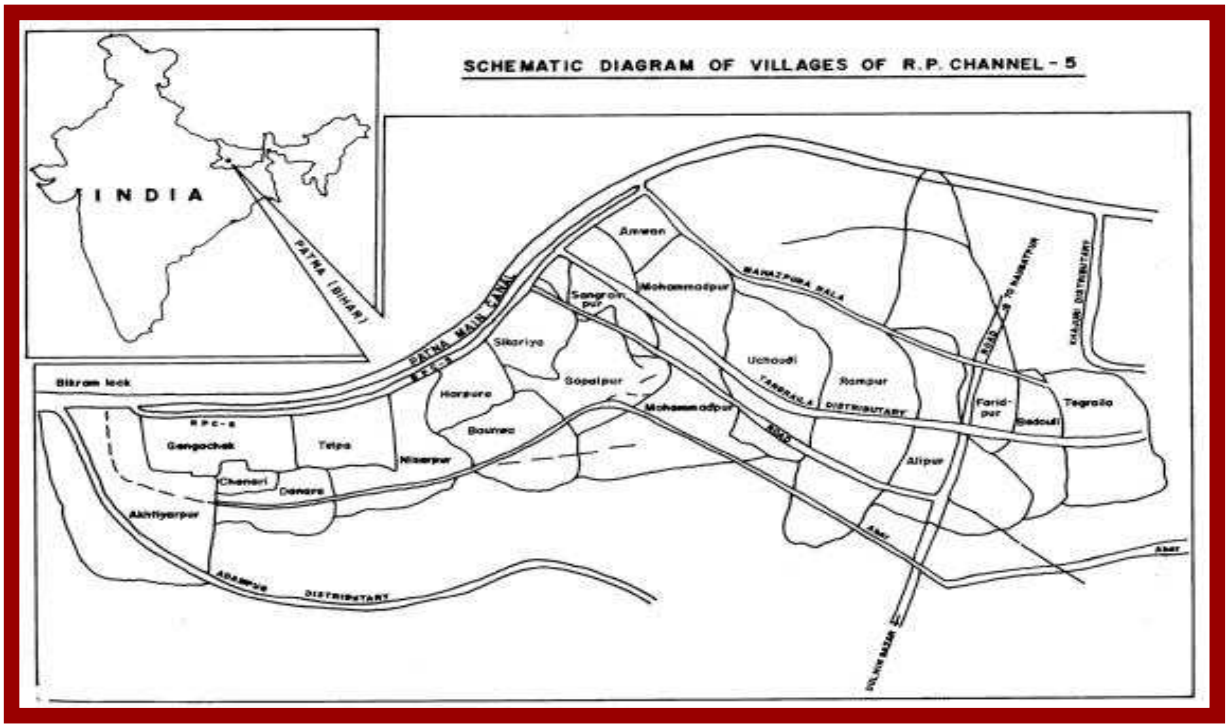
This concept also facilitated the use of ground water and emergence of groundwater market in the study area. It has been observed that during non-availability periods of canal water the ground water sale by same service providers increased from Rs. 42, □□/- in 1□□□-2□□□ to Rs. 1, □4, 55□/- in 2□□3-□4 registering a hike of 2.5 times. 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 of leaflets and motivation of farmers. Initially this concept was adopted by some interest/focused groups/members belonging to two villages in RPC-V covering an area of 135 ha and 16□ farmers. The future strategies for scaling up the community nursery- raising programme and timely transplanting through training programme, demonstration and distribution of communication product in local language was developed for livelihood improvement. One thousand farmers attended the training programme and their feedback has been positive to adopt ORT. There was shift in transplanting dates and the technology has spread to 178 villages of seven distributaries of Sone Command. As a result of our study and dialogue with the canal managers, Department of Water Resource, Govt. of Bihar rescheduled the canal operation for timely release of canal water for nursery raising and transplanting.

1. Introduction

1.1 Background

The project (R783□) was implemented in target areas located in the command of RPC-V of Sone canal system at Patna in Bihar and Maharajganj in eastern Uttar Pradesh (U.P.). The region comprising of central and northern Bihar and eastern U.P., has predominantly rural population with 87 percent living in rural areas and has average land holding size of □·2 ha (86.7% as per cent total). The population density of this region is very high (656 persons km^{-2}) with low literacy rate (37.□%). This work was undertaken in RPC-V command area in Bihar. RPC-V comprises of 2□ villages covering 3□□2 ha area. The RPC-V originates from the gated diversion at □2.□□ km RD (denotes location of origin at Reduced Distance of the main canal) of PMC just before Vikram fall (Fig. 1). RPC-V starts about 78□□m before Vikram Lock, which is the X^{th} lock on Patna Main Canal with a design discharge capacity of approximately 28 cusec. Tangraila originates near Sangrampur from gated inlet and travels a distance of 5.1 km and transverse to the RPC-V at its right side to Barka Tangraila. The RPC-V and its minor Tangraila has various outlets. RPC-V has outlets at its right bank only while Tangraila has outlets at its left and right bank. There are some drop structures built on the length of Tangraila after a certain intervals to raise the head of canal water. The total culturable command area (CCA) is 14□□ha. RPC-V and its minor Tangraila lies at the upper side of the command while a drain which originates just before the village Danara near Adampur distributary makes the lower boundary of the command.

The traditional schedule for providing irrigation water in the canals of Bihar indicates that water is not available until 25th June (Bihar Irrigation Bihar Commission Vol. III). However, for successful cultivation of kharif paddy, the seedlings have to be raised well in advance with the support of tube well/tank water for transplanting rice in time with the use of canal water.



1.2 Proposed project activity

The focus of this project is to increase the agricultural production through promoting the technology for scientific and sustainable management of water resources and better crop husbandry practices to increase the poor farmers income from agriculture in a participatory mode through building knowledge base. The working paper aims to quantify the interactive effects of rain, surface, and ground water utilization in conjunction with appropriate crop husbandry practices on crop production and resource conservation. It aims to develop knowledge to answer the following questions:

- How do various dates of transplanting and or maturity group of rice during wet season (June to October) affect the utilization of rain water in crop production and timely availability of land for sowing subsequent winter (November to April) crops so that productivity of irrigated rice-based production system is increased ?
- How to promote optimizations of rice transplanting dates ?

