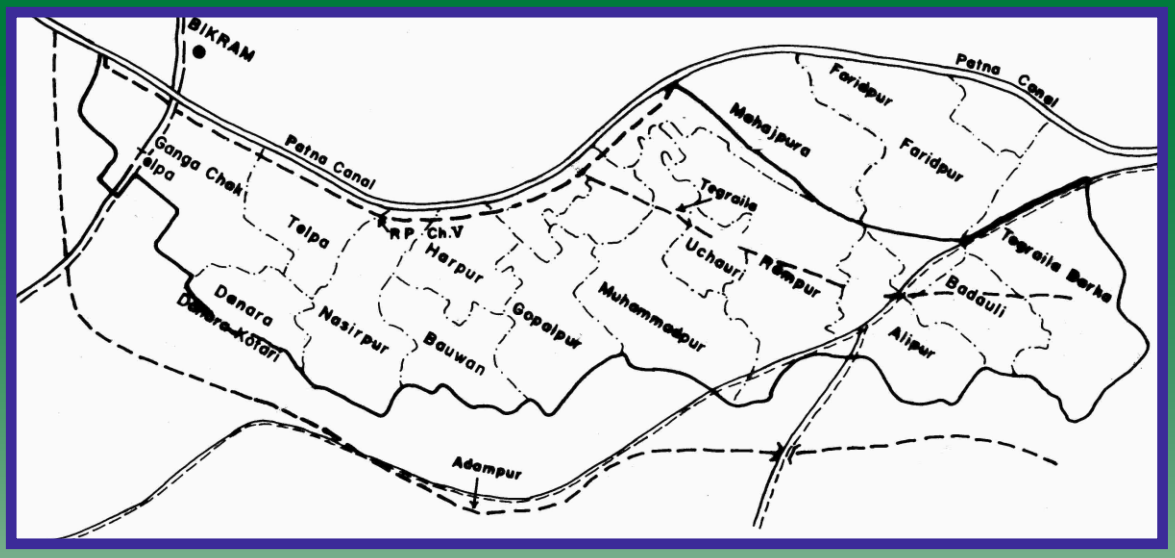
Exploring Options for Conjunctive Use of Surface and Ground Water in Canal Command of Bihar

Ashutosh Upadhyaya



ICAR Research Complex for Eastern Region
ICAR Parisar, P.O. Bihar Veterinary College
Patna-800 014, Bihar

Exploring Options for Conjunctive Use of Surface and Ground Water in Canal Command of Bihar

Ashutosh Upadhyaya

ICAR Research Complex for Eastern Region
ICAR Parisar, P.O. Bihar Veterinary College
Patna-800 014, Bihar

Correct Citation:
Upadhyaya, A. 2012. Exploring options for conjunctive use of surface and ground water in canal command of Bihar. Technical Bulletin No. R-36/PAT-24, ICAR Research Complex for Eastern Region, Patna, pp. 22.

Technical Bulletin No. R-36/PAT-24

Exploring Options for Conjunctive Use of Surface and Ground Water in Canal Command of Bihar

Ashutosh Upadhyaya
ICAR Research Complex for Eastern Region, Patna

Year : 2012

Published by the Director, ICAR Research Complex for Eastern Region, Patna-800 014, Bihar.
Laser typeset and Printed in The Composers Press, 2151/9A/2, Behind Shadipur Petrol Pump, New Patel Nagar, New Delhi-110 008. Tel.: 011-25707869; (M) 9810771160

CONTENT

Summary

India is perceived to be endowed with large and reasonably good land and water resources, but with alarming increase in population, per capita resource availability is progressively decreasing, whereas challenge to produce more from these finite resources to feed ever increasing population is increasing. Better utilization and management of land and water resources seems the only feasible way to increase production on sustainable basis.

Bihar in general and Patna in particular, though sufficient rain, surface and unexplored good quality ground water is available, yet crop production is poor, which is a matter of concern and investigation. Unfortunately, due to drought like situation in the current year, the yield is further expected to go down. Under such constraints, perfect blending of information, technology and management may show us the path of enhancement in crop production. Keeping this in view, data/ information about land use, rainfall pattern, stage of ground water development, and area irrigated by various sources at Patna were collected and Bikram block where stage of ground water development is least i.e. 28.9% was selected for study. It was realized that due to delayed transplanting of rice or sowing of wheat, yield of rice and wheat reduced drastically.

Timeliness in sowing/transplanting operation gives much better yield, which was evident from couplets of great Agro-meteorologist and poet 'Ghagh'. In order to maintain timeliness in establishing rice nursery and transplanting or sowing of wheat, use of ground water through tube well in the absence of any other source of water is essential. So explore and promote conjunctive use options (use of rain, surface and ground water jointly or separately) in canal command to improve crop production. Farmers of the selected area were interviewed to know the constraints in adoption of conjunctive use practice in the area.

According to farmers, major constraints in adoption of conjunctive use practice were: (i) no land consolidation, (ii) uneconomical because it needs high initial investment, (iii) high recurring expenditure due to hike in price of diesel, (iv) frequent power failure, (v) lack of awareness about selection of pump, motor/engine as per farmers' requirement and source of loan/funding, (vi) lack of trained manpower to efficiently operate and timely maintain the pump, engine/motor and other attachment, and (vii) difficulty in transportation.

Famers also shared their valuable experience about timeliness and informed that if rice nursery is established in Rohini Nakshtra through ground water in the absence of canal or rain water, not only the yield of rice increases to the tune of 10-15 kg/Katha (1 Katha = 125 m^2) but due to timely harvesting of rice, wheat is also sown in time and its yield increases to the tune of 5-8 kg/Katha. This experience was quite encouraging and with the help of selected example farmers could be convinced more effectively about advantages and applicability of conjunctive use practice in canal command. After interaction with scientists and farmers and

knowing indigenous technical knowledge, it was realized that scope for promotion of conjunctive use practice exists in the canal command because it helps in increasing yield of rice and wheat crops by maintaining timeliness in sowing/transplanting time.

Keeping this in view a decision support tool in English was developed employing Visual Basic Platform and data collected from farmers was analyzed and demonstrated to farmers. Since decision support tool is users friendly and interactive, it was found quite capable of exploring conjunctive use options and convincing farmers to adopt conjunctive use options under various situations like (i) own tube well, (ii) Renting pumping set to run tube well and (iii) Purchasing water from tube well owners. This tool can be effectively utilized to convince farmers, researchers, planners and policy makers about importance and applicability of conjunctive use.

1.0 Introduction

India is perceived to be endowed with large and reasonably good land and water resources, but with alarming increase in population, per capita resource availability is progressively decreasing. Immense pressure on our natural resources can be gauged from the fact that India shares 2.45 % geographical area and 4% fresh water resource of the world while supports 16% population and 18% livestock of the world. Earlier irrigation was treated as protective measure to save the crop from drought like situation but later on irrigation was being realized as productive measure to increase agricultural productivity. Singh et al. (2002) reported that the net irrigated area increased by 24% during 1980-81 to 1990-91 and by 18% from 1990-91 to 2000-01. Over the past 15 years, increase in irrigated area has mainly taken place from ground water source. It has also been indicated that yields in groundwater irrigated areas are higher by one third to one half than in areas irrigated from surface sources, and as much as 70-80% of India's agricultural output may be groundwater dependent. Groundwater expansion growth rate in Bihar is only 1.25 %, which is the lowest compared to other states in India. Poor development/ lesser use of groundwater has been identified as one of the constraints in enhancement of agricultural production in Bihar. It seems quite possible to enhance agricultural productivity and farmer's income in Bihar, provided groundwater is utilized efficiently and judiciously in crop production system.

