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Original Research Article

Low Cost Water Saving Techniques Implementation through Farmers' Participatory Approach in Command Area

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A B S T R A C T

Developing infrastructure for the water resources and their management have been the common policy agenda in many developing economies, particularly in the arid and semi-arid tropical countries like India. International Water Management Institute (IWMI) has shown that around 50 per cent of the increase in demand for water by the year 2025 can be met by increasing the effectiveness of irrigation. Water is the most crucial input for agricultural production. Globally, agriculture accounts for more than 80% of all freshwater used by humans, most of that is for crop production security and contribute about 40% of total food production. Since productivity of irrigated land is almost three times higher than that of rainfed land. Strategies for efficient management of water for agricultural use involve conservation of water. Suitable irrigation methods and water saving techniques adoption in farmers' field in the project of Ministry of Water Resources is implementing Farmers' Participatory Action Research Programme (FPARP). By adopting the research cum demonstration technology two years (2008-09 and 2009-10) i.e., alternatively alternate furrow irrigation in maize for, it was recorded the higher grain yield (7286 kg/ha) as compared to the control (6533 kg/ha), increase in the yield (753 kg/ha) was more by 11.53 % over all furrow irrigation (control). This resulted in increase in the gross income, net income and water use efficiency in farmers' field. Another Border strip method of irrigation with 80% cutoff length in chickpea demonstrated on farmers field and the research cum demonstration results revived higher chickpea grain yield (2,125 kg/ha) as compared to control (1,821 kg/ha), Increase in the gross income and net income, higher water use efficiency (5.20 kg/ha – mm) in the treatment over control (3.77 kg/ha-mm) of the farmer due to adoption of the improved irrigation technology. In same method (Border strip method of irrigation with 80% cutoff length) in wheat, recorded higher wheat grain yield (2,124 kg/ha) as compared to control (1,843 kg/ha), increase in the gross income, net income and yield was produced per unit of water spent as indicated by higher water use efficiency (4.52 kg/ha – mm) in the treatment over control (3.40 kg/ha – mm) of the farmer's due to adoption in this methods saving water and avoid excess improper use of irrigation methods and heavy irrigation in command areas and under lift irrigation schemes in basins.

Keywords

Water saving technologies, Crops, water use efficiency and Economics

Introduction

India is an agrarian country with majority of population engaged and dependent on agriculture. Adequate water resources are instrumental in ensuring food security and affordability for whole of the society. India has made significant progress in development of its water resources over the past 60 years. The expansion of irrigation system along with modern agronomic practices has increased the production of food grains from a meager 51 million tonne in 1951 to more than 249 million tonne at present. While irrigation projects have helped in making the country self-sufficient in food and fiber, at the same time development of irrigation has brought into focus certain problems like availability of utilizable water resources, under-utilization of created potential, water logging, salinity/alkalinity, inequitable distribution of water amongst the beneficiaries, lack of reliability of supply of water both in terms of its quantum and time, low operational efficiencies, lack of maintenance, low yields from irrigated agriculture compared to possible potential. The Food and Agriculture Organization has predicted a net expansion of irrigated land of about 45 million hectares in 93 developing countries (for a total of 242 million hectares in 2030) and projected that water withdrawals by the agriculture sector will increase by about 14% during 2000 – 2030 to meet food demand (FAO, 2006). Agriculture sector in India has been and is likely to remain the major consumer of water but the share of water allocated to irrigation is likely to decrease by 10 – 15 per cent in the next two decades. Developing infrastructure for the water resources and their management have been the common policy agenda in many developing economies, particularly in the arid and semi-arid tropical countries like India.

Demand of water for various sectors

Worldwide, agriculture uses about 70% of all water. Developing countries require more water for agriculture and it is estimated that in India, irrigated agriculture consumes about 80% of total developed fresh water resources. With increase in population and better standard of living, the water demands for various uses are on rise and will continue to do so. Water requirement for various sectors as assessed by the National Commission on Irrigation and Water Resources Development (NCIWRD) is as under.

A study by the International Water Management Institute (IWMI) has shown that around 50 per cent of the increase in demand for water by the year 2025 can be met by increasing the effectiveness of irrigation (Shelke *et al.,* 1999). Current use efficiency or productivity of irrigation water is so low that most, if not all, of our future water needs could be met by increased productivity or efficiency alone, without development of additional water resources. Strategies for efficient management of water for agricultural use involves conservation of water, integrated water use, optimal allocation of water and enhancing water use efficiency by crops. Surface Water Resources of India has been divided into 20 river basins. These comprise of 12 major basins each having a catchments area exceeding 20,000 sq km and 8 composite river basins combining suitably together all the other remaining medium and small river systems. The total water potential of these basins is estimated at 187.9 million ha million. A break up of this resource reveals that 105 million ha m is the runoff from rainfall that flows into rivers and streams including reservoir and tanks.