The project R-783□ is a companion to the proposed DFID NRSP project (R-783□) 'Livelihoods improved though improved crop and soil management' submitted by IACR, Rothamsted, U.K. The work presented in this report pertains to RPC-V in Bihar.

1.3 Rationale

The agricultural sector in India in general, and Bihar in particular, continues to occupy the center-stage in overall economic progress and development. The role of agriculture including animal husbandry, dairy, and fisheries in generating broad based economic growth is evident from the fact that the sector has been contributing nearly 2□ per cent of the GDP, and giving employment to about 66% of the population in the country. The average rainfall is 1142.5 mm, major portion of rainfall continued from July – September, where rice is predominant crop. Agriculture is the predominant occupation of the people in this region. The slow growth in agriculture is responsible for the poverty in this region. Rice and wheat are the major crops of kharif and rabi seasons occupying 5.□7 million ha (mha) and 2.13 mha area respectively. The average yields of rice-wheat cropping system was 1.3□-1.□□ t/ha as against the experimental yields of 7.21 - 3.□6 t/ha, obtained in experimental plots at Sabour (Bihar). Even though the state is rich in soil and water resources, the existing gap in experimental and average yields of rice-wheat-cropping system is computed as 5.□- 2.□4 t/ha. Thus, there is a considerable scope to increase the productivity of rice and wheat in Bihar.

The proposed project is 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. One of the major routes for poverty alleviation is through improved and scientific management of land and water resources for sustainable agricultural production to increase the income of the resource poor farmers. In the proposed project, constraints associated with land and water management were analyzed by adopting a livelihood approach. The major focus of the project was on capacity building of resource poor farmers and communities rather than provision of resources required for land and water management. Through communication process, capacity building and strategic field demonstrations, the technology for optimization of rice transplanting was promoted. **This ANNEX-B-iv relates to the Project Output-2.**

2. Materials and Methods

In this study snowball sampling technique has been employed for identifying and subsequent 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. It is interesting to note that water management emerged as the most important problems of the project area, which needs to be addressed effectively. The details of methodology and outcomes of constraints analysis are presented in ANNEX-B-ii, section 2.2 A team of scientists from ICAR-RCER conducted farmers' training camps in the command area of RPC-V, to emphasize on advancing the date of transplanting by 15-2□ 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 irrigation requirement and would also help in timely sowing of Rabi crops.

2.1 Identification of crop production constraints

A team of scientists from the ICAR Research Complex for Eastern Region, Patna and scientist from Rothamsted, U.K. visited the project site at Saharampur and discussed about their problems. 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 different irrigation waters. It is corroborated from the fact that out of 135 farmers surveyed during 2□□1 only 41.3% had completed transplanting up to 23 July and remaining

Scientists - Farmers Interactions at RPC-V

58.7% up to 27th August. The aforementioned constraints have inhibited the realization of production potential in the plains of central Bihar.

In order to identify other constraints, several farmers' group meetings were organized between April to June 2□□1 in the commands of RPC-V. The critical analysis of the interactive meetings revealed other production constraints as: (i) lack of capital, (ii) lack of suitable rice and wheat cultivars and use of poor quality seeds, (iii) lack of proper water management strategies (iii) imbalance and limited application of fertilizers, (iv) inadequate awareness about plant protection measures; (v) non-availability of seed drill and other farm equipments; and (vi) lack of proper technical guidance and support from developmental agencies. Based on the discussion with farmers, and their problems, constraints and needs, the efforts were focused in developing strategy for promoting improved crop and water management technology practices for livelihood improvement.

2.2 Identification of alternative interventions to enhance rice production

The monsoon at Patna breaks in second week (11th) of June. The forty years mean weekly rainfall data (1□6□ to 1□□□) of Patna is given in Table 1 and figure 1 (Das and Subash, 2□□1, personal communication). The annual rainfall is 1142.5mm and bulk of the rain occurs between June and October.

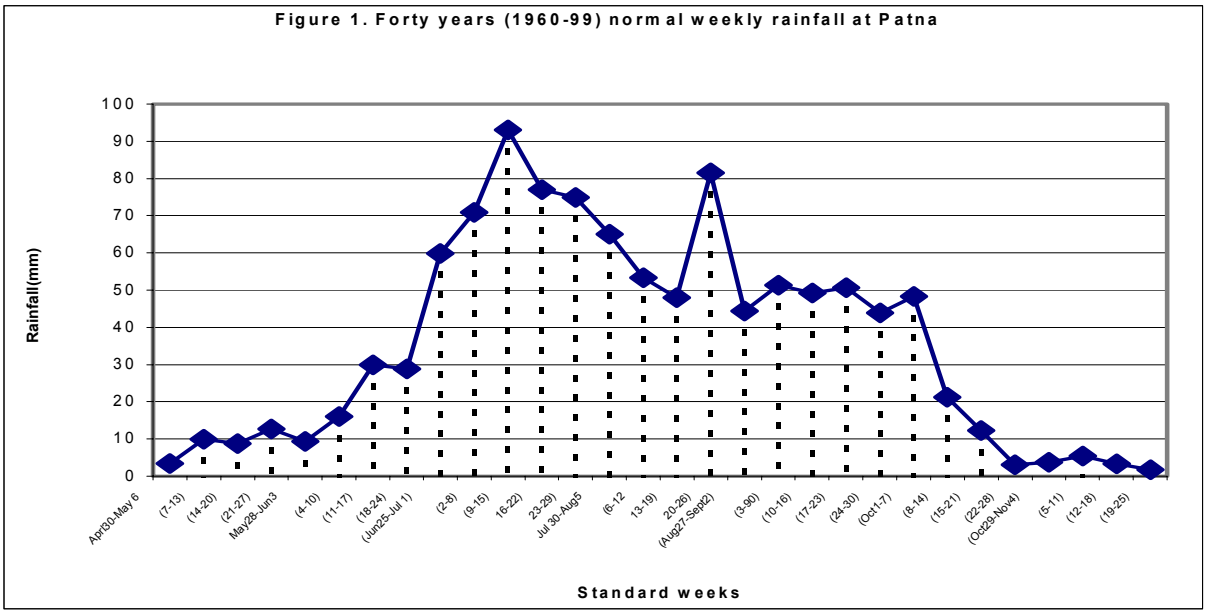
Table 1. Forty years (1960-1999) normal weekly rainfall at Patna