2.0 Objective- Why this Project?

In Patna, normal onset and withdrawal dates of monsoon are June 15 and October 5, respectively and average annual rainfall is 1122 mm. On the basis of 42 years daily rainfall data analysis at Patna it was found that on average 134 mm, 340 mm, 260 mm and 205 mm rainfall occur during June, July, August and September months with 6, 13, 12, and 10 average rainy days, respectively. In Patna, normally the rainfall of 110 days (July 06 to October 23) is more than total evaporation during this period and the rainfall of two 18 days spells i.e. (June 18 to July 05) and (October 24 to November 10) is more than 50% of evaporation. As per present trend, in Patna District, rice nursery is established in about 20% area during Rohini Nakshtra (May 25 to June 06), about 80 % area during Adra Nakshtra, and negligible area during Mrigshira Nakshtra (June 07 to 21). The reason for not establishing rice nursery during Mrigshira Nakshtra is a blind belief of farmers. According to them mother earth has menstrual cycle during this period and farmers don't like disturbing mother earth during this period.

In the current year our country has faced severe drought like situation. Due to delayed arrival of monsoon, transplanting of rice nursery could be possible only in around 60 % area in Patna District and it is being estimated that production will further reduce by 40% due to transplanting of overage nursery, insect and pest

attack and less availability of water. Those farmers, who could establish rice nursery in time and irrigate through groundwater in the absence of rainfall and canal water may have less adverse impact of drought on rice productivity than those who delayed rice transplanting. Farmer's experience and opinion may be very valuable in understanding the concept and applicability of conjunctive use of water resources and effectively propagate conjunctive use practice among farmers. In order to explore and promote groundwater use along with surface and rainwater (i.e. conjunctive use) in Patna District, a project was formulated with the following objectives.

1. To understand the concept of conjunctive use.
2. To collect and compile rainfall availability, groundwater and surface water status in Patna
3. To compile constraints, advantages and farmers' response about conjunctive use.
4. To explore the possibility of conjunctive use of water by farmers in selected canal command of Patna.
5. To develop decision support tool in English to explore and promote conjunctive use options in canal command.

3.0 Methodology

In order to understand the concept of conjunctive use and get information about net sown area irrigated by various sources in Patna, status of rainfall in Patna during current year, stage of ground water development in various blocks of Patna, information was collected from IMD, Patna and CGWB, Patna. A number of farmers were interviewed. Number of questions were asked from farmers about impact of timeliness in agriculture, conjunctive use of rain, surface and ground water, and constraints and advantages of conjunctive use option through questionnaire given below and collected and compiled their experience, response/opinion.

4.0 Questionnaire to collect data/information from farmers

A questionnaire having 21 questions was designed and developed in Hindi to collect data/information from farmers in order to understand and explore possibility of conjunctive use of canal and ground water. The developed questionnaire (English version) having 21 questions is given below.

1. Name of farmer
2. Age
3. Name of village
4. Total area of land (Katha)
5. Is land consolidated at one place? If not then at how many places you have pieces of lands?

6. What are the major crops during *Kharif* and *Rabi* seasons?
7. When do you establish rice nursery?
8. When do you transplant rice nursery?
9. When do you harvest rice?
10. What is the source of irrigation? (a) Rain, (b) Canal water, (c) Ground water or (d) any other
11. What is the cost of providing irrigation through canal?
12. If you use ground water, do you have your own tubewell or purchase it from others?
13. If you irrigate through tube well, do you use diesel engine or electric motor?
14. What is the cost of irrigation through ground water?
15. Do you follow Nakshatras while establishing rice nursery or transplanting?
16. Do you establish rice nursery during Mrigshira Nakshatra?
17. Do you think that to adopt timeliness use of ground water is essential?
18. What is the impact of timeliness on agricultural production?
19. Do you think that use of ground water (when essentially required) can improve rice yield?
20. If yes, then to what extent rice yield may be enhanced?
21. Do you think that after harvesting rice in time, wheat can also be sown in time and yield may enhance?

Data/information was collected from 100 farmers of Bikram block through the designed questionnaire. Detailed analysis is given in section 4.1.

3.2 Concept of conjunctive use of water

Isolated development of surface water and ground water resources in the country has created unfavorable condition for crop production and environmental sustainability. Conjunctive use of surface and ground water combines the advantages of ground water storage with surface water system and serves both a remedial and corrective measures for efficient management.

Conjunctive use is defined as operation of surface and groundwater in such a way, which enhance their combined output. The term is used when sources which could be operated separately, are used to give better effect under integrated operation, whether they are reservoir releases, river diversions or groundwater. Conjunctive use of water also includes the use of harvested rainwater through tanks or ponds in ground water irrigated areas to provide supplemental irrigation. Conjunctive use of surface and groundwater is practiced by carrying out irrigation by pumping groundwater through tube wells when canal water is not available. Another aspect of conjunctive use deals with the utilization of saline groundwater and surface water to bring down the salinity of mixture within usable limits. In this way, irrigation supplies during crucial periods, when freshwater supplies are lacking or inadequate may be met.

Need for conjunctive use of rain, surface and ground water is realized because it helps in (i) mitigating the effect of shortages in canal water supplies often subjected to steep variation in river flow, (ii) increasing the dependability of existing water supplies, (iii) alleviating the problem of high water table resulting from canal irrigation, (iv) facilitating the use of high salinity groundwater, which cannot otherwise be used without proper dilution.

Bihar in general and Patna in particular, number of good quality shallow groundwater zones are available, which may safely be developed and utilized more efficiently and judiciously in crop production system to enhance agricultural productivity and income of farmer. But before studying applicability of conjunctive use concept, information about source wise area irrigated in Patna district and study of availability of water from various sources is important.

3.3 Land and water resources of Patna district

As per Bihar at a Glance (2007), the geographical area of the Patna district is 317236 ha and net sown area is 201103.63 ha, which is 63.39% of total geographical area. The net irrigated area is 139929 ha, which is 69.58% of net sown area and rainfed sown area is 61174.63 ha, which is 30.42% of net sown area. Source wise area irrigated (ha) in Patna District is given in Table 1.

Table 1: Source wise area irrigated in Patna District

Source	Area (ha)	Percent
Tube well	75,819	54.18
Canal	43,175	30.86
Tank	6,235	4.46
River lift Irrigation	2,984	2.13
Dug well	2,784	1.99
Others	8,932	6.38
Net irrigated area	1,39,929	100.00

It may be observed from Table 1 that Tube well and Canal are the two major sources of irrigation. 54.18% of net irrigated area is irrigated through tube well and 30.86% through canal network. Besides this, area irrigated through Tanks is 4.46% of net irrigated area and a minimum of 1.99% of net irrigated area is irrigated through dug wells.

Actual Rainfall at Patna during June 01 to September 30 in the current year 2009 was collected from IMD, Patna and cumulative actual weekly rainfall was compared with cumulative normal weekly rainfall as shown in Fig. 1 .

