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Agricultural Economics

Impact of Water Saving Technology On Blue Wateruse and Productivity: Analysis fron North Gujarat Region, India

O.P. Singh, P.K. Singh, Rakesh Singh, P.S. Badal and H.P. Singh

Department of Agricultural Economics, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi – 221 005, India;

Email: singhop@bhu.ac.in

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Abstract

North Gujarat is an absolutely water scarce region in Gujarat, though it contributes around 40 per cent of total groundwater draft in the state. Excessive withdrawal of groundwater for irrigation is leading to alarming drops in groundwater levels in many parts of the region. Since scope of supply side intervention is limited, it is imperative to manage irrigation water from demand side interventions aimed at to reducing its use. Overall objective of the present study was to analyse the impact of water saving technologies on applied water productivity. A study on experimental plot revealed that highest physical water productivity was found for castor under drip irrigation with plastic mulching as compared to flood irrigation followed by crop with organic mulching and lowest under drip irrigation. In case of groundnut, highest physical water productivity was obtained from the crop irrigated by easy drip method, whereas in case of sprinkler, highest physical water productivity was obtained from the micro-sprinkler. Potato crop was grown under drip and sprinkler methods of irrigation and highest physical water productivity was recorded from micro-sprinkler. From farmers' field data, it was observed that farmers are using different types of water saving technologies for variety of crops. Before adoption of water saving technologies, on average blue water use for crop production was estimated to be 8397 m^3 per hectare which was reduced to 5175.45 m^3 per hectare after adoption of water saving technology, showing a decline of 61.6 per cent. Per hectare net income received by farmers before adoption of water saving technology was Rs 54615.46 and it increased to Rs 95759.41 after adoption of water saving technology. The variation in physical water productivity for same crop under different types of water saving technologies, suggested that government/promotional agencies should promote suitable water saving technology for different crops, which would help in achieving water saving and improvement in crop production and productivity.

Highlights

Adoption of water saving technology resulted into reduction in per hectare water use and increase in net income by 61.6 and 57 per cent, respectively.

Keywords: Water productivity, Blue water use, Physical water productivity, Economic water productivity

The per capita renewable fresh water in Gujarat is less than many other Indian states. Going by M. Falkenmark's criterion, Gujarat falls into the category of "water stressed" and per capita renewable fresh water resource availability for the year 2001 was estimated to be 1137 m^3 per annum in the state (IRMA/UNICEF, 2001). Further, North Gujarat falls under the category of "absolutely water scarce" region as per capita renewable freshwater availability is less than 500 m^3 per annum. Looking at the fragile nature of water ecology, North Gujarat appears not favourable for irrigated crop production. But the reality is different; North Gujarat alone contributes about 40 per cent (3822 MCM) of the total groundwater draft in the State. Excessive withdrawal of groundwater for irrigation and other uses in the region has led to alarming drops in groundwater level in many parts of the region. The rate of declining water levels ranges from 0.91 m to 6.0 m per annum in different parts of the region (CGWB, 1998). Since, supply side intervention to augment water availability is limited due to unreliable and insufficient rainfall for water harvesting, it is imperative to manage irrigation water by demand side interventions (Molden *et al.,* 2001).

The water saving technology is one of the advanced methods of irrigating crops by which irrigation water is provide directly into the root zones of the soil. The use of water saving technology for irrigating crops leads not only to saving of irrigation water in substantial volume but also increases crop yields as compared to traditional method of irrigation (Kumar and Palanisami, 2010; 2011; Palanisami *et al.*, 2011; Narayanamoorthy, 2012; Blanke *et al*., 2007). Different types of water saving technologies are available in the market and it can be categorised into two broad groups i.e. drip and sprinkler. There are several constraints in adoption of water saving technology. These are physical, socio-economic, financial, institutional, pricing, subsidies, extension service and policy related (Narayanamoorthy, 1996; 1997; Sivanappan, 1998; Kumar *et al.,* 2003; Palanisami *et al*. 2011). There is a positive correlation between subsidies and adoption of water saving technology (Liu *et al.,* 2008; Dagnino and Ward, 2012). In case of technical constraints, providing knowledge and technical advice through extension service activities is an effective way to increase the adoption rate of agricultural water-saving technology (Ommani *et al*., 2009).