Std. Week	Month	Date	Rainfall (mm)	Std. Week	Month	Date	Rainfall (mm)
1	**January**	1-7	2.1	**26**	**July**	25-1	5□.□
2		8-14	1.4	**27**		2-8	7□.□
3		15-21	3.3	**28**		□-15	□3.1
4		**22-28**	**2.8**	**29**		16-22	77.1
				30		**23-29**	**74.9**
5	**February**	2□-4	2.7	31	**August**	3□-5	65.□
6		5-11	2.□	32		6-12	53.3
7		12-18	5.1	33		13-1□	48.□
8		1□-25	3.□	34		**20-26**	81.5
□	**March**	26-4	2.5	35	**September**	27-2	44.4
1□		5-11	2.4	36		3-□	51.3
11		12-18	2.6	37		1□-16	4□.2
12		1□-25	3.2	38		17-23	5□.7
				3□		**24-30**	**43.9**
13	**April**	26-1	1.3	4□	**October**	1-7	48.3
14		2-8	□.7	41		8-14	21.3
15		□-15	1.3	42		15-21	12.2
16		16-22	3.3	**43**		**22-28**	3.1
17		23-2□	6.1				
18	May	3□-6	3.5	44	**November**	2□-4	3.8
1□		7-13	□.□	45		5-11	5.5
2□		14-2□	8.8	46		12-18	3.3
21		21-27	12.7	**47**		1□-25	1.8
22	June	28-3	□.4	48	**December**	26-2	2.7
23		4-1□	16.□	4□		3-□	1.5
24		11-17	3□.□	5□		1□-16	2.□
25		18-24	28.8	51		17-23	2.1
				52		**24-31**	**5.0**

Annual rainfall = 1142.5 mm

The analysis of rainfall data (Singh et al.1□□6) of Patna has revealed that on an average (i) the rainfall during the period 18th June to 5th July for 18 days, and during 24th October to 1□th November for 18 days is greater than 5□percent of potential evaporation but less than potential evaporation, and (ii) the rainfall for 11□ days during the period 6th July to 23rd October is greater than potential evaporation. The authors have termed the aforesaid periods of moisture availability as Moist 1 (18th June – 5th July), Humid (6th July –23rd October), and Moist 2 (24th October- 1□th November) regimes. The moisture regimes for Patna are reported in Table 1.

The late harvesting also delays the sowing of lentil, Bengal gram and other rabi crops.



The optimum time of sowing lentil in central Bihar is 15th October to 15th November. The late sowing exposes the crop to low temperature and frost at the sensitive growth stage of flowering. This required optimization of rice transplanting together with other improved agronomic practices.

2.3 Strategy for technology promotion

The strategy was mostly focused at creating awareness about the technology, knowledge dissemination through communication products like leaflets, brochure etc, capacity building through conducting training workshops and camps in the field and limited strategic field demonstrations during the first year. Besides the visit of team of scientists from IRCER, volunteers of SHGs (SHGs formed under R-783□ by CIRRUS) were also encouraged to disseminate and promote the technology of optimizing rice transplanting dates and other improved agronomic practices.

The awareness and farmers' training camps were conducted in the canal command villages to emphasize on advancing the date of transplanting by 15-2□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 irrigations usually required by the late transplanted rice during its last growth phase. Sowing of nursery during last week of May, required a maximum of three irrigations by tube well water prior to the availability of canal water.

Land preparation for nursery raising

Scientific method for seedling raising

Improved method of rice transplanting

Effective use of rainwater in timely transplanting

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 1□□□farmers participated.

The team of scientists also advised the farmers to use improved cultivars like Pusa 44 and Pusa Basmati for short duration, and MTU 7□2□and MTU 1□□1 for long duration cultivations. In order to grow healthy nursery for transplanting 1.□ha area, the farmers were advised to sow 25 kg of good quality rice seeds in 1□□□ m^2 bed as against their normal practice of sowing 6□-7□ kg seed from 25th May to first week of June. A balanced basal dose of 5 kg urea, 11 kg single supper phosphate, 1.5 kg muriate of potash, and 2.□kg zinc sulphate was applied in nursery bed. The farmers were told to apply 1□4 kg urea, 36□kg SSP, 6□kg MOP and 2□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 2□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. Traditionally the farmers were transplanting 8-12 seedlings per hill and were using only urea as fertilizer. 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 5□% EC) in 15 kg of sand and broadcast in one-hectare rice field between fourth to seventh day after transplanting. The team also suggested three top dressings of rice

fields by urea at the rate of 1□4 kg urea in two splits at tillering and flowering as top dressing, besides plant protection measures.

The scientists of the ICAR Research Complex for Eastern Region, Patna, organized several farmers'-scientists' interaction on improved wheat production technology in different villages. Farmers were advised to use balance dose of N: P: K at the rate of 12□:6□:4□ kg/ha. Thus in one hectare 21□ kg urea, 13□ kg DAP and 65 kg muriate of potash were applied. Full dose of phosphorus (13□ kg DAP), potash (65 kg MOP) and half the dose of urea (1□5 kg) were applied at the time of sowing as basal dose and the remaining urea was applied in two-split doses at the time of first and second irrigation. *Phalaris* minor, a narrow leaf weed resembling wheat plant, was the major weed infesting wheat fields, sometimes up to 6□ % of the total plant population. In order to control this menacing weed, Isoproturan @ one kg a.i./ ha was applied between 3□-35 days after sowing of the wheat crop.

In the absence of the field channels, the farmers of the Sone canal command apply uncontrolled field-to-field irrigation to rice as well as wheat crops. In this way they apply heavy watering to the cropped fields, and make wasteful use of water. The farmers were advised to apply light irrigation of 5-7 cm such that the irrigation water does not stagnate in the cropped field for more than 12 hrs as wheat crop is affected by water logging. They were further advised to apply irrigation depending upon the availability of irrigation water, it is evident that a maximum of four irrigations at an interval of 2□-25 days are required to alleviate moisture stress to wheat crop.