It may be observed from Fig. 1 that actual rainfall at Patna during June 01 to September 30, 2009 is always less than normal rainfall in all the weeks except one week i.e (June 03-10), where it is 90% more than normal rainfall.. Percent departure from normal rainfall is varying from (-16%) during June 1-17 to (-86%) during June 1-3. In two weeks departure is -52% and -53%, in four weeks it is between -40% to

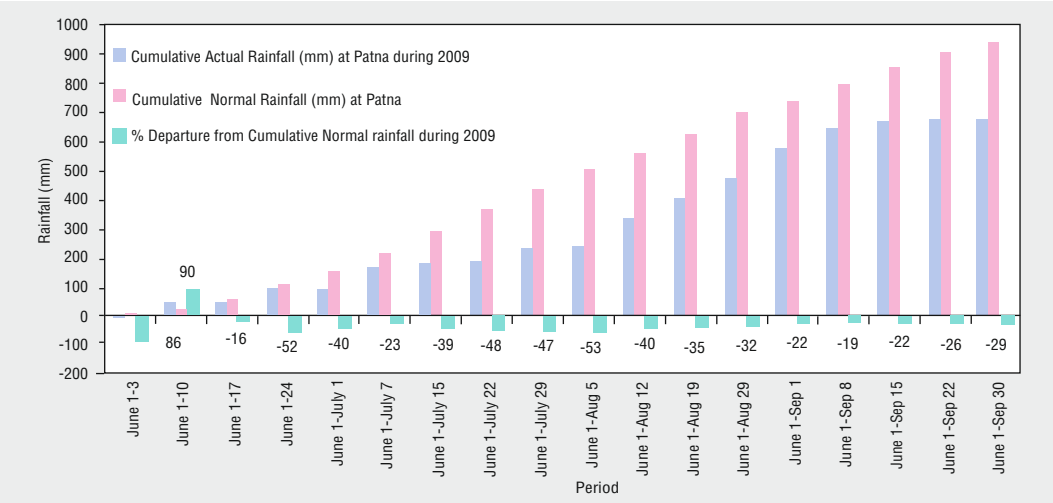


Fig. 1: Cumulative Normal rainfall, Actual rainfall of 2009 and Percent departure at Patna

-50%, in three weeks departure is between (-39 % to -32%), in rest six weeks departure varies in the range of (-19% to -29%). Rainfall analysis clearly indicates that this year monsoon got delayed and amount of rainfall was also significantly lesser than normal rainfall leading to drought like situation.

A couplet of great Poet and Agro-meteorologist 'Ghagh', is given below.

Awat adar na diyo, jat diyo na hast
Dono hi pachtat hai, pahun aur grihast

Though this couplet was written by 'Ghagh' long back but in recent age also it is true. It means if respect is not paid to guest at his arrival, and at the time of departure his blessings are not received or he is not bidden farewell properly, the guest repents, whereas if during Adra Nakshtra (June 22 to July 05) and during Hatia Nakshtra (September 27- October 10) God didn't give rain, then a family holder will repent due to reduction in agricultural production as a result of lack of water at the crucial stage of growth of rice.

During this year in both Adra and Hatia Nakshtras, rainfall was minimum, so certainly this year Bihar had drought like situation, and due to this yield of rice will be severly affected.

Stage of groundwater development in different blocks of Patna and in whole district as on March 31, 2004 in percentage as reported by CGWB, Patna (2007) is given in Fig. 2.

It may be seen from Fig. 2 that stage of ground water development is varying in the range of minimum of 28.9% in Bikram block to maximum of 75.2% in Barh block. Out of 23 blocks, stage of ground water development is varying between (28.9% and 36.5%) in 4 blocks, between (44.3% and 48.8%) in 3 blocks, between (50.3% and 59.5%) in 6 blocks, between (62.0% and 68.4%) in 7 blocks and between

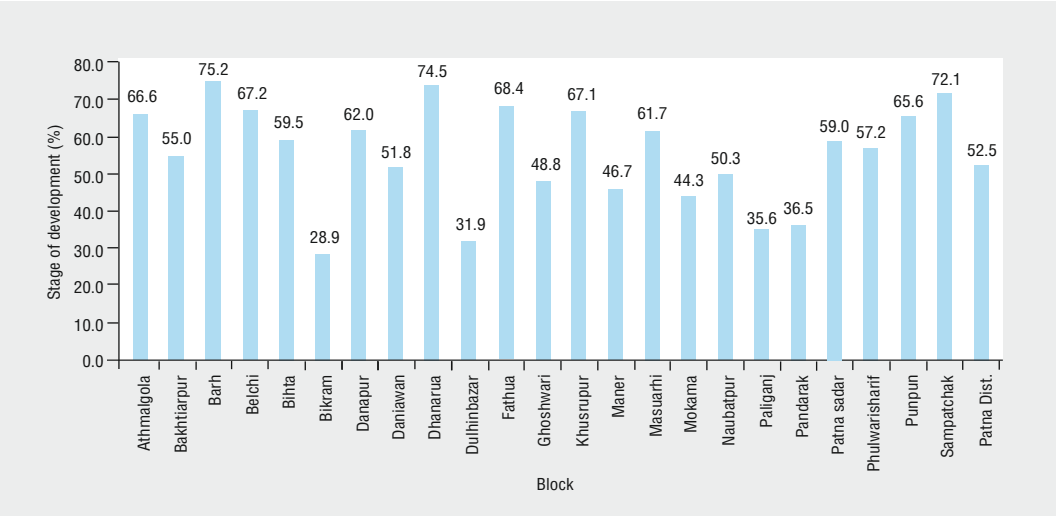


Fig. 2: Stage of Groundwater development in various blocks of Patna and whole district

(72.1% and 75.2%) in 3 blocks. In Patna district stage of ground water development is 52.5%. All the blocks have been categorized as safe area and none is critical or over exploited. In every block there is scope of ground water development provided planning of recharge and withdrawal is done simultaneously to maintain equilibrium.

3.4 Study Area

With this basic information and concept, Right Parallel Channel (RPC-V) distributary command in Bikram block, where stage of ground water development is least i.e. 28.9% was selected for study. A schematic diagram of RPC-V command where transect walk was done and interaction with farmers was made is shown in Fig. 3.

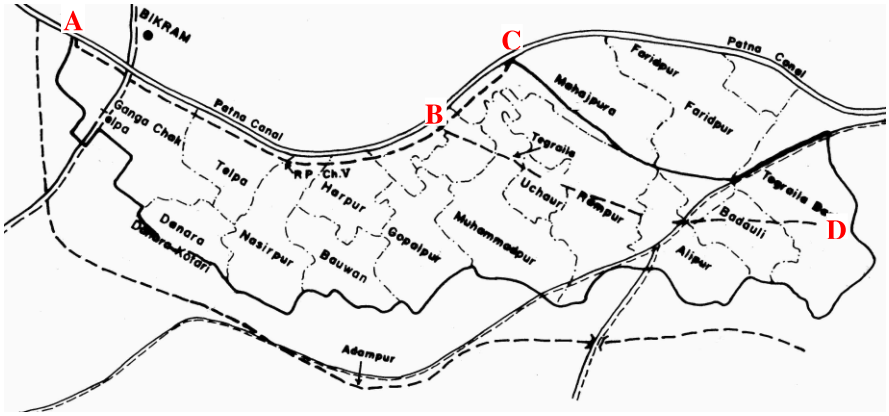


Fig. 3: Schematic diagram of RPC-V command area

Information about number of wells in head, middle and tail reaches of RPC-V and cost of canal water during various years was also collected and is presented below. Upadhyaya et al. (2004) reported that in this area conjunctive use of rain, surface and ground water is poorly developed, despite the chronic unreliability and shortage of canal water. Tube well irrigation is practiced mostly at the tail end of RPC-V, where canal water supply is poor. Although many wells and tube wells have been created, as shown in Table 2, yet farmers use them rarely.

Table 2. Wells and Pumpsets in RPC V

Reach	Number of wells		Open+	Pump sets	
	Open	Tubewells	Tubewells	Motor	Diesel
Head	57	26	2	-	28
Middle	69	46	4	2	45
Tail	131	101	14	17	98

The cost of tube well water varies from Rs. 60/- to Rs. 100/- per hour depending on location, time and amount of water supply, whereas cost of canal water supply in the command varies from Rs. 217/- to Rs 371/- per ha depending on the crop. The cost of canal water supply is given in Table 3.