In water scarce regions, researchers and policy makers are highly concerned about how to maximize output from every unit of water used for crop production. The economic value of water in agriculture is much lower than that in other sectors including manufacturing sector (Xie, *et al*., 1993). Growing physical scarcity of water availability for crop production on one hand and scarcity of economically accessible water owing to increasing cost of abstraction and supply of water on the other, preoccupied researchers with increasing productivity of water use in agriculture in order to get maximum production or value from every unit of water used. Water productivity can be estimated at the plant level, field level, farm level, system level and river basin level and its value would change with the scale of analysis change (Molden *et al.*, 2003). The water productivity is measured in three ways: physical water productivity expressed in kg per unit of water consumed (kg/m^3); combined physical and economic water productivity expressed in term of net return per unit of water use (Rs/m^3); and economic water productivity expressed in term of net income returns from a given amount of water consumed against the opportunity cost of using the same amount of water (Rs/Rs) (Kijne *et al*., 2003).

At the farmers' field level, there is no single barometer to access the efficiency of water use in crop production. Measures to enhance yield to raise water productivity in biomass per unit of water depleted, might increase the cost of production and this leads to reducing net return per unit of water depleted (Kumar *et al.,* 2008). Therefore, crop productivity needs to be assessed in terms of both physical crop output (kg/m^3) and net or gross present value of the crop output (Rs/m^3). There are two major ways of improving the physical productivity of water used in irrigated agriculture. First, the water consumption or depletion for producing a certain quantum of biomass for the same amount of land is reduced. Secondly, the yield generated for a particular crop is enhanced without changing the amount of water consumed or depleted per unit of land. Often these two improvements can happen together with an intervention either on the agronomic side or on the water control side (Kumar *et al*., 2007). Keeping in view the above facts present study was undertaken to find out appropriate water saving technology for field crops and its impact on irrigation water use, crop yield and applied agronomic and net economic water productivity. The specific objectives of present study were: (1) To study the impact of micro-tube drip irrigation system on irrigation water use and water productivity for castor crop with and without plastic mulching on experimental plot level; (2) To study the different types of drips (inline drips and easy drips) and sprinkler systems (micro and mini sprinklers) on water use and water productivity for potato and groundnut crops on experimental plot level; and (3) To study the physical water productivity (kg/m^3) and economic water productivity (Rs/m^3) at farmers' field level.

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Materials and Methods

Data collection

Present study was based on primary data and it was collected for agriculture year 2011-12. The data was collected on two level i.e. experimental plots and farmers' fields. The experiment was conducted on the research and documentation farm located at Palanpur taluka of Banaskantha district. The basic objective of development of research and documentation farm is to find out appropriate water saving technology for a particular field crop. After getting favourable results, it is recommended to farmers for adoption of that technology for particular crop on larger scale. From the research and documentation farm, we collected data on different parameters like irrigation water use, crop production under different methods of irrigation i.e. flood and water saving technology.

For analyzing the viability of water saving technology (WST) at farmers' field level, a primary survey was conducted. A sample of 114 WST adopters was selected from 49 villages of eight talukas of two districts i.e. Banaskantha and Mehsana of Gujarat state. The primary data were collected using pre-tested schedules. The data were collected on different parameters like type of water saving technology, crop grown before and after adoption of water saving technology (WST), cost and subsidy on of WST, area under crops, inputs used for crop production and their value, crop outputs and their market price etc.

About Experiment

a) Water saving system for potato crop was inline drops, easy drips, micro tube, micro sprinkler and mini sprinkler. The irrigation water application rate for drippers, easy drips and micro-tube drip was kept close to evapo-transpiration (ET) estimated on the basis of canopy and potential evapo-transpiration. Water application rates for mini and micro sprinkler was kept much higher in the view of the larger area of wetting.

b) In case of groundnut we used inline drippers, easy drips, flood method of irrigation, micro-tube, micro-sprinkler and mini-sprinkler. Water application rate for inline drips and easy drips was kept close to estimated evapo-transpiration (ET). Daily irrigation for micro-irrigation system and a total nine irrigation in case of flood method of irrigation were applied.

c) Treatments for castor crop were plastic mulching with micro-tube, organic mulching with micro-tube drip, micro-tube drip, and flood irrigation. Water application rate for crop with micro-drip was fixed at Evapo-transpiration (PET*CP*K); for flooding the conventional practice was followed; frequency of irrigation water reduced for castor crop under drip with plastic and plastic mulching with micro tube drips.