3. Results and Discussion

3.1 Timely nursery raising of rice

It is evident form the Table 2 that 87% 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 2□ villages of RPC-V during 2□□2 in head, middle and tail end was completed by 27th standard week.

Table 2. 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 (%)
22nd (28 May-□1June)	□25	1.16	1.16	□52	1.46	1.46	□2□	□88	□88
23rd (□4 June-1□June)	□375	1.74	2.□□	NIL	NIL	NIL	3.□□	17.26	18.14
24th (11 June-17 June)	1.□□4	8.83	11.73	3.4□	□57	11.□3	7.□8	35.32	53.46
25th (18 June-24 June)	11.1□	52.□4	63.77	13.1□	37.15	48.18	6.□□	26.56	8□.□2
26th (25 June-□1 July)	7.7□5	35.81	□□58	18.3□	51.82	1□□.□□	4.1□	18.54	□8.56
27th (□2 July-□8 July)	□.□8	□42	1□□.□□	NIL	NIL		□31	1.44	1□□.□□
Total area in villages	21.5□4	1□□%		35.5□	1□□%		22.5□		

Table 3. Number of farmer's sown nursery in head, middle and tail end (2002).

Std. Week	Head			Middle			Tail end		
	Total No. of farmers	Week wise (%)	Cumu-lative (%)	Total No. of farmers	Week wise (%)	Cumu-lative (%)	Total No. of farmers	Week wise (%)	Cumu-lative (%)
22nd (28 May-3 June)	2	0.73	0.73	8	1.56	1.56	2	0.52	0.52
23rd (4 June- 10June)	3	1.10	1.83	NIL	NIL	1.56	61	15.92	16.44
24th (11 June-17June)	13	4.70	6.62	40	7.82	9.38	150	39.16	55.60
25th (18 June-24June)	140	51.66	58.28	191	37.37	46.75	91	23.75	79.35
26th (25June-1July)	111	40.95	99.23	272	53.23	100.00	74	19.32	98.67
27th (2 July – 8 July)	2	0.77	100.00	NIL	NIL	100.00	5	1.33	100.00
Total no. of farmers in each village	**271**	**100.00 %**	**--**	**511**	**--**	**--**	**383**	**--**	**--**

It is evident from the Table 3 that more farmers (511) were engaged in raising seedlings in middle reach followed by tail end (383) and head reach (271). In general, maximum (> 38%) nursery was raised during 3rd and 4th week of June in head and middle reach, whereas in tail end it was in 2nd and 3rd week of June.

3.2 Timely rice transplanting

Table 4 gives the percentage of farmers fields transplanted in different weeks during kharif 201. The sample has been drawn from 135 ha area in 2 villages. It is revealed from Table 4 that the bulk of the transplanting to the tune of about 45.0% took place during 16-26th July corresponding to 25th and 35th weeks. Only about 1.74% area was transplanted on 2nd to15th July (27th and 28th week). But more than 50% of transplanting was done after 35th week and continued upto 35th week due to dry spell in the beginning of July, 201 whereas the percentage decreased to 16.84% during kharif 202 due to dry spell and unavailability of rain and canal water.

Table 4. 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 farmers field trans-planted (2001)	Cumul-ative Percent age (2001)	Area trans-planted (ha) (2002)	Percentage of Farmers' field transplanted (2002)	Cumul-ative Percentage (2002)
26th(25 June-1 July)	--	--	--	41	0.4	0.4
27th(2 July-8 July)	5.64	4.17	4.17	11.76	1.43	1.47
28th(0July-15 July)	0.1	6.67	10.74	32.76	3.8	5.45
29th(16 July-22 July)	30.68	22.70	33.44	44.81	5.46	10.90
30th(23 July-29July)	17.10	12.65	45.90	48.83	5.95	16.84
31st(30July-5 Aug.)	13.13	9.71	54.80	128.54	15.65	32.48
32nd(6 Aug.- 12Aug.)	14.54	10.71	65.51	164.17	19.98	52.46
33rd(13 Aug.-19Aug.)	29.15	21.57	87.08	203.67	24.78	77.46
34th(20Aug.-26 Aug.)	13.46	9.96	97.04	140.98	17.15	94.42
35th(27 Aug.-2 Sept.)	2.45	1.81	100.00	45.93	5.58	100.00
Total	**135.16**	**100.00**	**--**	**820.86**	**100.00**	**--**

Rice transplantation in different reaches of the canal command in RPC-V i.e. head (5 village), middle (6 village) and tail end (village) presented in Table 5 revealed that area transplanted in head, middle and tail end up to 2 th July, 2 2 was 2.6 %, 16.11% and 65.65%, respectively. Transplanting in head and middle reach was meager due to unavailability of canal water and delay in rainfall resulted in dry spell during July, 2 2. Total area transplanted in head, middle and tail end was 36 6 ha, 352. 2 ha and 1 3 ha, respectively. Initially area transplanted in head and middle reach was less but later on it was observed that farmers of all reaches completed their transplanting in more than % of the area before 34th week (2 26 August).

Table 5. Rice area transplanted in different standard weeks during kharif 2002 in the command of head, middle and tail reach in R.P.Channel-5.

Std. Week	Head Reach – 5 villages			Middle Reach – 6 villages			Tail End - 9 villages		
	Area trans-planted (ha.)	Area trans-planted (%)	Cumu-lative (%)	Area trans-planted (ha.)	Area trans-planted (%)	Cumu-lative (%)	Area trans-planted (ha.)	Area trans-planted (%)	Cumu-lative (%)
26th(25June- 1July)	NIL	NIL	NIL	NIL	NIL	NIL	41	37	37
27th(2 July -8July)	37	1	1	2.5	7	7	8.8	8.12	8.4
28th(July -15July)	5	13	23	7.	1. 8	2.68	25.26	23.	31.58
2 th(16 July -22July)	2. 5	56	7	1 35	5.48	8.16	23.41	21.4	52. 8
3 th(23 July -2 July)	6.87	1.	2.6	28.	7. 5	16.11	11.87	12.67	65.65
Timely transplanting	**9.79**	**2.69**	2.6	**56.99**	**16.11**	16.11	**69.84**	**65.65**	65.65
31st (3 July- 5Aug)	1. 4	25.24	27. 3	31.17	8.83	24. 4	6.33	5.78	71.43
32nd(6Aug -12Aug)	127.45	35.34	63.27	33.48	48	34.42	3.24	2. 6	74.3
33rd(13 Aug -1 Aug)	55.88	15.4	78.76	131.23	37.18	71.6	16.56	15.13	8 52
34th (2 Aug -26Aug)	6 47	16.76	5.52	72.65	2 58	2.18	7.86	7.18	6.7
35th(27Aug- 2Sept.)	15. 7	4.48	1	27.4	7.76	1	2.56	3.3	1
Late transplanting by farmers	**350.81**	**97.29**	--	**295.93**	**83.89**	--	**37.55**	**34.35**	--
Total (timely + late) transplanting	**360.60**	1	--	**352.92**	1	--	**107.39**	1	--