Additional water is received from snow melt (10 million ha m), flow from outside India (20 million ha m), from groundwater (37 million ha m) and from irrigated areas (11 million ha m) making a total of about 183 million ha m. The largest potential of water is available in Ganga/ Brahmaputra/Barak and others making a total of 117 million ha m followed by Godavari and by west flowing rivers from Tapti to Tadri each having an average annual potential of more than 10 million ha m. Due to extreme variability in precipitation, which disallows assured storage of all the water, due to non-availability of storage space in hills and plains, evaporation losses and water going to the sea and outside India, it is anticipated that utilizable surface water resources would be 69 million ha m which will be utilized by the year 2025. It is assessed that on full development, 76 million ha area would be irrigated through surface water resources (Molden, 2007).

Agriculture sector in India has been and is likely to remain the major consumer of water but the share of water allocated to irrigation is likely to decrease by 10 – 15 per cent in the next two decades. Current use efficiency or productivity of irrigation water is so low that most, if not all, of our future water needs could be met by increased productivity or efficiency alone, without development of additional water resources. Improving water use efficiency by 40% on rainfed and irrigated lands would be required to counterbalance the need for additional withdrawals for irrigation over the next 25 years to meet the additional demand for food.

Growing more crop per drop of water use is the key to mitigating the water crisis, and this is a big challenge to many countries. Vagaries of monsoon and declining water table due to over exploitation have resulted in shortage of fresh water supplies for agricultural use, which calls for an efficient use of this resource. Strategies for efficient management of water for agricultural use involves conservation of water, integrated water use, optimal allocation of water and enhancing water use efficiency by crops.

In most crops including heavy water requiring crops such as sugarcane alternatively alternate furrow irrigation is most suitable for wide spaced crops like cotton, maize, Wheat, sunflower, etc. The present proposal envisages demonstrations on the farmer's field's water saving techniques in Malaprabha command area.

Materials and Methods

Improving irrigation and their and reduction in the water application has become important area of research in view of fast receding water resource. Of the many solutions to the problem evolving better irrigation techniques and methods have received greater attention. Conventional irrigation methods are not efficient. The newer techniques like alternatively alternate furrow irrigation border strips with appropriate cut off length, providing irrigation at critical stage, use of appropriate land configuration etc. have become important tools in efficient management of water resources. At the international level alternate furrow irrigation skip row irrigation, wide spaced furrow irrigation etc. have been demonstrated and widely used in USA (Mitchel *et al*., 2012) to improve irrigation efficiency in potato, corn, sorghum, cotton and peppermint. Large water saving (up to 50%) without a loss in yield has been achieved in USA. At the national level most of the All India Co-coordinated Research Project Centers, SAU's are using these simple techniques to save water. In most crops including heavy water requiring crops such as sugarcane alternatively alternate furrow irrigation is most suitable for wide spaced crops like cotton, maize, sunflower, etc. The present proposal envisages demonstrations of Water saving technology on the farmer's fields. (A) Alternatively alternate furrow irrigation, Treatments: a) Alternatively Alternate Furrow Irrigation and b) Farmers method (All Furrow Irrigation) ii) Replication: 12 per year (total 24), iii) Area of each demonstration: 2000 sq. m/treatment iv) Crops: Maize, v) Cultivation Practices: As per recommendation vi) Observations ;Hydraulics (flow velocity and quantity of water applied),Yield and growth parameters, Water saving, WUE, water productivity, Providing data to end users with emphasis on educating the water productivity difference, economics, environmental benefits and vii) Analyses: A suitable statistical analysis will be employed for understanding variation between the two pairs of treatment.(B) Border strip in chickpea and wheat: i) Treatments: Border strip with 80% cut off and Farmers practice (Border strip without cut off), ii) Replication: 11 per year (total 22), iii) Area: 2000 sq. m/treatment, iv) Crops: Chickpea and wheat) Observations: Hydraulics (flow velocity and quantity of water applied),Yield and growth parameters, Water saving, WUE, water productivity Providing data to end users with emphasis on educating the water productivity difference, economics and environmental benefits. (C). SRI method of paddy cultivation for higher water productivity: Treatments: SRI method of paddy cultivation, and conventional methods ii) Replication: 20 per year (total 40), iii) Area: 2000 sq. m/treatment, iv) Crops: Paddy, v) Observations: Hydraulics (flow velocity and quantity of water applied), Yield and growth parameters, Water saving, WUE, water productivity, Providing data to end users with emphasis on educating the water productivity difference, economics and environmental benefits. (C) Water resource based on critical stage concept: i) Treatments: a) Irrigation at critical stages. b) Farmers practice, ii) Replication: 2 per year (total 20) iii) Area: 2000 sq. m/treatment iv) Crops: Sunflower, v) Observations: Hydraulics (flow velocity and quantity of water applied), Yield and growth parameters, Water saving, WUE, water productivity, Providing data to end users with emphasis on educating the water productivity difference, economics and environmental benefits.