Analytical Procedure

The physical water productivity for a given crop (kg/m^3) was estimated using the data on crop yield and the estimated volume of water applied for growing that crop. The Physical productivity of water in crop production (kg/m^3) can be defined as:

$$WP_{Crop} = \frac{Q_{CP}}{V_{Crop}}$$

Where, WP_{crop} is physical water productivity for a given crop (kg/m^3), Q_{CP} is the crop production (kg) and V_{crop} is the total volume of water (m^3) used during crop period.

The net economic water productivity for a given crop (Rs/m^3) was estimated using the data on crop yield, market price of the crop, input costs and the estimated volume of water applied for growing that crop. The net economic productivity of water (Rs/m^3) can be defined as:

$$WP_{(Rs/m^3)} = \frac{(Q_{CP} * P_{CP}) - IC_{crop}}{V_{Crop}}$$

Where, $WP_{(Rs/m^3)}$ is net economic water productivity for a given crop (Rs/m^3), is the crop production (kg), is the market price of the crop (*Rs*), is the inputs cost (*Rs*) and is the total volume of water used (m^3) during crop period.

Results and Discussion

Experimental Plot Level

Castor

The castor crop is a two season crop grown during the *kharif* season and harvested during *rabi* season. The crop is grown in rows resulting into greater exposure of the soil to sunlight during the initial stage of growth. It leads to higher rate of non-beneficial evaporation losses. But in later stages of crop growth, the non-beneficial evaporation losses from soil surface are reduced because the crop canopy prevents soil from being exposed to direct sunlight. The non-beneficial evaporation losses can be minimized by use of plastic or organic mulching. The mulching also helps in reduction of weed growth in field. On the experimental farm, the plot size was 1110 m^2. Duration of water application days under the drip method of irrigation with and without mulching was 96 days each, whereas in case of flood irrigation without mulching it was 9 irrigation days. The highest irrigation water used under the flood method of irrigation was 469.9 m^3 followed by drip method of irrigation without mulching (425.5 m^3) and lowest for the drip with plastic mulching (301.7 m^3). The highest castor yield was obtained under drip with plastic mulching with 150 kg per plot, followed by flood irrigation (140 kg), drip without mulching (125 kg), and lowest with drip with organic mulching i.e. 110 kg per plot (Table 1).

The lowest irrigation water used for castor production was observed under drip irrigation with plastic mulching (0.272 m^3 per m^2 area) and it was highest under flood method of irrigation with 0.423 m^3 per m^2 area. The physical water productivity was found to be highest under the drip irrigation with plastic mulching (0.5 kg/m^3) and it was lowest under flood method of irrigation (0.30 kg/m^3). It was due to very low level of non-beneficial evaporation from the plot under drip with plastic mulching. Due to very low weed germination under drip with plastic mulching, the castor plants were getting maximum applied nutrients which helped in better plant growth and crop yield. The highest irrigation water could be saved under drip with plastic mulching (55.75 per cent) followed by crop with organic mulching with 34.30 per cent and lowest under crop irrigated by drip i.e. 10.44 per cent as compared to flood method of irrigation. Farmers were able to enhance their crop production by adopting drip with plastic mulching upto 7.0 per cent as compared to flood method of irrigation (Table 1).

Groundnut

Groundnut crop was grown during *kharif* season and crop duration was about 90 days. Traditionally farmers were using flood method to irrigate groundnut crops. The experiment was conducted with different types of water saving technologies viz., inline-drip, easy-drip, micro-sprinkler, mini-sprinkler and under the conventional method of irrigation. In case of drip irrigation, 72 days of irrigation was given to crop with different water application rate (Table 2). In case of flood method of irrigation, 12 irrigations were given to the groundnut crop during entire crop season with an average depth of irrigation water of 69.57 mm per irrigation.