It is evident from the Table 6 that maximum transplanting was done using canal water (63%), followed by rainfall (26%) and tube well (1 %). The farmers of head, middle and tail reach have used canal water whereas only tail end farmers have used tube well water for transplanting.

Table 6. Percentage distribution of source of irrigation in field during transplanting in R.P. Channel-5

Standard Week	Rainfall	Tube well	Canal
26th (25 June-1 July)	12	NIL	NIL
27th (2 July-8 July)	1.32	NIL	1.66
28th (July-15 July)	8.24	27	NIL
2th (16 July-22 July)	2.7	5.	NIL
3th (23 July-2July)	2.	4.55	NIL
31st (3July-5 Aug.)	2.26	33	157
32nd(6 Aug.- 12 Aug.)	8	NIL	15.18
33rd (13 Aug.-1Aug.)	5.4	NIL	18.51
34th (2Aug.-26 Aug.)	2.72	NIL	12.65
35th (27 Aug.-5 Sept.)	78	NIL	4.27
Total	**26.34**	**10.15**	**62.84**

Percent distribution of farmer's field dependent on different sources of irrigation in head, middle and tail end in RPC-V is presented in Table 7. It is evident from the data that 7% and 88% farmers of head and middle reach were dependent on canal irrigation whereas in tail end only 5.% farmers were dependent on canal irrigation. Farmers of tail end (28%) used tube well water for transplanting.

Table 7. 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	Head			Middle			Tail		
	Rain fall	Tube well		Rain fall	Tube well	Canal	Rain fall	Tube well	Canal
26th (25 June-1 July)	NIL	NIL	NIL	NIL	NIL	NIL	37	NIL	NIL
27th (2 July-8 July)	1	NIL	NIL	76	NIL	NIL	3.12	NIL	5.
28th (July-15 July)	13	NIL	NIL	1.5	83	NIL	23.	NIL	NIL
2th (16 July-22 July)	56	NIL	NIL	1.43	NIL	NIL	6.4	15.	NIL
3th (23 July-2July)	1.	NIL	NIL	4.37	1.	NIL	NIL	12.67	NIL
31st (3July-5 Aug.)	NIL	NIL	25.2	1.	1.	6.51	5.78	NIL	NIL
32nd (6 Aug.- 12 Aug.)	NIL	NIL	35.34	NIL	NIL	121	2.6	NIL	NIL
33rd (13 Aug.-1Aug.)	NIL	NIL	15.5	NIL	NIL	45	15.13	NIL	NIL
34th (2Aug.-26 Aug.)	NIL	NIL	16.8	1.	NIL	21.17	7.18	NIL	NIL
35th (27 Aug.-5 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**

Table 8. Rice area transplanted in different standard weeks by number of farmers in head, middle and tail end in R.P.Channel-5.

Std. Weeks	Head reach		Middle reach		Tail end	
	No. of farmers	% of farmers	No. of farmers	% of farmers	No. of farmers	% of farmers
26th (25June-□1July)	NIL	NIL	NIL	NIL	4	1.1
27th (□2July-□8July)	1	□18	□	□81	21	6.□□
28th (□□July-15July)	2	□37	8	□72	58	16.71
2□th(16 July -22July)	11	2.□7	32	2.□1	67	1□3□
3□th(23 July -2□July)	28	5.28	58	5.28	47	13.54
Timely transplanting	**42**	**7.90**	**107**	**9.72**	**190**	**55.55**
31st (3□July-□5Aug)	14□	26.36	5□	4.55	2□	8.3
32nd (□6Aug -12Aug)	18□	33.8□	71	6.46	11	3.1
33rd (13Aug -1□Aug)	□2	17.32	353	32.74	63	18.15
34th (2□Aug -26Aug)	63	11.86	2□□	26.41	34	□7
35th (27Aug-□2Sep)	14	2.63	227	2□67	2□	5.7
Late transplanting	**489**	**92.10**	**991**	**90.28**	**157**	**45.25**
Total no. of farmers	**531**	**100**	**1098**	1□□.□□	**347**	1□□.□

It is evident from Table 8 that less than 1□% farmers completed their transplanting in time in head and middle reach whereas in tail end more than 5□% farmers completed their transplanting in time.

3.3 Efficient 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 3□ 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 2□, and August 2□to 26th corresponding to 26th, 3□th, and 34th weeks during the Kharif season 2□□1 was 721.8 mm (66.1%), 5□□4 mm (54.□%) and 471.4 mm (43.2%), and the corresponding figures for the kharif 2□□2 were 87.5 %, 5□5 %, and 21.1 %. respectively.

Table 9. 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		
	2□□1	2□□2	Forty years average
26th(25 June-□1 July)	721.8	8□4.5	□65.2
27th(□2July-□8 July)	686.4	673.□	□□5.3
28th(□□July -15 July)	647.2	63□5	834.4
2□th(16 July -22 July)	638.1	614.5	741.3
3□th(23 July -2□July)	5□□4	6□8.3	664.2
31st(3□July –□5 Aug)	574.5	431.□	58□3
32nd(□6 Aug -12 Aug)	567.2	257.□	524.3
33rd(13 Aug -1□Aug)	524.6	224.4	471.□
34th(2□Aug -26 Aug)	471.4	215.5	432.□
35th(27Aug.- □2 Sept)	356.8	213.3	285.□

Rainfall between June-11 to December-□2 For the year 2□□1 & 2□□2 = 1□□2 mm & 1□22 mm

Cracks formation due to non-availability of irrigation water in rice crop

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, 1□□4).

