CAPACITY BUILDING OF FARMERS FOR ENHANCING WATER PRODUCTIVITY THROUGH ADOPTION OF WATER SAVING TECHNOLOGIES AT FIELD LEVEL

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ABSTRACT

Efficient utilization of available water resources is crucial for a country like, India, which shares 17% of the global population with only 2.4% of land and 4% of the water resources. Agricultural sector is the largest consumer of water. The overall efficiency of the surface irrigation system ranged between 25 to 40%. To meet the food security, income and nutritional needs of the projected population in 2050, the food production in India will have to be almost doubled. Management of water, may help in savings of significant amounts of water and increase the quality and quantity of produce. All these emphasize the need for water conservation and improvement in water-use efficiency to achieve ***"More Crop per Drop"*** *at the field level. To solve totally, or to reduce, the severity of water scarcity, water management must improve at field level. Thus, agriculture has the greatest potential for solving the problem of water scarcity.*

Water saving technologies interventions can be made to fill the gaps and to enhance the water use efficiency at the field level. Three villages namely Tilwar, Sunehra and Gujuki of district Alwar, Rajasthan were selected to study the impact of water saving technologies on savings of water and energy, increase in yield and improvement in the water use efficiency. Capacity building through training of farmers, field visits and institute visit on various technologies and their interaction with other progressive farmers to motivate the farmers for large scale adoption of water saving technologies was done. The interventions included laser leveling to improve water application and micro irrigation at the field level to improve overall irrigation efficiency. The laser leveling indicates the possibilities of enhancing wheat yield by at least 25%, making it 47.25 million tons in whole Indo-Gangetic Plain and can also help in saving of a minimum of 30 % (1.45 million ha-m) of irrigation water. Total 25 ha area was placed under drip irrigation, utilizing low discharge of tube wells which is not possible in flood irrigation. Micro irrigation system was found to result in 30 to 70 % water savings in various vegetables crops along with 10 to 60 % increases in yield as compared to conventional methods of irrigation. Mulching with drip further enhanced the crop yield to the tune of 10-20 % and controlled weeds up to 30-90%. Impact of these technologies motivated other farmers of nearby villages and now many farmers are coming forward for these technologies for their large scale adoption.

Keywords: Irrigation efficiency, PRA, land leveling, micro irrigation

INTRODUCTION

Efficient utilization of available water resources is crucial for a country like, India, which shares 17% of the global population with only 2.4% of land and 4% of the water resources. The annual food grain requirement of India, is estimated as 450 million tons by the year 2050 and the per capita availability, in terms of average utilizable water resources, which were 6008 m^3 in 1947 (presently 1250 m^3) is expected to dwindle down to 760 m^3 by 2050. Agriculture, a main stay in India, accounts for 25 % of the Nations Gross Domestic Product and 15% exports have dependence of 65% of Indian population. Agricultural sector is the largest consumer of water. The overall efficiency of the surface irrigation system ranged between 25 to 40%. To meet the food security, income and nutritional needs of the projected population in 2050, the food production in India will have to be almost doubled. Management of water, may help in savings of significant amounts of water and increase the quality and quantity of produce. All these emphasize the need for water conservation and improvement in water-use efficiency to achieve **"More Crop per Drop"** at the field level. To solve totally, or to reduce, the severity of water scarcity, water management must improve at field level. Thus, agriculture has the greatest potential for solving the problem of water scarcity.

With a view to addressing the above issues and to particularly increase the water use efficiency and productivity of vegetables and wheat at field level, a study was taken up in the district Alwar, Rajasthan.

SELECTION OF THE STUDY AREA

Alwar has an important place in agriculture production in Rajasthan. Total geographical area of the district is 7,82,897 hectares which is about 2.5 % of the State. The net cultivated area is 5,09,107 hectares from which about 83 % is irrigated and remaining 17 % is unirrigated. Double cropped area is 2,72,508 hectares of which 32,230 hectare (12%) area is irrigated and remaining 2,40,278 hectare (88%) area is unirrigated. In kharif season bajra, maize, jowar, kharif pulses, arhar, sesamum, cotton, guar etc. are sown in about 3,29,088 hectare (42%) and in Rabi season wheat, barley, gram, mustard, taramira and rabi pulses etc. are sown in about 4,52,527 hectare (58%). The main source of irrigation is tubewells. About 35470 electric motors and 66502 diesel pump sets are being used for irrigation purposes. The normal rainfall for the district is 657.3 mm. The rainfall distribution in the district is uneven and scattered which resulted sometimes flood problems and some time draught position which affect the agriculture production as well as cropping pattern in kharif and rabi season. Three villages namely Tilwar, Gujuki and Sunehra were selected in the Alwar district each representing the normal irrigation practices in vegetables–wheat cropping system of the area. The villages having no canal irrigation facility for irrigation.