The irrigation water used under drip irrigation was highest for inline-drip (0.399 m^3) and lowest under easy-drip (0.396 m^3) per m^2 area. In case of flood method of irrigation, water used per m^2 area was 0.835 m^3. In case of sprinkler, the highest irrigation water used per square meter area under mini-sprinkler was 0.438 m^3 and lowest under micro-sprinkler with 0.434 m^3 (Table 2). Out of the different types of drip (inline drip and easy drip), agronomic water productivity was highest for the easy drip with 0.631 kg/m^3, whereas in case of both types of sprinkler i.e. mini-sprinkler and micro-sprinkler, the highest agronomic water productivity was obtained from the micro sprinkler (0.628

Table 1: Blue Water Use, Crop Production and Productivity of Castor Crop

Method of Irrigation	Agronomic Practices	Plot size [m^2]	Average water application rate [mm/ irrigation]	Duration of water application [Days]	Total Water Use[m^3]	Yield [Kg]	Per m^2 area		
							Water use[m^3]	Yield [kg]	Physical water productivity [kg/m^3]
Micro-tube	P. M.	1110	2.83	96	301.7	150	0.27	0.14	0.50
Micro-tube	O. M.	1110	3.28	96	349.9	110	0.32	0.10	0.31
Micro-tube	Drip	1110	3.99	96	425.5	125	0.38	0.11	0.29
Flood	-	1110	47.04	9	469.9	140	0.42	0.13	0.30

P. M.: Plastic Mulching; O. M. : Organic Mulching

Table 2: Blue Water Use, Crop Production and Productivity of Groundnut Crop

Method of Irrigation	Plot size[m^2]	Average water application rate [mm/ irrigation]	Duration of water application [Days]	Total Water Use[m^3]	Yield [Kg]	Per m^2 area		
						Water use [m^3]	Yield [kg]	Physical water productivity [kg/m^3]
Inline drip	304	5.55	72	121.4	62.0	0.399	0.204	0.511
Easy drip	304	5.50	72	120.4	76.0	0.396	0.250	0.631
Micro-Sprinkler	638	6.03	72	277.2	174.0	0.434	0.273	0.628
Mini-Sprinkler	638	6.09	72	279.7	114.0	0.438	0.179	0.408
Flood	304	69.57	12	253.8	49.0	0.835	0.161	0.193

kg/m^3) and lowest for mini-sprinkler. In case of flood method of irrigation, it uses highest volume of water (0.835 m^3 per m^2 area) as compared to drip and sprinkler and least agronomic water productivity with 0.193 kg/m^3. The water saving due to adoption of different types of water saving technologies as compared to flood method of irrigation showed that farmers could save about 52 per cent of irrigation water by using inline drip and easy drip, whereas in case of sprinkler, farmers could save irrigation water upto 48 per cent. The adoption of water saving technology not only saved scarce natural resource i.e. irrigation water but it also enhanced the crop production as compared to flood method of irrigation. After adoption of micro-sprinkler method of irrigation for groundnut crop, farmers can get upto 69 per cent higher yield, whereas in case of easy drip, inline drip and mini-sprinkler it was about 55, 26 and 11 per cent, respectively.

Potato

The potato is one season crop and grown in *rabi* season. The duration of water application was 56 days for drip method of irrigation and 59 days for sprinkler method of irrigation. The average water application rate was 7.24 mm per irrigation for drip method of irrigation and 13.66 mm per irrigation in case of sprinkler. The experiment was conducted using different types of water saving technologies i.e. inline drip, easy drip, micro-tube drip, micro-sprinkler and mini-sprinkler. Due to the coverage of all fields with crop canopy, there were minimum non-beneficial evaporation losses. Therefore, mulching was not required for potato crop. Total irrigation water used for crop production under drip method of irrigation was 123.3 m^3 for plot size of 304 m^2 area, whereas in case of sprinkler method of irrigation, it was 245 m^3 for same plot size (Table 3).

The irrigation water used per m^2 area under drip and sprinkler was 0.406 m^3 and 0.806 m^3 (Table 3). Both types of water saving technology, the highest water productivity was observed for micro-sprinkler with 1.633 kg/m^3 and lowest for the micro-tube drip method of irrigation with 0.365 kg/m^3 of irrigation water for one meter square area. Among the different types of drip technologies farmers