3.4 Increased rice yield

The effect of dates of transplanting on rice yield, as observed in farmers fields during kharif 2□□1 and 2□□2, is reported in Table 1□. 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 2□□1 and 2□□2, were obtained with the help of the farmers in the commands of RPC-V. Each data point of 2□□1 and 2□□2 are average of 2 to 5 harvests.

Rice transplanting was started in RPC-V from 26th standard weeks (□-15 July) and continued up to 35th weeks (27 Aug- 3 Sep). Majority of the farmers completed their transplanting in between 2□th 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, □1, 15.2, 16.7, 1□7, 24.2, 34.8 and 51.5%, respectively during 2□□1 and 2□□2 (Table 1□). It indicates that the transplanting of rice should be done in between 27th –2□th week, to increase the grain yield of rice 2 folds. The yield of rice transplanted in subsequent weeks was 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 form the farmers' fields spread over 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.* 2□□2).

Effect of optimization on rice crop at maturity stage

Table 10. 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	
	2□□1	2□□2	Pooled		2□□1	2□□2
26th(25 June –□1July)	6.□	6.3	6.6	--	1.□	1.□
27th(□2 July -□8 July)	6.7	6.4	6.5	1.5	□.□71	1.□15
28th(□□July -15 July)	6.5	5.8	6.1	6.1	□.□42	□.□21
2□th(16 July -22 July)	6.2	5.6	5.□	□1	□8□8	□888
3□th(23 July -2□July)	5.□	5.4	5.6	15.2	□855	□857
31st (July 3□-Aug □5)	5.7	5.3	5.5	16.7	□826	□841
32nd(□6 Aug -12 Aug)	5.6	5.1	5.3	1□2	□812	□8□□
33rd(13 Aug -1□Aug)	5.2	4.8	5.□	24.2	□754	□762
34th(2□Aug -26 Aug)	4.4	4.3	4.3	34.8	□638	□683
35th(27Aug.-□2Sept.)	3.1	3.2	3.2	51.5	□44□	□5□7

Effect of age of seedling on grain yield of rice is presented in Table 11. It has been observed that 2.88, 1.46 and 53.57% seedlings (3□-4□ days old), 6□88, □57 and 25.66% seedling (4□-45 days old) and remaining 36.18, 37.□□ and 18.54% seedling (5□-55 days old) were transplanted in head, middle and tail end, respectively. There is a direct correlation between age of seedling and yield of rice crop. It has been observed that when the age of seedling is more than 3□ – 4□ days, there is reduction in grain yield of rice in all the reaches irrespective of availability of rain, canal and tube well water. It is also interesting to note that more than 6□% & 75% transplanting was completed in head and tail end whereas only 11% transplanting was completed in the middle reach up to 3□th weeks.

Table 11. Effect of age of seedling on yield of rice crop during 2002.

Std. Weeks	Head reach		Middle reach		Tail end	
	Age of seedling	Yield (q/ha)	Age of seedling	Yield (q/ha)	Age of seedling	Yield (q/ha)
26th(25 June –1 July)	3	66.	3	6 38	3	62.66
27th(2 July – 8 July)	3	67.	3	61.5	3	63.5
28th(July –15 July)	35	64.2	35	56.3	35	54.44
2 th(16 July –22 July)	4	58.44	4	56.34	4	53.32
3 th(23 July –2 July)	45	54.38	45	55.38	45	52.22
31st(3 July - 5 Aug)	45	54.22	45	53. 2	45	51.1
32nd(6 Aug –12 Aug)	5	53.	5	5 5	5	4 5
33rd(13 Aug –1 Aug)	5	51.	5	48.	5	46.
34th(2 Aug –26 Aug)	5	48.	5	43.	5	38.
35th(27 Aug - 2 Sept)	55	35.7	55	3 58	55	2 8

3.5 Adoption of rice production technology:

The rice production technology was demonstrated in two villages namely Bedauli and Saharampur in the commands of RPC-V distributary during Kharif season of 2 1 to demonstrate and test the recommended production package on farmer's fields. 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*. (2 2). The farmers adopted the recommended practices in 111.2 ha in Sahar Rampur 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 system approached us to seek technical know how and adopt their villages.