PARTICIPATORY RURAL APPRAISAL IN THE SELECTED VILLAGES AND DATA COLLECTION

Participatory Rural Appraisal (PRA) techniques were conducted in the villages to get an insight in to the farmers' perceptions. Lack of awareness among farmers about the consequences of inefficient water application and the lack of appropriate technologies for regulated and uniform application of the desired quantity of water at appropriate time are among the major causes of low water use efficiency at the field level. Water productivity can be enhanced by adopting a good water application method along with laser leveling, micro irrigation, low head drip system and raised bed technology. Appropriate technology for uniform distribution, application and enhancing water holding capacity are needed to have effective irrigation with a view to realize high water use efficiencies.

Daily values of meteorological data comprising maximum and minimum temperatures, average relative humidity, wind speed, rainfall and sunshine hours were collected. These data were analyzed to obtain their monthly average values. Physico-chemical properties of soils, quality of irrigation water, source of water, duration of irrigations, crop details were monitored in the farmers' fields. Fields were surveyed with the help of dumpy level and the reduced levels at a square grid of 10m x 10m were determined. Grid survey data were analyzed to prepare the topographical maps.

The average values of field capacity and wilting point moisture content of the soil were determined and were 20.3 and 10 per cent, respectively (Fig. 1 and 2). To determine nutrients status of soil, analysis of soil samples were done. Soils of these villages were nitrogen deficient (av. 151.9 kg/ha) but having very high phosphorous (52.2 kg/ha) and potassium (436.1 kg/ha).The average bulk density of soil was 1.48 g/cm^3. All the cultural practices followed by the farmers were maintained. A total of 3-5 post sowing irrigations were applied in tube well irrigated fields (Table 1, Fig. 3).

Fig. 1 Survey of farmers field

Fig. 2 Determination of tube well discharge

Table 1 Existing crops and irrigation technologies in the villages

Season	Crop	Methods of water application	No. of irrigations
Kharif	Bajra	Furrow	3
	Jwar	Furrow	3
	Gwar	Furrow	3
	Till	Furrow	3
	Cotton	Furrow	4
Rabi	Wheat	Check basin	5
	Barley	Furrow	5
	Musturd	Check basin	5
	Tomato	Check basin	3
	Chilli	Check basin	3

Fig. 3 Interaction with farmers during PRA

LAND LEVELING PRACTICES IN THE VILLAGES

Responses of different farmers (in form of ranks) for different land leveling technologies under different criteria were obtained. Different criteria selected in consultation with farmers included, availability and cost of equipment, leveling quality, ease in operation and availability of repair facilities. The average assigned values of different technologies based on their ranking by farmers corresponding to different criteria were determined and is presented in Table 2. The overall ranks of different land leveling equipments as per their adoption by the farmers of villages Sunehra and Tilwar (Table 2) reveals that the most favorite leveling equipment used in the village was a tractor drawn leveler (I) followed by buck scraper (II), wooden plank (III), and ditcher/trencher (IV), respectively. Most farmers expressed that their land is not leveled and needs further leveling.

Table 2 Ranking of different land leveling equipments adopted by the farmers

	Wooden Plank	Singh Patela	Buck Scraper	Tractor drawn leveler	V-ditcher / A-trencher	Laser leveler

Village Sunehra						
Total scores	50.6		52.6	54.3	44.5	-
Overall rank	**III**		**II**	**I**	**IV**	**-**
Village Tilwar						
Total	56.2		58.8	60.1	47.2	-
Rank	**III**		**II**	**I**	**IV**	**-**

□ No farmer was aware about the laser leveler, consequently the farmers assigned no rank to these technologies during PRA

TRAININGS OF FARMERS

Capacity building through training of farmers, field visits and institute visit on various technologies and their interaction with other progressive farmers to motivate the farmers for large scale adoption of water saving technologies (Fig. 4).