Table 3: Blue Water Use, Crop Production and Productivity of Potato Crop

Method of Irrigation	Plot size[m^2]	Average water application rate [mm/ irrigation]	Duration of water application [Days]	Total Water Use[m^3]	Yield [Kg]	Per m^2 area		
						Water use [m^3]	Yield [kg]	Physical water productivity [kg/m^3]
Inline drip	304	7.24	56	123.3	114.0	0.406	0.375	0.925
Easy drip	304	7.24	56	123.3	125.0	0.406	0.411	1.014
Micro-tube drip	304	7.24	56	123.3	45.0	0.406	0.148	0.365
Micro-Sprinkler	304	13.66	59	245.0	400.0	0.806	1.316	1.633
Mini-Sprinkler	304	13.66	59	245.0	275.0	0.806	0.905	1.122

were getting higher water productivity under easy drip with 1.014 kg/m^3 and lowest for the micro-tube drip with 0.365 kg/m^3. In case of sprinkler method of irrigation, the highest water productivity was observed for micro-sprinkler with 1.633 kg/m^3 of irrigation water.

Farmers' Filed Level

Socio-economic Background

The average family size of the sample farmers of Banaskantha and Mehsana districts of Gujarat was 8.22. Out of this, share of adult male, adult female, children male and children female was 31.39, 31.75, 20.44 and 16.30 per cent respectively. The female family members were also helping male members in farming and decision making related to farming.

The average size of land holding of sample farmers was 3.79 hectares. Out of this, cultivable area was 3.76 hectares accounting for about 99.21 per cent. The cultivated land was 3.34 hectares (98.68 per cent) and all the cultivated land was irrigated.

Total income received by the sample farmer in the study area before adoption of water saving technology was Rs 171824.56 per year (Table 4). The highest share comes from the income received by farmers from crop production i.e. 63.78 per cent followed by the dairy farming (26.59 per cent) and lowest from the selling of water i.e. 0.10 per cent. After adoption of water saving technology, the annual income received by the sample farmer was Rs 341315. The incremental benefit from the agriculture after adoption of water saving technology was estimated to be Rs 98342.11. This may due to change in the cropping pattern of the farmers. After adoption of water saving technology, farmers of the study area were receiving sufficient quantity of green fodder to feed livestock to get more income. The incremental benefit from the dairy farming in the study area was estimated to be Rs 13912.28 per annum. After adoption of water saving technology, farmers were able to save sufficient amount of irrigation water and they sell to needy farmers to earn income. The study suggests that farmers were selling irrigation water of Rs 175.44 per annum before adoption of water saving technology and after adoption of water saving technology it was increased to Rs 350.88 showing an incremental benefit of Rs 175.44 (Table 4)

Cost of Water Saving Technology

The different types of micro-irrigation systems are available in the market suited for different crops and with different level of water application efficiency. Farmers were using three types of micro-irrigation system viz., sprinkler, drip and micro-tube depending upon the crop grown by the farmers. Within sprinkler, three types of sprinklers i.e.

Table 4: Source-wise Income (Rs/year)

Source of Income	Before adoption of WST	After adoption of WST	Incremental benefit
1. Agriculture	109587.72	207929.82	98342.11
2. Dairy	45684.21	59596.49	13912.28
3. Business/Trader	14561.40	1754.39	-12807.02
4. Service	1815.79	71684.21	69868.42
5. Water selling	175.44	350.88	175.44
Total	171824.56	341315.79	169491.23

Table 5: Per Hectare Cost of Micro-Irrigation System

Types of micro-irrigation system	Total cost of micro-irrigation systemirr		Subsidy on micro-igation system		Net cost of micro-irrigation system	
	Rs.	Per cent	Rs.	Per cent	Rs.	Per cent
1. Sprinkler	65843.96	100.00	30831.95	46.83	35012.02	53.17
2. Sprinkler - Nandan	79206.01	100.00	38392.09	48.47	40813.92	51.53
3. Sprinkler - Mini Israel	88938.22	100.00	40540.54	45.58	48397.68	54.42
4. Drip Irrigation-Online	53429.60	100.00	24791.13	46.40	28638.47	53.60
5. Drip Irrigation-inline	133147.65	100.00	59360.78	44.58	73786.87	55.42
6. Micro-tube	56250.00	100.00	0.00	0.00	56250.00	100.00

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simple sprinkler, sprinkler-Nandan and mini Israel were available in the market and farmers installed in the study area. In case of drip irrigation system it was two types i.e. drip irrigation – online and inline. Per hectare cost of micro-irrigation system, subsidy given by the government and actual cost incurred by the farmers is given in Table 5. Out of the total cost of micro-irrigation system, farmers received subsidy ranging between 44 to 48 per cent and remaining cost of system i.e. 52 to 56 per cent paid by the farmers. In case of micro-tube, no subsidy was reported by the sample farmers.