Table 3: Cost of canal water (Rs./ha per crop season)

Crop	1985-95	1995-2001	2001-02 till date
Rice	89.41	172.9	217.36
Wheat	51.13	148.2	185.25
Sugarcane and vegetables	157.59	296.4	370.50

Low cost of canal water misleads cultivators into avoiding use of water sources that are more expensive. Hence they avoid the cost of paying for water from wells or tube wells in the belief that this would be unnecessary in the event that canal water becomes available, or rain occurs. Because canal water is inadequate, irregular, untimely and uncertain, many farmers wait to buy water until it is too late and their crops fail.

4.0 Progress of Study

4.1 Analysis of data/information collected from farmers

Data collected from 100 farmers of Gopalpur and Sangrampur villages were analyzed and salient findings are presented below.

- The age of farmers interviewed varied in the range of 25 to 55 years.
- Data collected about total land holdings of the surveyed farmers is presented in Fig.4.

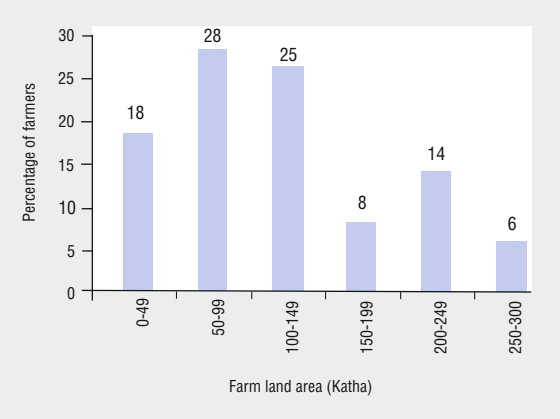


Fig. 4: Variation in land holding of surveyed farmers

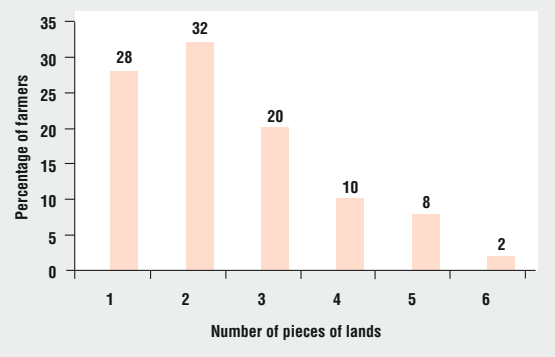


Fig. 5: Variation in land holding of surveyed farmers

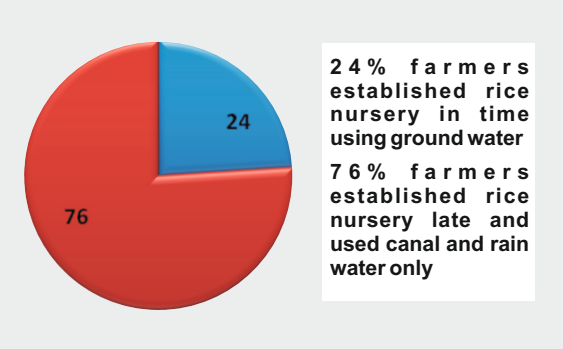


Fig. 6: Rice nursery establishment period reported by farmers

It may be observed from above graph that land holding of farmers varied in the range of a minimum of 0-49 Katha to a maximum of 250-300 Katha. 18% farmers were found to possess land in the range of 0-49 Katha; 28 % in the range of 50-99 Katha; 26% in the range of 100-149 Katha; 8% in the range of 150-199 Katha; 14% in the range of 200-249 Katha and only 6% farmers in the range of 250-300 Katha.

- All the farmers reported that there is no land consolidation. Number of pieces of lands possessed by surveyed farmers are shown in Fig. 5.

  It may be observed from the bar graph that 28% farmers had land at one location; 32% at 2 locations; 20% at 3 locations, 10% at 4 locations; 8% at 5 locations; and 2% at 6 locations. As pieces of lands/locations increased, difficulty in management of land, water and other input resources by farmers also increased.
- According to farmers Rice is the major *Kharif* crop and wheat, lentil and gram are major *Rabi* crops.
- Rice nursery establishment period reported by farmers is presented below in Fig. 6.
- It may be observed from Fig. 6 that 24% farmers reported that rice nursery is established during Rohini Nakshatra, where as rest 76% farmers

reported that rice nursery is established during Adra Nakshatra. Same 24% farmers reported that they used ground water, canal water and rain water, whereas rest 76% farmers reported that they used only canal water and rain water only.

- Farmers reported that rice transplanting is done generally after 25 to 30 days of establishing nursery.
- Farmers who established nursery during Rohini, reported harvested during last week of October to first week of November, whereas farmers, who established nursery during or after Adra, reported harvesting during last week of November to first week of December.
- All the farmers reported that cost of canal water is Rs.88/- per acre during *Kharif* season and Rs.75/- per acre during *Rabi* season.
- All the farmers using ground water reported that they use diesel engine only and not electric motor due to non availability of electricity.
- Farmers purchasing ground water and owning tube well are shown in Fig. 7.
  It may be observed from Fig. 7 that 58% farmers using ground water purchased it from tube well owners whereas 42% farmers using ground water reported that they owned their tube well.
- Cost of purchasing ground water as reported by farmers is given in Fig. 8.
  The cost of ground water was found to be varying between Rs. 60/- to Rs. 100/- per hour. 40% farmers reported its cost as Rs. 80 per hour.
- Most of farmers consider Nakshatras while establishing rice nursery or transplanting.
- None of the farmers said that rice nursery is established during Mrigshira Nakshatra because of their blind belief.