Results and Discussion

Initially, irrigation efficiency or water use efficiency was used to describe the performance of irrigation systems. In agronomic terms, '*water use efficiency*' is defined as the amount of organic matter produced by a plant divided by the amount of water used by the plant in producing it (Alien. 2014). However, the used terminology '*water use efficiency*' does not follow the classical concept of '*efficiency*', which uses the same units for input and output. Therefore, International Water Management Institute (IWMI) has proposed a change of the nomenclature from '*water use efficiency*' to '*water productivity*'. The water productivity per unit of gross inflow (WPG) is the crop production divided by the rain plus irrigation flow. The discussion in the paper however is limited to improving water use efficiency and thus water productivity through various water management practices, adoption of modern technologies in water application in irrigated commands *etc.* Irrigation management is a WUE can be improved with better systems for conveyance, allocation and distribution and water losses can be drastically reduced by using irrigation methods including drip irrigation systems that allow water to be delivered precisely when and where it is needed (Anonymous, 2010). In Malaprabha and Ghataprabha command areas, alternatively alternate furrow irrigation in hybrid maize, hybrid cotton and chickpea saved irrigation water by 25-27%. Border strip method of irrigation in wheat and chickpea with cut off irrigation water at 80% of the length of the border strip saves irrigation water by 15-20%. Demonstration of proven technology in farmer field under the Adohoc project of Ministry of Water Resources is implementing Farmers' Participatory Action Research Programme (FPARP) throughout the country for conducting demonstrations at farmers' fields. FPARP involves field demonstration of water saving technologies developed by various institutes for increased productivity per drop of water. As per the details received from the institutes, in general, the demonstrations show that the saving of water ranges between 10 to 30 % (maize from 5 to 33%, Bengal gram from 23 to 40% and paddy from 25 to 54%) and yield improvement of the crops ranges between 10 to 40% (maize t ranging from 16 to 43%, Bengal gram from 10 to 23%, paddy from 10 to 62%). Farmers have also shown their interest to support the programme and have positive view in respect of water saving and increase in yield by such demonstrations (Anonymous, 2012).

Technology 1: Higher water productivity through alternatively alternate furrow irrigation for broad spaced crops (Maize) = 24 Research cum Demonstrations

Pooled data of 2 years (2008-09 and 2009-10 from Table 1 and Fig. 1) data revealed that in the technology of Alternatively alternate furrow irrigation in maize recorded higher maize grain yield (7286 kg/ha) as compared to control (6533 kg/ha) where all furrows were irrigated. The increase in the yield by adopting improved irrigation method was by 13.5% (753.17 kg/ha). This resulted in increase in the gross income and net income of the farmer due to adoption of the improved irrigation technology. Apart from this more yield was produced per unit of water spent as indicated by higher water use efficiency (14.84 kg/ha – mm) in the improved irrigation technology in farmers field adopted treatment over control (11.92). The results are in conformity with the earlier findings in New Delhi (Annomous2006).

Technology 2: Border strip method of irrigation with 80% cut off length: 22 researches cum demonstration trials

Mean of 2 years (2008-09 and 2009-10) Border strip method of irrigation with 80% cutoff length in chickpea demonstrated on farmers field and the research cum demonstration results recorded higher chickpea grain yield (2,125 kg/ha) as compared to control (1,821 kg/ha). The increase in the yield over control was by 16.69 % (Table 2). This resulted in increase in the gross income and net income of the farmer due to adoption of the improved irrigation technology. Apart from this more yield was produced per unit of water spent as indicated by higher water use efficiency (5.20 kg/ha – mm) in the treatment over control (3.77 kg/ha-mm). In wheat, by adoption of border strip irrigation method with 80% cutoff length recorded higher wheat grain yield (2,124 kg/ha) as compared to control (1,843 kg/ha) in table 2.