Crop Water Productivity

The physical and economic water productivity of crops grown by sample farmers before and after adoption of water saving technology is presented in Table 6. After adoption of water saving technology some crops those were grown by farmers before adoption of water saving technology was not growing after adoption of water saving technology and some new crops were introduced in the study area. During monsoon season, sample farmers were cultivating bajra and moong crops but it was replaced by the rajka (green fodder), kola and pomegranate. In case of winter season, potato and flowers were introduced after adoption of water saving technology and it was replaced with mustard and rajgaro. Before adoption of water saving technology farmers were cultivating rajka bajari (fodder crop) and vegetables, but it was replaced with choli after adoption of water saving technology in the study area during summer season. The pomegranate was entirely new crop in the study area and it was introduced in the study area along with introduction of water saving technology.

Per hectare water application rate for different crops during monsoon, winter and summer season were worked out by using number of irrigation, hours required to irrigate cropped area per irrigation and pump discharge rate and it was presented in Table 6. Farmers of the study area were irrigating crops using traditional method i.e. flood irrigation before adoption of water saving technologies. This led to higher volume of water applied to all the crops. Farmers of the study area applied highest volume of irrigation water to bajari crop (12750 m^3) and lowest for moong (840 m^3) during monsoon season. During the winter season, farmers of study area applied highest volume of irrigation water to potato crop with 13964 m^3 and lowest for rajgaro with 3600 m^3. During the summer season, highest water application rate was observed for rajaka bajari (fodder crop) and lowest for bajari crop. In general, after adoption of water saving technology, the water application rate to all the crops drastically reduced without any negative consequences on economic benefit from the crop production. Farmers in the study area applied highest volume of irrigation water to rajka (fodder) crop and lowest to kola crop during the monsoon season. During winter season, the highest volume of water applied to Potato crop and lowest to wheat. During summer season, millets were consumed highest volume of irrigation water and lowest for bajari crop (Table 6).

Before adoption of water saving technology, the highest economic water productivity was received from the brinjal (Rs 44.91/m^3) and lowest from the bajari (Rs 0.76/m^3) during monsoon season. Among all the crops grown during winter season, highest economic water productivity was received by the farmers from mustarded (Rs 7.98/m^3) and lowest from the rajgaro with (Rs 1.16/m^3). The highest economic water productivity was received from bajari with Rs 3.49/m^3 among different crops grown during summer season.

After adoption of water saving technology, among different crops grown during monsoon season, highest economic water productivity was received from chilli (Rs 148.09/m^3) and lowest from the castor crop with Rs 6.85/m^3. During the winter season, highest economic water productivity were received by the sample farmers from tomato (Rs 50.32/m^3) and lowest from flower (Rs 1.41/m^3). The economic water productivity was highest from choli crop (Rs 16.78/m^3) among different crops grown during summer season in the study area.

Conclusion

The water saving technologies available in the market do not only save one of the important inputs and scarce resources of crop production i.e. irrigation water but also enhance the quantity and quality of crop produce. Normally, water saving technology was used for the row and high value crops. Past researchers have suggested that the use of water saving technologies can cut down irrigation water, a prestigious and scarcest resource. The researchers compared irrigation water use and yield enhancement between different types of available water saving technologies and conventional method of irrigation (Naryanamoorthy, 1997; Kumar and Palanisami, 2010; Palanisami *et al.*, 2011; Reddy *et al.*, 2012). Researchers found higher crop yield per unit area with less irrigation water as compared to traditional method of irrigation which