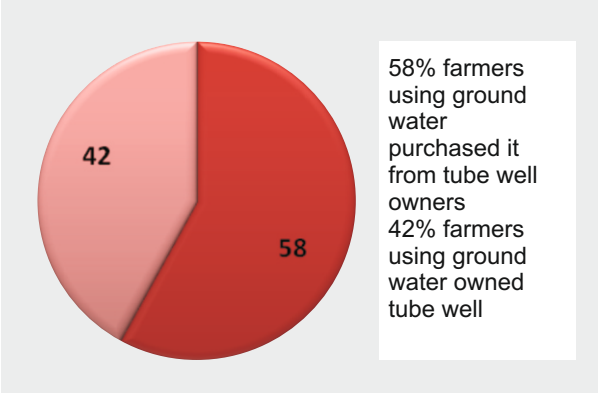


Fig. 7: Farmers purchasing ground water and owning tube well

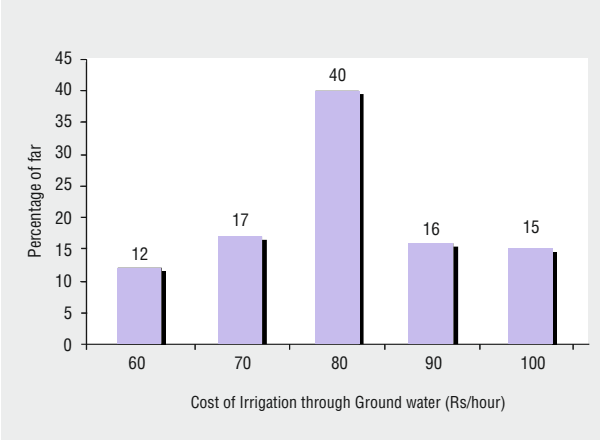


Fig. 8: Variation in cost of ground water

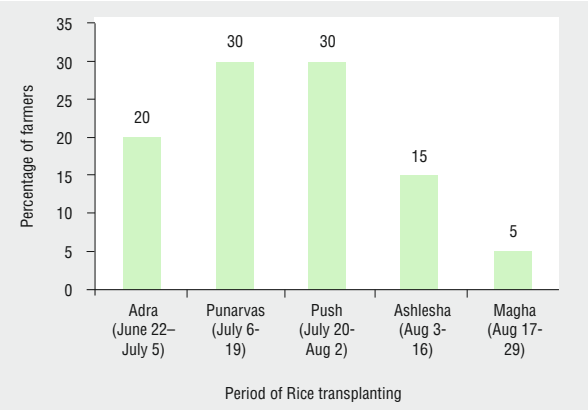


Fig. 9: Variation in Rice transplanting period

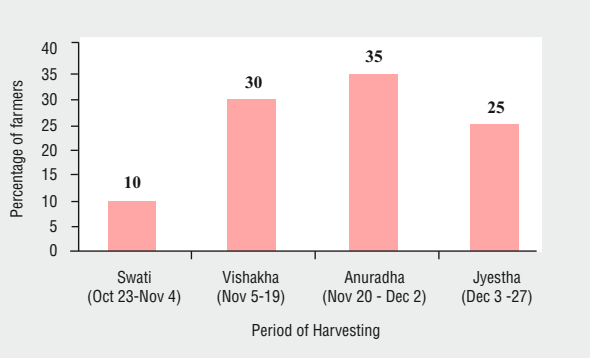


Fig. 10: Variation in Rice harvesting period

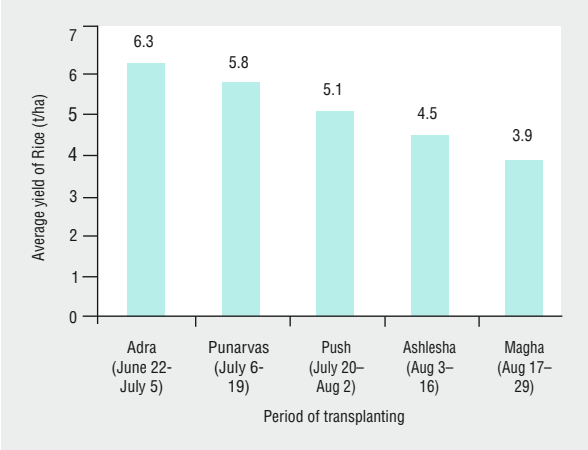


Fig. 11: Variation in average yield of Rice with transplanting period

- The period in which rice nursery was transplanted by surveyed farmers is presented in Fig 9.
  It may be observed from Fig. 9 that 20% farmers transplanted in Adra Nakshatra; 30% in Punarvas Nakshatra; 30% in Push Nakshatra; 15% in Ashlesha Nakshatra; and 5% in Magha Nakshatra. Only 20% farmers transplanted rice in time whereas 80% farmers were late in transplanting.
- All the farmers reported that for maintaining timeliness, use of ground water is essential because during nursery period neither rainfall nor canal water is available.
- The rice harvesting period as reported by farmers is presented in Fig. 10.
  It may be observed from Fig. 10 that 10% farmers reported harvesting of Rice in Swati Nakshatra; 30% in Vishakha Nakshatra; 35% in Anuradha Nakshatra; and rest 25% in Jyestha Nakshatra.
- Variation in average yield of rice with transplanting period is shown in Fig. 11.
  It may be observed from Fig. 11 that average yield of rice reduced from maximum of 6.3 t/ha transplanted during Adra Nakshatra to minimum of 3.9 t/ha transplanted during Magha Nakshatra. Figure clearly shows tha delay in transplanting causes reduction in yield of rice.

- Most of the farmers reported that due to timeliness not only yield of rice increases but yield of next *rabi* crop also increases.
- Most of the farmers reported that if ground water is utilized in rice crop, its yield will increase.
- Most of the farmers reported that rice yield may increase in the range of 10-15 Kg per Katha.
- Most of the farmers reported that if rice harvesting is done at appropriate time, yield of wheat will also increase due to timely sowing of wheat.

4.2 Comparison of cost of canal water and ground water

Upadhyaya (2009) reported that the cost of tube well water was found to be varying in the range of Rs. 60/- to Rs. 100/- per hour and in one hour area irrigated through tube well by farmers varied in the range of 2 to 4 Katha (i.e. 250 m^2 to 500 m^2). Considering average cost of tube well water as Rs. 80/- per hour and area irrigated in one hour as 3 Katha (375 m^2), the cost of providing one irrigation to 1 ha area through tube well water (considering 27 hours to irrigate 1 ha area) was computed as Rs 2160/-. Contrary to this, in case of irrigation through canal water farmer is required to pay only Rs. 217/- per ha during *Kharif* season, irrespective of number of irrigations applied, because canal water charges are on area basis and not on volume basis. This shows that there is tremendous difference in cost of canal water and tube well water and farmers always give priority to canal water over ground water due to it's much lesser cost

4.3 Constraints in conjunctive use based on farmers' interview

Before propagating the concept of utilizing rain, surface and ground water conjunctively in the canal command farmers were interviewed and their responses towards conjunctive use were analyzed. Major constraints in adoption of conjunctive use as reported by farmers are:

No land consolidation

55 % farmers in the head reach, 35% farmers in the middle reach and 32 % farmers in the tail reach of RPC-V distributary reported that small and fragmented land holding and non-existence of land consolidation were the major problems in owning a tube well and utilizing groundwater along with canal and rain water conjunctively.

Uneconomical because it needs high initial investment

All the farmers reported that utilization of ground water has become uneconomical because initial investment ranges from Rs. 30,000/- to Rs. 50,000/- depending on the selection of pump, engine/motor and other accessories, whereas canal water though irregular and unreliable, but available at much cheaper rate.

High recurring expenditure due to increase in price of diesel

All the farmers were of the opinion that due to hike in price of diesel recurring expenditure increases and it discourages the farmers to withdrawal ground water and utilize it for crop production.

Frequent power failure

Power supply in the villages is totally unreliable and there is a frequent failure so electric motors are very limited in use and farmers are compelled to use diesel engine in place of electric motors.

Lack of awareness about selection of pump, motor/engine as per farmers' requirement and source of loan/funding

60 % farmers reported that they don't have knowledge about selection of pump, motor/engine and other accessories and they purchase either on the basis of experience of other farmers or on the advice of supplier. Due to this they don't get the expected output of pump and face problem due to early failure. Due to lack of awareness about source providing loan/ funds and complicated procedures of Banks or other financial institutions accessibility to loan also becomes very difficult, which results in unwillingness of farmer to go for ground water utilization through tube well.

Lack of trained manpower to efficiently operate and timely maintain the pump, engine/motor and other attachment

All the farmers reported that trained and efficient mechanic is not easily available and accessible in affordable price. Due to this repair and maintenance of pumping unit is not done at proper time, which results in frequent loss of time and money.

Transportation from one place to another is difficult

Some people have boring in their fields but don't have pumping unit, whereas some people have pumping unit but no boring. These people face problem in transportation of pumping unit due to heaviness of whole assembly.

Advantages of conjunctive use quoted by farmers

When farmers were asked about the advantages of conjunctive use, they reported that ground water is assured source of water supply and we can use it efficiently and economically as per requirement of the crop. 42 % farmers in the head reach, 56 % farmers in the middle reach and 72% farmers in the tail reach, who are also using ground water, reported that use of ground water only during nursery period, helped them in attaining higher yield of rice.

Few farmers shared their valuable experience, which was quite interesting and encouraging to promote conjunctive use of water among farmers. Farmers told that timeliness is very important in agriculture. If rice nursery is sown in ($1/10^{th}$ to

1/15th of the area to be transplanted) during Rohini nakshtra (i.e. May 25 to June 06) and transplanted after 25-30 days, it gives much better yield compared to rice nursery sown during Adra nakshatra (i.e. June 22 to July 05) or later. The difference in the yield of rice may vary in the range of 10-15 Kg/Katha. In addition to this, once rice is harvested timely and *Rabi* crop like wheat is sown timely, it will lead to better yield of wheat crop too.