Fig. 4 Training of farmers

RESULTS AND DISCUSSION

Based on PRA and field observations on different cultural practices, gaps between the existing and appropriate technologies were established. The interventions included laser leveling to improve water application and low cost bucket drip system, micro irrigation at the field level to improve overall irrigation efficiency.

LASER LEVELING

Precision land leveling (Laser leveling) may be applied as part of a resource management system. Several equipments/ methods are available for land leveling operations. Different methods require different field conditions and operating time to complete the task. Laser leveling systems are commonly used in agricultural applications in Australia, Japan and the United States. Increasingly, laser guided systems are being used in developing countries as well. Laser leveling results in a much more level field. Accuracy can be improved by as much as 50% (Rickman, 2002).

The laser leveling system requires a laser transmitter, a laser receiver, an electrical control panel and a twin solenoid hydraulic control valve. The laser transmitter transmits a laser beam, which is intercepted by the laser receiver mounted on the leveling bucket (Fig. 5). The control panel mounted on the tractor interprets the signal from the receiver and opens or closes the hydraulic control valve, which will raise or lower the bucket. Some laser transmitters have the ability to operate over graded slopes ranging from 0.01% to 15% and apply dual controlled slope in the field.

Laser leveling has been introduced in India in last decades. Using the laser leveler, 34 fields of selected farmers were leveled (Fig. 5) (Table 3). The cost of precision leveling through laser leveler varied from about Rs. 2400/- to Rs. 6400/- per hectare, depending upon the undulations in the field. Laser leveling encouraged the farmers to go for larger basin sizes for irrigation, on their own (data not shown here). Significant changes were observed in the average basin sizes that the farmers adopted before and after the laser leveling.

Fig. 5 Laser levelling of field

Table 3 Laser leveled field

S. No.	Farmers Name	Area (ha)	Time	Laser leveling cost (Rs./ha)
1	Mr. Shiv Dayal	0.500	3.30	3300
2	Mr. Gyan Chand	1.300	12.2	4692
3	Mr. Gyan Chand	0.250	1.40	2800
4	Mr. Gulab Rai	0.525	4.40	4190
5	Mr. Ram Chand	0.250	2.00	4000
6	Mr. Dileep	0.500	3.30	3300
7	Mr. Prem chand	0.250	2.40	4800
8	Mr. Prabhu Dayal	1.025	12.1	5902
9	Mr. Sohan Lal S/o dataram	0.525	4.00	3810
10	Mr. dalveer	0.550	3.40	3091
11	Mr. Shyam Lal	0.750	6.10	4067
12	Mr. Mohan Lal S/o Meer chand	0.250	1.20	2400
13	Mr. Tilak Raj	0.250	2.10	4200
14	Mr. Harbansh S/o Dayal Chand	0.250	1.30	2600
15	Mr. Jumma Mev	0.250	3.20	6400
16	Mr. Jagdesh	0.250	1.20	2400
17	Mr. Suresh	0.250	1.30	2600
18	mr. Bhupesh	0.250	1.50	3000
19	Mr. Satish	0.250	1.50	3000
20	Mr. Lal Chand	0.275	3.50	6364
21	Mr. Fakir Chand	0.275	2.20	4000
22	Mr. Prabhu Dyal	0.500	5.30	5300
23	Mr. Lakshman Singh	0.500	4.00	4000
24	Mr. Mahaveer Singh	0.275	2.30	4182
25	Mr. Som Nath	0.250	1.50	3000
26	Mr. Bharat lal	0.500	2.40	2400
27	Mr. Gyan Chand	0.250	2.40	4800

28	Mr. Bheem Singh	1.000	7.80	3900
29	Mr. Mahendra	2.825	19.7	3487
30	Mr. Harvansh Singh	0.250	2.00	4000
31	Mr. Darhsn Batiya	0.250	2.40	4800
32	Mr. Bemsi lal	0.750	7.20	4800
33	Mr. Surjeet	0.500	3.30	3300
34	Mr. Sanjeet	0.250	1.00	2000

EFFECT OF LAND LEVELING ON CROP YIELD

Laser leveling increased onion, cotton and wheat yield significantly. In unleveled fields, least yield (11 t/ha) of onion was recorded in the field in comparison to laser leveled field. The average yield of 13.5 t/ha (± 20%) was recorded from all the laser-leveled fields (Table 4). In wheat crop, 30 % of water could be saved besides 25 % enhance in yield (Table 5). Johnson et. al. (1978) had also reported 26 % increase in grain yield of wheat by laser leveling of fields as compared to traditionally leveled field . This is because of better distribution and less loss of irrigation water as reflected by higher irrigation efficiencies.