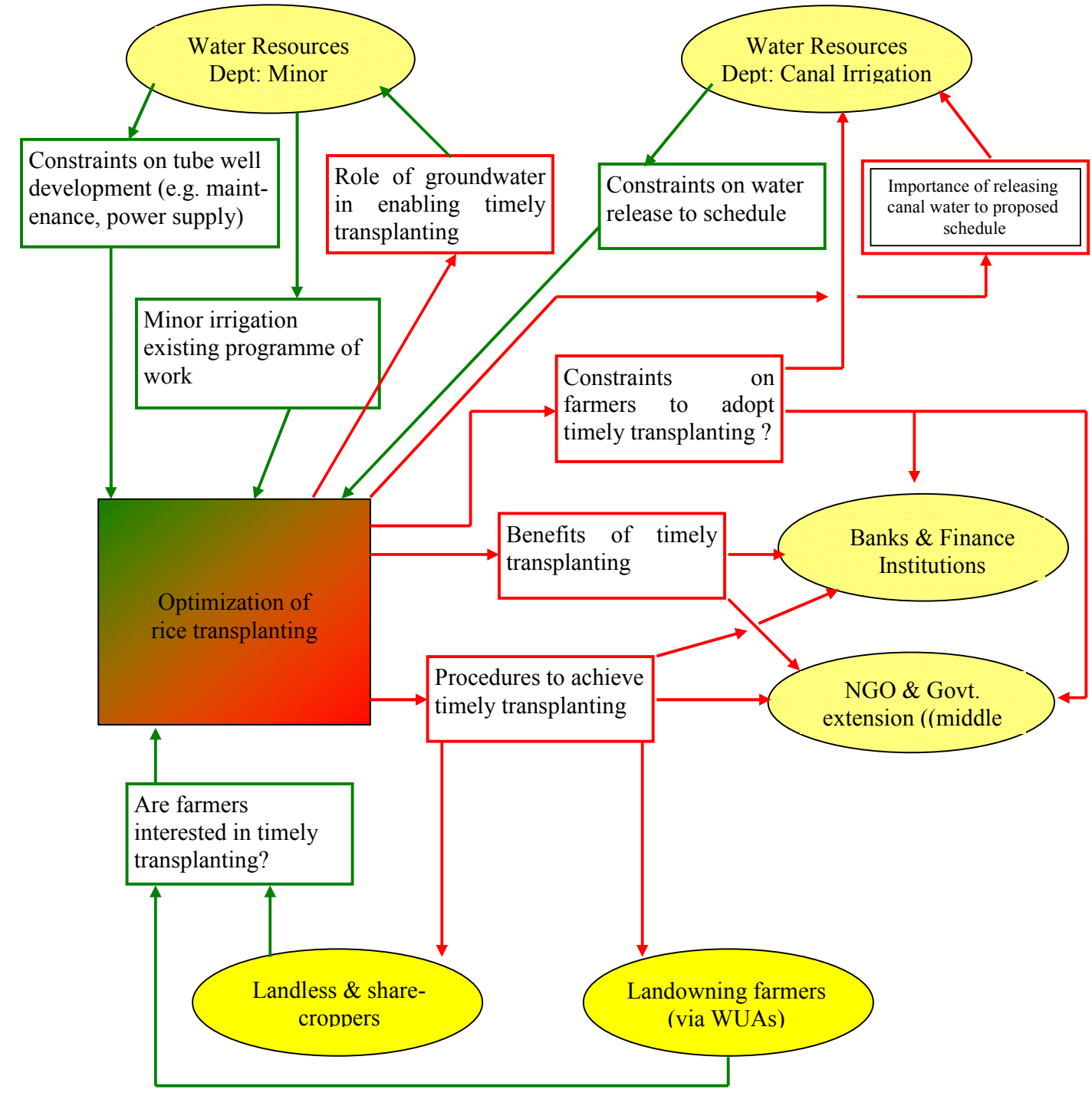
Timely and late transplanting of rice

Maximum vegetative stage of rice crop

The scientists of the ICAR Research Complex for Eastern Region conducted surveys in 2 villages in RP Channel- 5 distributary about the date of transplanting of rice by the farmers who have adopted the improved rice production technology. The sample area comprised of 135 ha. Consequently during kharif 2□□2, the farmers in the commands of RPC-V followed the improved methods of rice production in 82□86 ha spread in 2□villages (Singh et.al. 2□□4), as given below.

Name of the distributary	No. of villages in the command	Culturable command area, ha	Adoption of improved crop production technology							
			Rice technology in Kharif-2□□1		Wheat technology in Rabi 2□□1-□2		Rice technology in Kharif-2□□2			
			No. of villages	Area, ha	Villages	Area, ha	No. of villages	Area, ha	Partial adoption	
									No. of Villages	Area, ha
RPC-V	2□	22□3	□2	135	□2	135	2□	82□86	2□	22□3

3.6 Communication map for optimization of rice transplanting



3.7 Improved wheat production technology

Delayed sowing of wheat is one of the major constraints in the command of Sone canal system that results in low crop yields. Farmers were advised to use zero-till seed drill for proper placement of seed as well as basal fertilizers. Weed infested fields were ploughed once before seeding using either a tractor drawn cultivator or country plough. No ploughing was done to the fields having lesser weeds, and seeds were sown directly by zero-till seed drill. In this way the farmers were able to save ten to fifteen days time which they were using for land preparation. Seed rate of 12□kg/ha for early sowing, and 14□kg/ha for late sowing was recommended.

Effect of timely sowing of wheat crop at tillering stage

3.8 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. The average (maximum, minimum) temperatures at Patna during Nov 5-11, Nov 12-18, Nov 1□-25, and Nov 26 to Dec □2 has been observed to be (24.74), (23.□4), (21.28) and (18.4□) °C during 2□□1-2□□2 and (24.8□), (23.74), (22.48) and (1□86) °C during 2□□2-2□□3, respectively.

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 1□-25, November 26 to December 2, December 3-□, Dec. 1□–16, Dec. 17-23, and Dec. 24-31 during 2□□1-2□□2 and 2□□2-2□□3 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 x 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 percent.

The data presented in table 12 reveals the effect of date of sowing of different wheat cultivars on crop yield during the rabi season of 2□□1-2□□2 and 2□□2-2□□3. Wheat sown during the period November 1□-25 has yielded maximum grain during both the years. Likewise, the

Table 12. 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 (t/ha)	Actual relative average yield (%)
	2□□1	2□□2	2□□1	2□□2		
47th(1□Nov.-25 Nov.)	4.□	5.1	1.□	1.□	5.□	1.□
48th(26 Nov.-□2 Dec.)	4.1	4.□	□84	□78	4.1	□82
4□th(□3 Dec.-□□Dec.)	3.6	3.3	□73	□65	3.5	□7□
5□th(1□Dec.-16 Dec.)	3.2	3.2	□66	□63	3.2	□64
51st(17 Dec- 23 Dec.)	3.2	3.1	□65	□61	3.2	□64
52nd(24Dec.-31 Dec.)	2.5	2.5	□5□	□51	2.5	□5□

Ry_w = relative yield of wheat

Relative yield is a measure of the fraction of maximum yield that has been achieved by sowing wheat in different weeks. As the data have been collected from the farmers' fields spread over 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. Data indicates the decline in wheat yield in comparison to the maximum yield of November 1□-25 by 18, 3□, 36, 36 and 5□ percent, respectively, when sown during the weeks November 26-December 2, December 3-□, December 1□-16, December 17-23, and December 24-31 during the rabi season 2□□1- 2□□2 and 2□□2-2□□3 respectively.