Table 6: Physical and Economic Water Productivity Before and After WST Adoption

Season	Name of the crops	Before adoption of water saving technology				After adoption of water saving technology			
		Irrigation Water Use (M^3/Ha)	Net Income (Rs/Ha)	Water Productivity		Irrigation Water	Net Income Use (M^3/Ha)	Water Productivity (Rs/Ha)	
				Physical (Kg/m^3)	Economic (Rs/m^3)			Physical (Kg/m^3)	Economic (Rs/m^3)
Monsoon	Guvar	2548.98	13194.24	0.56	7.68	1305.00	20575.00	1.15	15.77
	Castor	7890.12	21070.10	0.27	3.04	7695.00	51150.00	0.43	6.85
	Groundnut	5602.79	11133.74	0.37	4.13	5258.21	27894.17	0.41	9.36
	Chilli	11500.00	411833.33	5.22	34.87	3540.00	524250.00	21.19	148.09
	Rajka (fodder)	-	-	-	-	12815.10	55349.57	12.64	7.36
	Brinjal	5966.67	157533.33	7.82	44.91	1180.00	86650.00	21.19	122.96
	Kola	-	-	-	-	540.00	4800.00	7.41	8.89
	Pomegranate	-	-	-	-	3333.96	81662.50	1.26	41.37
	Bajari	12750.00	4663.33	0.13	0.76	-	-	-	-
	Green Gram	840.00	4450.00	1.43	5.30	-	-	-	-
	Cotton	7150.59	68876.42	0.46	10.32	3510.00	52822.88	1.13	18.81
	Fennel	2455.25	12333.33	0.29	6.27	1728.00	23730.29	0.92	45.60
Winter	Mustard	6337.01	43994.00	0.51	7.98	-	-	-	-
	Wheat	7835.96	23195.36	0.47	4.58	1957.50	32527.78	1.70	16.62
	Potato	13964.89	60684.85	2.42	7.04	12721.42	126751.81	3.13	17.99
	Tomato	-	-	-	-	9440.00	475000.00	12.71	50.32
	Flower	-	-	-	-	3540.00	5000.00	2.82	1.41
	Rajgaro	3600.00	4182.00	0.11	1.16	-	-	-	-
Summer	Bajari	8368.19	19771.10	0.27	3.49	5030.78	15082.45	0.81	4.74
	Millet	11338.57	26797.62	0.52	2.15	8776.13	22099.55	0.63	2.97
	Rajaka Bajari (fodder)	20850.00	28583.33	4.20	1.56	-	-	-	-
	Vegetable	13750.00	16166.67	0.36	1.18	-	-	-	-
	Choli	-	-	-	-	5611.50	22564.00	0.71	16.78
	Average (Per hectare)	8397.00	54615.46			5175.45	95759.41		

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it leads higher net income (Palanisami *et al*., 2011; Kumar and Palanisami, 2010).

The plastic/organic mulching with the combination of water saving technology was one of the new concepts and helped in reduction of non-beneficial evaporation from the crop field which has less canopy coverage like castor crop. Present study suggests that the drip irrigation with plastic mulching in castor field reduced irrigation water upto 56 per cent and increased the crop yield upto seven per cent as compared to flood method of irrigation. This would help farmers to cover the cost of plastic mulching. In case of groundnut, highest water productivity was found with easy drip method of irrigation. Farmer could save irrigation water upto 52 per cent as compared to flood method of irrigation to get higher yield up to 69 per cent. The water saving point of view, easy drip was suitable for groundnut irrigation. In case of potato crop, highest water productivity was found for micro-sprinkler as compared to different types of water saving technology available in the market. But sprinkler requires energy to maintain the required water pressure for increase efficiency. Whereas, in case of different types of drip highest water productivity was observed for easy drip. Farmers' filed level data suggests that farmers were using different types of water saving technology for variety of crops. Per hectare cost of micro irrigation system was ranging between Rs. 56250 to 133147.65 depending on the types of micro-irrigation system. Out of this, subsidy amount ranging between 44.58 to 48.47 per cent and remaining cost was incurred by the farmers. Before adoption of water saving technology, on farm level average blue water use per hectare for crop production was 8397 m^3 and it was reduced to 5175.45 m^3 after adoption of water saving technology, showing a decline in irrigation water use by 61.64 per cent. Reddy *et al.*, (2012) reported that water saving in case of onion crop irrigated by drip as compared to furrow irrigation was ranging between 34 to 66 per cent. Past researchers found that after adoption of water saving technology, net income per hectare had increased 22 per cent in case of tomato and 29 per cent in case of mulberry (Chandrakanth *et al*., 2012). In the present study net income received by the sample farmers was Rs 54615.46 per hectare before adoption of water saving technology, and it increased to Rs 95759.41 per hectare after adoption of the technology. If we need to save irrigation water and energy then we can promote easy drip for potato cultivation. From the above discussion it can be concluded that the promotion of water saving technology is required with crop and location specific.

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