Table 4 Performance of laser levelling in Onion crop during kharif 2011

S. No.	Parameter	Laser levelled field	Control plot	Saving (%)
1	No. of Irrigation	6	6	0.0
2	Time per Irrigation (h)	18	24	25.0
3	Total Time of Irrigation (h)	108	144	25.0
4	Irrigation Cost	16200.0	21600.0	25.0
5	Total Irrigation Water (m^3)	5200.0	6500.0	20.0
6	Fert./ Manure Cost (Rs/ha)	3549.0	3549.0	000
7	Yield (q/ha)	135.0	110.0	22.7
8	Total Income(Rs/ha)	67500.0	55000.0	22.7
9	Energy (kWh/ha)	969.80	1193.60	18.7
10	IWP(l/kg)	138.67	209.45	33.8

Main product: Rs. 5 per kg

Table 5 Performance of laser levelling in wheat crop

S. No.	Parameter	Laser levelled field	Control plot	Saving (%)
1	No. of Irrigation	6	6	0.00
2	Time per Irrigation (h)	24	36	33.3
3	Total Time of Irrigation (h)	144	216	33.3
4	Irrigation Cost	21600.00	32400.0	33.3
5	Total Irrigation Water (m^3)	4200.00	6000.0	30.0
6	Fert./ Manure Cost (Rs/ha)	1522.22	1522.2	0.0
7	Yield (q/ha)	52.5	42.0	25.0

8	Total Income(Rs/ha)	42000.0	33600.0	25.0
9	Energy (kWh/ha)	1074.24	1611.4	33.3
10	IWP(l/kg)	398.0	740.0	46.2

Main product: Rs. 8 per kg

LOW COST BUCKET SYSTEM

Many farm women are being encouraged to use these drip system through different capacity building programs being organized by Water Technology Centre. A low head bucket drip system was designed for kitchen gardening (25 to 50 m^2). This system is having a bucket, portable laterals, and drippers. The drip system operates by gravity from a bucket of 25 litre capacity placed at 1 to 1.5 m height. This technology is very ideal for rural conditions and small scale agricultural production in rural areas in the back yard of village houses. The management of the bucket kit system is very easy and requires no special skills. Farmers can install and maintain it on their own. The cost of this system varies from Rs. 750 to Rs. 1000/= per unit (Table 6). Forty (40) family low cost drip systems were installed to farmers with special emphasis to women farmers with their participation. Results of these family drip systems were very encouraging and about 25 to 50 plants of vegetables can be irrigated by using the single system. Bucket kit produced 150 kg of bottle gourd, 90 kg of bitter gourd, 75 kg of okra in one season (March to June) (Fig. 6).

Table 6 Cost of bucket drip system

Item	No.	Rate	Total
Bucket (25 litre)	1	85.0	85
Inline lateral, 16mm, 0.60 m spacing, 2 Lph	24	15.0/m	360
Plain lateral, 16 mm	7	8/m	56
T, 16 mm	6	5.25	31.50
End clip	6	1.20	7.20
Jointer	1	6.75	6.75
Elbow-2, 16 mm	2	3.75	7.50
Gate valve, 16 mm	1	40	40
Fitting etc.		100	100
Total, Rs.			700