The increase in the yield over control was by 15.25% (Table 2 and Fig. 3). Apart from this more wheat yield was produced per unit of water spent as indicated by higher water use efficiency (4.52 kg/ha – mm) in the treatment over control (3.40 kg/ha-mm). This resulted in increase in the gross income and net income of the farmer's due to adoption of the border strip irrigation method with 80% cutoff length in wheat. Similar results were noticed by Morison (2011).

Technology 4: System of rice intensification (SRI) method of paddy cultivation for higher water productivity 20 researches cum demonstration trials

System of Rice Intensification (SRI) is a new and evolving alternative to conventional methods of rice cultivation. In this method, rice seedlings are transplanted early (eight to 12 days old compared to 21 days in the conventional method). They are transplanted in un-puddled condition; the seedlings are widely spaced (up to 20, 25, 30 or even 50 cm apart). The fields are alternately kept wet and dry; they are not flooded until the panicle initiation stage (1-3 cm of water in the field during the reproductive phase). The field is drained 25 days before harvest and organic manure is used as much as possible. Mechanical weeding should start around 10 days after transplantation; at least two weeding are necessary, more are recommended. It is supposed to provide better growing conditions in the root zone, save inputs, improve soil health and optimize water use efficiency. The looming global water crisis threatens the sustainability of irrigated rice, which is the Asia's biggest water user. Aerobic rice is a new concept of growing rice in non-puddle and non-flooded aerobic soil. Supplementary irrigation, however, can be supplied in the same way as to any other upland cereal crop (Kijne *et al.*, 2013). The yields that can be obtained here range from 4.5 to 6.5 t ha^{-1} (Yadav *et al.*, 2012).

Table.1 Effect of alternatively alternate furrow irrigation on average maize yield (kg/ha), water used (mm), gross income, net income (Rs/ha), B: C ratio and WUE (kg/ha-mm) during

Sl. no	Name of the farmer	Name of Technology	Grain yield (Kg/ha)	Water used (m^3)	Gross Income (Rs/ha)	Net Income (Rs/ha)	B.C. ratio	WUE (kg/ha -mm)
1	Mean of 2 years (2008-09 &2009-10)	T1 T1-Alternatively alternate furrow irrigation(AAF) in Maize	7285.79	421.20	64177	39806	2.67	16.84
		T2 - Control	6532.62	548.66	57668	35529	2.66	11.92

Table.2 Effect of border strip method of irrigation with 80% cut off length on Chicpea and wheat yield (kg/ha), water used (m^3), gross income, net income (Rs/ha), B: C ratio and WUE (kg/ha-mm) during *rabi*- 2008-09

Sl. NO	Name of the farmer	Name of Technology	Gross yield (kg/ha)	Water used (m^3)	Gross Income (Rs/ha)	Net Income (Rs/ha)	B:C ratio	WUE (kg/ha -mm)
1	Mean of 22 Research cum demonstrations	T1-Border strip with 80% Cut off in Chickpea	2,125	408.0	38,250	23412	2.57	5.20
		T2 - Control	1,821	484.5	32,778	18528	2.29	3.07
2	Mean of 22 Research cum demonstrations	T1-Border strip with 80% Cut off in wheat yield	2,124	468.32	21,240	12990	2.66	4.82
		T2 - Control	1,843	544.32	18,430	10380	2.78	3.10

Table.3 Effect of SRI method of paddy cultivation on paddy yield (kg/ha), water used (m^3/ha), gross income and net income (Rs/ha), B: C ratio and WUE (kg/ha-mm)

Sl. NO	Name of the farmer	Name of Technology	Grain yield (Kg/ha)	Water used (m^3/ha)	Gross Income (Rs/ha)	Net Income (Rs/ha)	B.C. ratio	WUE (kg/ha -mm)
1	Mean of 2 years (2008-09 & 2010) 20 research cum demonstrations	T1- Sri method of Paddy cultivation	9815	1235	89332	45459.5	3.04	7.99
		T2 - Control	7762	1518	71771	38760.6	2.08	4.33

Table.4 Effect of Irrigation at critical stage concept on Sun flower yield (kg/ha), water used (m3/ha), gross income and net income (Rs/ha), B: C ratio and WUE (kg/ha-mm)