A famous couplet of great Agro-meteorologist and Poet 'Ghagh' is given below.

Rohan tapke Mrig tape kuch kuch Adra Jaye
Kahe Ghagh sun Ghaghni Swan bhat nahi khaye

According to Poet 'Ghagh', if during Rohini nakshtra (May 25 to June 06) there is some rainfall, during Mrigshira Nakshtra (June 07 to June 21) there is slightly hot weather which continues till beginning of Adra Nakshtra, but again during Adra Nakshtra (June 22-July 05) if there is sufficient rainfall, there will be bumper yield of rice. Poet 'Ghagh' says to his wife 'Ghaghni' that yield of rice will be so high that even dog will feel bored eating rice.

Farmers' experience and couplet of 'Ghagh' both indicate the importance of timeliness in sowing and transplanting of rice and it's impact on rice production.

4.5 Scientific evidence of timeliness on yield of Rice and Wheat crops in study area

In order to find out the effect of timeliness of transplanting of rice or sowing of wheat on yield of respective crops a study was conducted by ICAR Research Complex for Eastern Region, Patna in the command of RPC-V for a duration of 3 years. The results reported by Singh et al. (2005) are given in graphical form in Figs. 12 and 13.

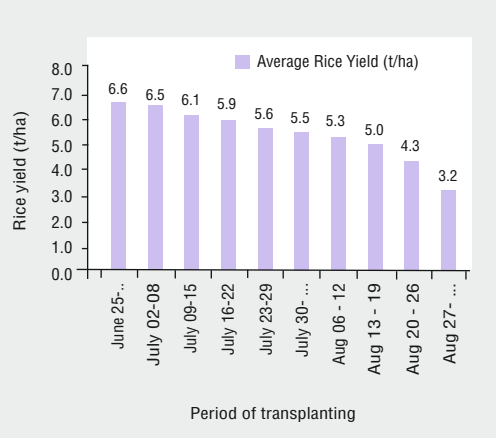


Fig. 12(a): Effect of date of transplanting on average yield of Rice

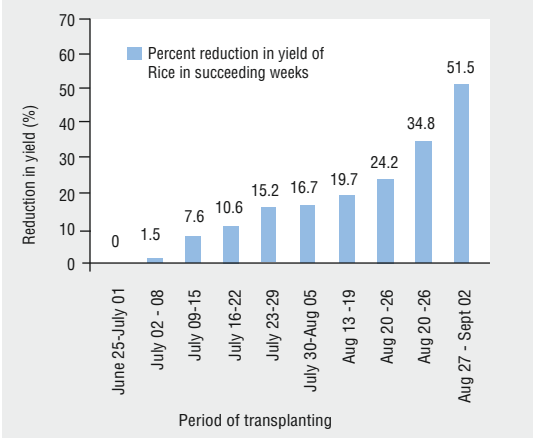


Fig. 12(b): Percent reduction in rice yield due to delay in transplanting

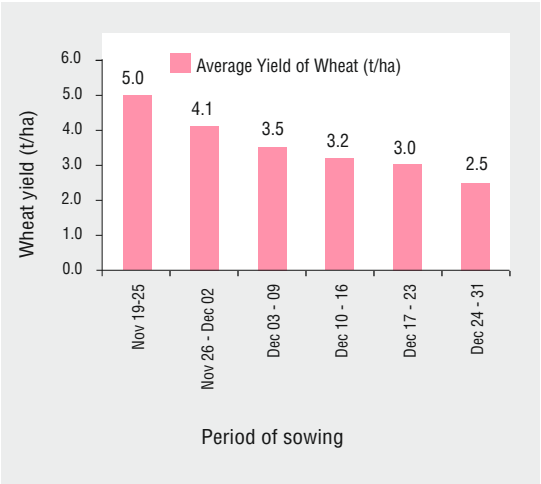


Fig. 13(a): Effect of date of sowing on yield of Wheat crop

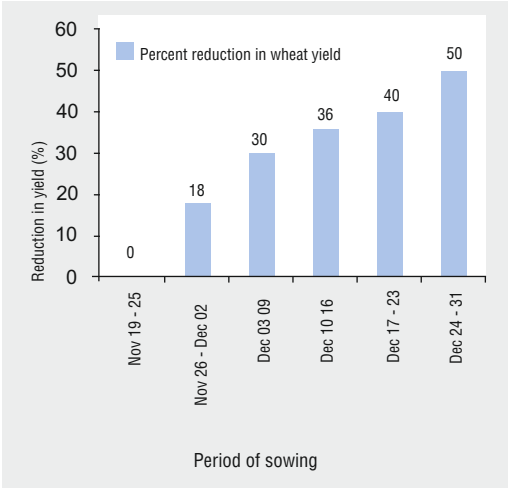


Fig. 13(b): Percent reduction in yield of Wheat due to delayed sowing

Figs. 12(a) and (b) very clearly reflect the effect of transplanting time on average yield of rice. It may be observed that as the transplanting was delayed by a week, there was reduction in yield of rice. The average yield of rice was maximum of 6.6 t/ha when transplanted during June 25-July 01and minimum of 3.2 t/ha when transplanting was done during August 27-September 02. The reduction in yield of rice due to delay in transplanting by one week after June 25-July 01 till August 27- September 02 was 1.5, 7.6, 10.6, 15.2, 16.7, 19.7, 24.2, 34.8, and 51.5%, respectively.

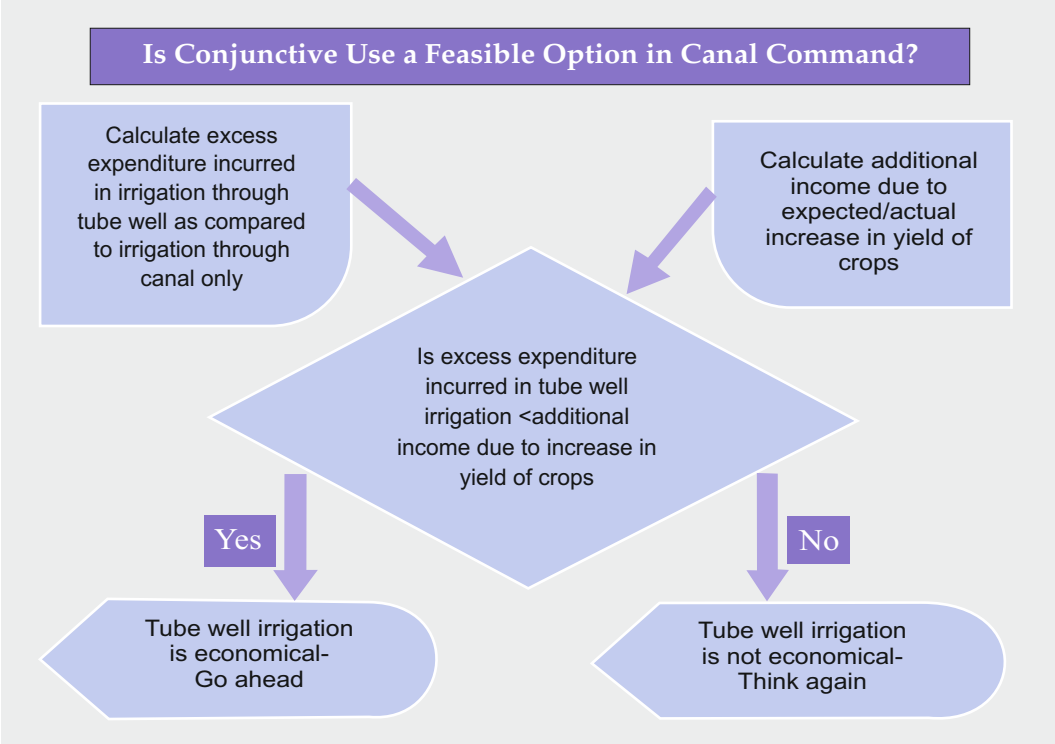
Similarly Figs. 13(a) and (b) reflect the effect of sowing time on average yield of wheat. It may be observed that as the sowing of wheat was delayed by a week, there was sharp reduction in yield of wheat. The average yield of wheat was maximum of 5.0 t/ha when sown during November 19-25 and minimum of 2.5 t/ha when sown during December 24-31. The reduction in yield of wheat due to delay in sowing by one week after November 19-25 till December 24-31 was 18, 30, 36, 40, and 50 %, respectively.