3.9 Impact of optimization of rice transplanting

- Direct interview was conducted with 15□ farmers in different reaches of RPC-V on livelihood improvement through optimization of rice transplanting in participatory mode.
  - Farmer's expressed their views on different aspects of crop production before and after interventions. The response was quit encouraging in terms of reduction in seed rate, number of irrigation for nursery raising and crop production, timeliness of nursery raising and transplanting, use of quality seed, fertilizer and insecticides, employment generation and increased production.
  - Farmers informed that there are psychological changes in farming community for growing of different agricultural crops like pulses, oilseeds, vegetables, cash crop and enhance input use efficiency.
  - Problems encountered by the farmer's included lack of capital, timely water supply, seed, fertilizer, control of insect, pest & disease, labour & minimum support price in all the seven distributaries of Sone Command.
- Trainings helped the farmers in adoption of improved rice and wheat production technologies. During kharif 2□□1, the farmers of 2 villages in the RPC-V adopted timely sowing of rice nursery using tube well water sufficient for transplanting 135.1□ha area. Consequently as a result of our communication strategy and results of previous year, the farmers in the commands of RPC-V followed the improved methods of rice production in 82□86 ha spread in 2□ villages during kharif 2□□2. Early nursery raising and transplanting of rice helped its early harvesting, thereby making the fields available for

timely sowing of wheat (Singh *et. al.* 2□□4). Now the technology has spread to 178 villages of seven distributaries of Sone Command.

- SHG members showed their interest to take up quality seed production of vegetable, rice and wheat, mushroom cultivation, bee keeping and dairy in the project area.
- There is knowledge up gradation in the farming community for efficient use of rainwater for timely community nursery raising, self reliance by means of micro financing, utilizing income derived from ORT for purchase of consumer durables like TV, clothes, and investment in education and medical care. Some farmers purchased farm implements such as power sprayers, tractor and zero tillage machines for adoption of improved farming practices.

4. Conclusions

- Rice transplanted during the week 25th June to 1st July in kharif 2□□1 & 2□□2 gave higher average yield of 6.6 t/ha while late transplanting during last week of August resulted in reduction of yield up to 52 per cent.
- Maximum wheat yield (5.□ t/ha) was obtained, when wheat crop was sown in the weeks of November 1□-25 but normally when wheat crop is sown in the last week of December, the yield is reduced by 5□per cent.
- The total production of rice and wheat has increased to the tune of 11-12 t/ha in the command of RPC-V. This is helping the farmers to take better care of their family as regards to higher education, health care and discharging social liabilities.
- In order to achieve higher crop yields, it is essential to install large number of shallow tube wells in the canal command so that favourable soil moisture regime for rice-wheat and other production systems could be maintained.
- This study also generated new knowledge and understanding that ORT facilitated the conjunctive use of ground water and emergence of ground water market. It has been observed that during non-availability periods of canal water the ground water sale by same service providers increased from Rs. 42,□□□/- in 1□□□- 2□□□ to Rs. 1.□4,55□/- in 2□□3-□4 registering a hike of 2.5 times.

4.1 Lessons learnt

- Management of natural resources by mutual co-operation of the farmers and develop suitable technology through farmers-scientist interaction.
- Landless, sharecropper or small-scale and marginal farmers do not consider development or incurring heavy expenditure on creating infrastructure for improved land and water management practices as their prime priority. Therefore, cost effective and low cost technologies like ORT when promoted through participatory process received appreciation.
- Improvements in the poor financial capacity of SHG members require strong linkages with financial institutions such as Banks, NGO's and other Government developmental agencies.

4.2 Policy issues

- Promotion of ORT may lead to conjunctive use of rain, ground and canal water. It was evidenced through increase in the number of pumping hours and an enhanced groundwater market. These indicators suggest a change in practice to support growth in adoption of conjunctive use of groundwater in the command area through encouraging policy on installation of shallow tubewells.
- Timely release of canal water by the Department of Water Resources, Govt. of Bihar for nursery raising and transplanting and this became effective also (ANNEX B-xii, State level sensitization workshop proceedings).

4.3 Strategies for scaling up of ORT

- Raising of community nursery of rice started in Bedauli and Bavanauli villages for selling seedlings to the farmer's, those who did not raise the nursery in time.
- Seed production in rice crop was initiated in three villages of RPC-V namely Aspura, Bedauli and Harpura involving 27 farmer's covering an area of 12.1 ha. In standing crop, roughing was done for pure seed production. The crop was harvested in the month of November, 2□□3. Farmers are using vacated land for wheat crop. Seeds produced by the farmers are of good quality and free from disease and pest.
- A committee comprising of ICAR-RCER and SAU's scientists visited all the fields of Aspura, Bedauli and Harpura and suggested methodology for sorting out odd type plants in the standing crop of rice. Farmer's adopted the same and were engaged in processing and packing of seed. A committee is also proposed to certify the quality of the seed for future use and disposal. They are also approaching certifying agencies, Govt. of Bihar for the disposal of the quality seed produced by them for future use.

5. References

Anonymous 1□□4. Reports of the second Bihar State Irrigation Commission, Govt. of Bihar, Patna (India).

Das, P.K. and N. Subash 2□□1. Forty years (1□6□-1□□□) normal weekly rainfall at Patna (Personnel Communication) DWMR, Patna.

Singh, R.D., Gautam, U.S., Kumar, Rakesh and J.P., Singh 2□□2. On-farm trial on optimization of rice transplanting in RPC-V of Sone Command. National seminar on sustainable management of water resources for enhanced agricultural production. Organized by Indian Society of Water Management, Water Technology Centre, IARI, New Delhi.

Singh, R.D., Sikka, A.K., Gautam, U.S. and S.R., Singh 2□□4. Participatory diagnostic Analysis and yield optimization in rice-wheat system of a canal command area pp27□-271. In National conference on resource conservation technologies for social upliftment. In: Indian Association of Soil and Water Conservation, CSWCR & TI, Dehradun, NASC Complex, New Delhi, Dec. 7-□, 2□□4.

Singh, S.R., Gautam, U.S., Rahman, A., Kumar, Ujjawal and S.K., Sinha 2□□2. A systems approach to enhance rice-wheat productivity Sone Command. Bulletin no.-3. ICAR RCER, Patna.

Singh, V.P., A.S.R.A.S. Sastri, S.S. Baghel and J.L., Chaudhary 1□□6 Agro-climatic Atlas of Eastern India, Volume I. Indira Gandhi Agricultural University, Raipur, India.