Sl. no	Name of the farmer	Name of Technology	Gross yield (kg/ha)	Water used (m^3/ha)	Gross Income (Rs/ha)	Net Income (Rs/ha)	B.C. ratio	WUE (kg/ha -mm)
1	Mean of 2 years (2008-09 & 2009-10) of 20 research cum demonstrations	T1-Critical Stage of Irrigation in Sunflower	1457	348	37267	25333	3.17	4.28
		T2 - Control	1271	391	31767	19767	2.69	3.25

Demand of water for various sectors

Sector	Water demand by NCIWRD (in BCM)		
Year	**2010**	**2025**	**2050**
Irrigation	557	611	807
Drinking water	43	62	111
Industry	37	67	81
Energy	19	33	70
Other	54	70	111
Total	710	873	1180

Irrigation requirement estimated by NCIWRD is with the premise that the irrigation efficiency will increase to 60% from the present level of 35 to 40%.

India's share in global resources

Resources	Per cent
Human Resource	16.0%
Land Resource	2.45%
Water Resource	4.00%
Livestock Resource	15.0%

Source: Ministry of Water Resources, 2016-17

Irrigated area under different crops

Crop	Area (m ha)	Per cent covered
Rice	24.57	56.7
Wheat	25.64	90.2
Maize	1.72	21.5
Total cereals	54.27	53.2
Total pulses	3.66	15.4
Total food grains	57.93	46.4
Sugarcane	4.83	92
Oil seeds	8.25	28.6
Cotton	3.20	35.12

Source: statistical at glance: 2016-17

Result revealed that, mean of two years 2008-09 and 2009-10, SRI method of paddy cultivation adoption in paddy recorded higher paddy grain yield (9815 kg/ha) as compare to control (7762 kg/ha). The increase in the yield over control was by 26.45 % (2053 kg/ha). The cost incurred by adoption of the technology was Rs.1500/- over control (Table 3 and Fig. 4). Water use efficiency in the treatment was higher 7.99 kg/ha –mm over control (4.33 kg/ha/mm). Adoption of this technology farmers opined that, SRI method of paddy cultivation saved more water and higher yield obtained. By adoption of this technology protects the soils from problem of salinity and sodacity hazards in command areas.

Technology 4: Higher water productivity through Irrigation at critical stage concept

Different methods of irrigation *viz*., critical crop growth stage approach, soil moisture depletion approach, irrigation water at different cumulative pan evaporation (IW/CPE) approach *etc*. that may be adopted for optimizing the timing of irrigation (Anonymous, 2012). Deficit irrigation, a strategy which maximizes the productivity of water by allowing crops to sustain some degree of water deficit and yield reduction, holds promise for severely water deficit areas. ICARDA studies in Syria have shown that applying 50% of the supplemental irrigation requirement only reduces yields by 15%. For deficit irrigation to function as a realistic strategy we need to better understand the relationship between yield and water deficit and we need to identify the types of support and incentives that farmers need to adopt the practice. Increased WUE of field crops in the dry season may be achieved through proper irrigation scheduling at critical growth stages. Extensive experimentation conducted over years has identified critical growth stages of various crops in respect of their water demand (Table 4). Irrigation needs to be applied at critical growth stages of the crops to realize maximum water use efficiency. In *rabi* season, critical stage of irrigation in sunflower recorded higher grain yield (1457 kg/ha) as compared to control (1271 kg/ha). The increase in the yield was by 14.63% more over the control. This resulted in increase in the gross income and net income of the farmer due to adoption of the improved critical stage irrigation technology. Apart from this more yield was produced per unit of water spent as indicated by higher water use efficiency (4.28 kg/ha –mm) in the treatment over control (3.25 kg/ha-mm) Supplementary irrigation, however, can be supplied in the same way as to any other upland cereal crop. The yields that can be obtained here range from 4.5 to 6.5 t ha^{-1} (Yadav, *et al.,* 2014).

Conclusion

Improving water efficiency by as much as 20% of existing about 35% by the year 2017 and in the process water productivity by taking measures for improving performance of irrigation systems and adoption of appropriate water application practices. Many promising pathways for raising water productivity are available to fully irrigated farming systems. From the results It is conducted that the adoption of water saving technologies along with the other practices like protective irrigation in deep black soils enhanced the soil moisture, yield levels and rainwater use efficiency, which ultimately resulted in to the, "More crop per drop of water " and are the solutions to solve the water crises in Agriculture. The Water saving technology intended for the demonstration will benefit in increasing productivity of lands and their by farm get income, Socio-economic conditions if the farmers *etc*.

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