These Figures also reflect that both the crops are very sensitive to timeliness of transplanting of rice or sowing of wheat. Further, wheat crop is more sensitive to sowing period as compared to rice crop to its transplanting period because due to delay in sowing of wheat, the rate of reduction in yield is more than rate of reduction in yield of rice due to delay in transplanting.

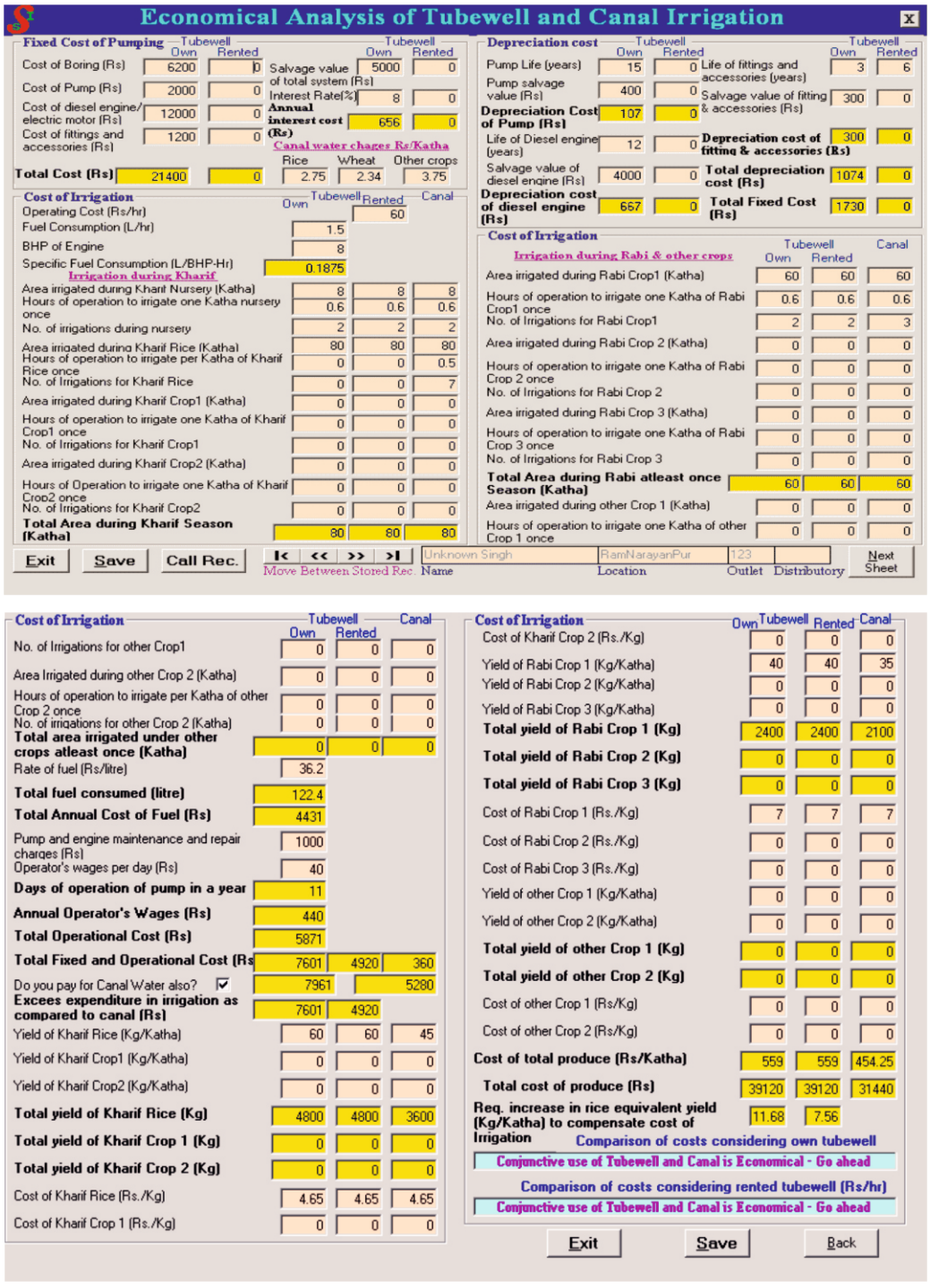
5.0 Problem Solving Attempt

In order to convince farmers about adoption of conjunctive use practice in RPC-V command an economic assessment of conjunctive use of water through an example was discussed, which is presented below.

Since rice nursery area is 1/10th to 1/15th of area to be transplanted. In this area, if 3 irrigations from tube well are provided it will cost maximum of Rs. 648/- for 1/10th of ha (considering Rs. 2160/- per ha for one irrigation). Similarly, in the absence of rain or canal water, if 2 irrigations are provided through tube well in 1 ha area, it will cost another Rs. 4320/-. So additional investment due to irrigation through tube well will be Rs. 4968/-. Whereas increase in yield of rice per ha will be in the range of 800 kg to 1200 kg or Rs 8000/- to Rs.12000/- when cost of rice is considered as Rs. 10/- per kg. The above example clearly shows that application of tube well water during nursery period and thereafter also during dry spells is quite helpful in increasing yield of rice and seems profitable option. Similarly during *Rabi* season in wheat crop if one or two irrigations are applied through tube well during critical crop growth stages the increase in yield will compensate the additional cost involved in providing irrigation through tube well. So there seems good scope for promotion of conjunctive use practice among farmers. Conjunctive use practice may be adopted by the farmers till increase in yield of crop or increase in income is more than the investment in providing ground water for irrigation of crop through tube well.



Based on this flow chart, a decision support tool in English was developed, which is given below.



Fig, 14. Decision support tool for conjunctive use

6.0 Decision Support Tool for Conjunctive Use

An interactive decision support tool in Visual Basic was developed in English and Hindi versions. A pictorial view of English version with example is given in Fig. 14.

This Decision Support Tool was developed to explore and promote conjunctive use of surface and ground water in canal command. Through this Decision Support Tool, conjunctive use options in three situations (i) Own tube well (ii) Renting pumping set to run tube well (iii) Purchasing water from tube well owners, can be studied and decision about adoptability of conjunctive use practice in canal command can be taken by farmers. This Decision Support Tool calculates (i) Annual Fixed and operational cost from tube well and canal (ii) Yield and total cost of produce (iii) Excess expenditure incurred in irrigation through tube well over and above canal water charges and (iv) the required rice equivalent yield increase to compensate for the additional cost of irrigation from tube wells.

On first page of the screen, there are three sections, which compute fixed cost of pumping, depreciation cost and cost of irrigation during *kharif*, *rabi* and other crops.

Computation of Total Cost and Annual Interest Cost

In the section of fixed cost of pumping, information about cost of boring, cost of pump, cost of diesel engine/electric motor and cost of fitting and accessories, salvage value of total system, interest rate (%) as well as canal water charges (Rs. /katha) for the rice, wheat and other crops, in case of own and rented tube well is collected from farmers. ['Katha' is a unit of area and 1 katha = 125m^2. In other words, 1 ha = 80 katha]. The box displayed in yellow color against total cost is computed after adding cost of boring, cost of pump, cost of diesel engine/electric motor and other accessories.