Fig. 6 Capacity building of women farmers

MICRO IRRIGATION SYSTEM IMPACT ON WATER SAVING AND ENHANCEMENT IN YIELD

Micro irrigation system came to India in seventies but its adoption started only in late eighties. Government started making efforts to promote micro irrigation through part financial support to offset its high initial cost syndrome through its central sponsored scheme on micro irrigation. Total 25 ha area was placed under drip irrigation, utilizing low discharge of tube wells which is not possible in flood irrigation. Fifteen (15) moveable Raingun sprinkler systems were installed for irrigation of wheat crop in the villages. Cotton under drip irrigation could save 38.7 % of water besides 75 % enhance in yield (Table 7). Water requirement for onion is 380 mm while for paddy it is 1200 mm that is almost 3 times higher than that of onion. Only 2% area is covered by onion during the kharif season in comparison of paddy. As the monsoon is quite undulating in India and the more than 80% of irrigation is given by groundwater. If the 25% of paddy growing area is replace by kharif onion in major paddy growing state, more than 50000 million meter cube water can be saved. So onion can be an optional crop for Kharif season specially for the water scarcity areas secondly farmers may have much profit by growing onion in kharif season in place of paddy because of 3 times of its productivity (Table 8). Tomato is a very popular vegetables and grown throughout the year. Tomato is long duration crop (about 6 months in open field) and needs equal amount of water as wheat. Tomato yield can be enhanced by 50 % by adopting drip irrigation with 26 % of water saving (Table 9).

Table 7 Performance of Micro irrigation in cotton crop (per ha)

S. No.	**Parameter**	**Drip irrigation**	**Flood irrigation (control)**	**Saving (%)**
1.	No. of Irrigation	30	3	-900.0
2.	Time per Irrigation (h)	3.5	40	91.25
3.	Total Time of Irrigation (h)	105	120	-15.0
4.	Irrigation Cost	9000.0	18000.0	50.0
5.	Water requirement (m^3)	6250.0	10200.0	38.7
6.	Fert./ Manure Cost (Rs/ha)	1200.0	2400.0	50.0
7.	Yield (q/ha)	28.0	16.0	75.0
8.	Total Income (Rs/ha)	128825.0	61625.0	109.0
9.	Energy (kWh/ha)	447.6	895.2	50.0
10.	IWP (l/kg)	308.57	691.2	55.4

Main product: Rs. 42 per kg ,By Product: Rs. 4.50 per kg

Table 8 Performance of Micro irrigation in onion crop (per ha)

S. No.	**Parameter**	**Drip irrigation**	**Flood irrigation (control)**	**Saving (%)**
1	No. of Irrigation	52	8	-550.0
2	Time per Irrigation (h)	2.5	36	93.06
3	Total Time of Irrigation (h)	130	288	54.86
4	Irrigation Cost	19500.0	43200.0	54.86
5	Total Irrigation Water (m^3)	3800.0	7000.0	45.71
6	Fert./ Manure Cost (Rs/ha)	1750.0	4800.0	63.54
7	Yield (q/ha)	240.0	152.0	57.89
8	Total Income (Rs/ha)	60000.0	51000.0	17.65
9	Energy (kWh/ha)	1007.1	2148.48	53.13
10	IWP (l/kg)	162.0	406.59	60.16

Table 9 Performance of Micro irrigation in tomato crop (per ha)

S. No.	**Parameter**	**Drip irrigation**	**Flood irrigation (control)**	**Saving (%)**
1	No. of Irrigation	72	7	-928.57
2	Time per Irrigation (h)	2	25	92.0
3	Total Time of Irrigation (h)	144	175	17.7

4	Irrigation Cost	21600.0	26250.0	17.7
5	Total Irrigation Water (m^3)	4800.0	6200.0	22.6
6	Fert./ Manure Cost (Rs/ha)	3700.0	3700.0	0.0
7	Yield (q/ha)	450.0	300.0	50.0
8	Total Income(Rs/ha)	136620	85800	59.2
9	Energy (kWh/ha)	1074.24	1305.50	17.7
10	IWP(l/kg)	83.48	161.54	48.3

Main product: Rs. 5.5 per kg

IMPACT OF WATER SAVING TECHNOLOGIES

The laser leveling indicates the possibilities of enhancing wheat yield by at least 25%, making it 47.25 million tons in whole Indo-Gangetic Plain and can also help in saving of a minimum of 30 % (1.45 million ha-m) of irrigation water. Micro irrigation system was found to result in 30 to 70 % water savings in various vegetables crops along with 10 to 60 % increases in yield as compared to conventional methods of irrigation. Mulching with drip further enhanced the crop yield to the tune of 10-20 % and controlled weeds up to 30-90%. Impact of these technologies motivated other farmers of nearby villages and now many farmers are coming forward for these technologies for their large scale adoption. The interventions made in the project are of very basic nature and have attracted the full support and participation of the farmers. There is a large likelihood of harvesting the similar benefits in terms of water saving and increased yields by implementing the suggested interventions and with the active participation of farmers.

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