Annual Interest Cost = 0.5 × (Total Cost - Salvage Value of total System) × (Interest Rate/100)

Computation of Depreciation and Total Fixed Cost

In this section, Salvage value and life of different components is required to be fed to compute Depreciation cost of pump, Depreciation cost of diesel engine/ electric motor, Depreciation cost of fitting and accessories.

Total depreciation cost and Total fixed cost are computed as below.

Depreciation Cost = (Fixed cost – Salvage value) / Life of component

Total depreciation cost = Depreciation cost of pump + Depreciation cost of diesel engine/Electric motor + Depreciation cost of fitting and accessories.

Total Fixed Cost = Annual Interest Cost + Total depreciation cost

In Cost of irrigation section, in case of rented tube well operating cost (Rs./

hour) may be fed in the box. In case of own tube well information regarding fuel consumption (litre/h), BHP of engine is provided to calculate specific fuel consumption (litre/BHP-hr). Data /information about area irrigated during *kharif* nursery, hours of operation to irrigate nursery once, numbers of irrigation during nursery, area irrigated during *kharif* rice, hours of operation to irrigate *kharif* rice once, numbers of irrigation for *kharif* rice under own tube well and canal system is provided. There is a provision of consideration of two other *kharif* crops in this DST. Similar type of information may be fed for three *rabi* crops and two other crops during the year.

On the next page of DST rate of fuel (Rs./litre) is required to be fed. Total fuel consumed (litre) is computed by the Decision Support Tool.

Total annual cost of fuel (Rs.) is computed by multiplying total fuel consumed (litre) with rate of fuel (Rs./litre). In the next box pump and engine maintenance charges are fed. Then operator's wages per day (Rs.) are fed.

In the next yellow box, DST computes days of operation in a year and annual operator's wages in (Rs.) by multiplying days of operation (days) in a year with operator's wages (Rs./day).

Total operational cost is computed by adding total annual cost of fuel, pump and engine maintenance charges, and annual operator's wages. Total fixed and operational cost is computed by adding total fixed and total operational cost in all the three cases. If payment for canal water charges is done, then it is added in fixed and operational cost of own and rented tube well. If payment for canal water is not added then total fixed and operational cost under own and rented tube well situations become excess expenditure incurred in irrigation through ground water as compared to canal.

Total yield of crop is computed by multiplying yield of crop (kg/katha) with area under the crop (katha). Data about cost of crop (Rs./ kg) is also required to be fed in the respective boxes.

Cost of total produce (Rs./katha) is computed after adding the multiplication of yield of individual crop (kg/katha) with cost of that crop (Rs./kg).

Total cost of produce (Rs.) is summation of yield of crop (kg) multiplied by cost of crop (Rs./kg).

Required increase in rice equivalent yield (kg/katha) is computed by dividing excess expenditure in irrigation with total area covered by crop and cost of rice crop. If, the additional income due to increase in rice equivalent yield is more than expenditure incurred in providing irrigation through tube well under conjunctive use practice than the Decision Support System displays the message that the **'Conjunctive use of tube well and canal water is economical - Go ahead'.** If, the additional income due to increase in rice equivalent yield is less than the excess expenditure incurred in providing irrigation through tube well under conjunctive use practice of water than the Decision Support System displays the message that

the **'Conjunctive use of tube well and canal water is not economical - Think again'.**

This Decision Support Tool seems to be capable enough in exploring and promoting conjunctive use options and convincing farmers to adopt conjunctive use practices, wherever applicable and beneficial in canal command.

7.0 Conclusions

Conjunctive use is basically operation and use of surface and groundwater in such a way, which enhances their combined output. Since long, researchers and planners are trying to recommend the concept of conjunctive use in canal command as well as salt affected areas, but so far there is hardly any evidence about wide adoption and acceptance of conjunctive use practices among water users due to many constraints and mainly due to tremendous difference in cost of canal water and ground water. Since canal water is available at much cheaper rates, water users don't prefer ground water utilization unless they feel that their production will reduce drastically in the absence of water.

Based on discussion/interaction with farmers it seems that there is good scope of ground water development and utilization in Bihar because here all blocks are under safe zone. Interactions with farmers of RPC-V in Bikram block and example considered indicate that yield of crops like rice and wheat may improve substantially provided timeliness is maintained and conjunctive use practice is widely adopted by the farmers as and when required.

A user interactive decision support tool was developed in English version using Visual Basic platform and demonstrated among water users in order to create awareness and explore the possibility of conjunctive use in the canal command. Farmers found this tool quite helpful in understanding and analyzing the concept of conjunctive use and taking appropriate decision for its adoption under the prevailing constraints.

8.0 Recommendations

Based on learning from collected data/information, and discussion/interaction with farmers it was realized that in Bikram block of Patna, stage of ground water development is the lowest and potential for ground water development exists. Specific recommendations from this study are as following.

- Land consolidation should be promoted because due to no land consolidation farmers find it difficult to efficiently manage their resources to enhance production.
- Timeliness, which has been identified as one of the most important factors influencing production, should be followed in all agricultural activities because due to delayed sowing and harvesting yield/production of whole crop sequence reduces substantially.

- In order to establish rice nursery in time, use of ground water in the absence of rain and canal water is essentially required in the area, where good quality shallow ground water aquifers exist.
- Both farmers and Scientist confirmed that if rice nursery is established in time and ground water is utilized during irrigation of nursery as well as during 2 or 3 other critical dry spells, income from increased yield of rice will compensate the cost involved in providing irrigation through ground water.
- Hence, options for conjunctive use of water should be explored and promoted in canal command and farmers should be convinced about benefits and applicability of conjunctive use practice.

9.0 Acknowledgements

Author acknowledges with thanks the help and guidance provided by Director, ICAR Research Complex for Eastern Region, Patna in carrying out this study. Author is also thankful to all the scientists and farmers who gave their valuable input and time. Author is also thankful to Mr. Shyam for helping him in development of decision support tool.

10.0 Bibliography

Bihar at a Glance 2007.

Central Ground Water Board (2007). Dynamic Ground Water Resources of Bihar State as on 31st March 2004. Govt. of Bihar. pp. 129.

India Meteorological Department, Patna. 2009

Singh,R.D., Gautam, U.S., Sikka, A.K., Gaunt, J., and Singh, S.R. 2005. Livelihood improvement through optimization of Rice transplanting and timely sowing of Wheat in participatory mode in RP Channel-V of Sone Command. Technical Bulletin No.: R-15/Pat-6, ICAR Research Complex for Eastern Region, Patna, pp. 22.

Singh, S.R., Gautam, U.S., Rahman, A., Kumar, U., Sinha, S.K. 2002. A system's approach to enhance rice-wheat productivity in Sone command.Bulletin No. 3. ICAR Research Complex for Eastern Region, Patna, pp.56.

Upadhyaya, A., Singh, A.K., Bhatnagar, P.R. & Sikka, A.K. 2004. Is conjunctive use a feasible option? A simple tool for participatory evaluation of the economic benefits of groundwater exploitation. Poster presented in the Workshop on Realizing Potential: Livelihood, Poverty and Governance at NASC Complex, Pusa Campus, New Delhi, August 3-4, 2004.

Upadhyaya, A. 2009. Exploring and promoting conjunctive use of water in canal command. Lecture delivered to farmers of Patna District at ICAR Research Complex for Eastern Region, Patna, September 15, 2009.

Upadhyaya, A. 2009. Samekit Jal Prabandh. TV talk telecast in Hindi in Krishi Darshan Progamme on September 22 by Patna Doordarshan.


भाकृअनुप
ICAR
हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch