IMPROVEMENT IN LAND AND WATER PRODUCTIVITY THROUGH FARMERS PARTICIPATION – A CASE STUDY

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ABSTRACT

Efficiently utilization of rain water (yield per unit of water used) is the only way of boosting agricultural production. Because of the fragile nature of the ecosystem the rainwater management in rainfed agriculture for soil and moisture/water conservation is of paramount importance, and shall receive top priority in rainfed farming as they form the foundation for the sustainable agriculture. Water resources development stimulates all further development in the rainfed farming. Water conservation is the first technology that be developed in semi-arid regions because other technologies cannot be effective unless thee is water available for involve risk, as the improved technologies can reduce but not eliminate the risk (Steward, 1990). Eswaran and Virmani (1990) identified soil specific constraints of water conservation in vertisols and suggested remedies to increase available water holding capacity and restrict the nutrient losses and soil erodibility. Research efforts of last 3-4 decades have led to development of different resources conservation techniques, which have clearly demonstrated their significant impact on the sustenance of crop productivity.

Due to adoption of the cultivation practices like across the slope and contour cultivation, raisebed, ridges and furrows across the slope and on contour and even square basin method enhanced the water use efficiency (kg/ha/mm), reduced the runoff, soil loss and nutrient losses, enhanced the soil moisture content in soil profile and increased the water and crop productivity significantly. Providing one or two protective irrigations during kharif and rabi enhanced the productivity and water use efficiency drastically. As a result participating and visiting farmers convinced about impact of the technologies towards, “More Crop per Drop of Water” and their attitudes are changing towards technologies adoption because now they are thinking that this the way to solve the water crises and to bring sustainability in rainfed agriculture.

Keyword : In situ soil and water conservation, soil moisture, water use efficiency, protective irrigation

INTRODUCTION

Indian agriculture mostly depends upon the monsoon rains receiving during June to September. Water is crucial input for augmenting agricultural production towards sustainability. Water is most limiting natural source in arid and semiarid region. In most of the areas only water available is rain water. The sustainability in the productivity of rainfed agriculture in India is frequently threatened by capricus monsoon creating vargaries in rainfall climatology. The hazard of monsoon vagaries frequently produces extreme weather regimes registering the negative impacts on farm productivity and adversely affects the farmer economy. Such shocks to productivity of crops and cropping systems can be insulated to some extent by insuring the adequate soil moisture regimes synchronous with the critical phenomenon in SAT areas including Marathwada. Under such situations, the judicious management of rain water comprising of in-situ soil moisture conservation during hydric state of environment and safe disposal of surplus rain water during hydric state of environment can be useful approach to ensure the adequacy of sustainable optimal soil moisture regime in the effective root zone of crops during its life cycle, as largely being practiced in popular concept of watershed management.

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The productivities of crops and their systems are highly unstable in semi-arid regions (15% at world and 43.56 per cent at India level out of geographical area) over temporal and spatial scales. The variances in these productivities are highly correlated with variability in edapho-climatic parameters. The land (soil) and water being the most crucial basic inputs for the sustenance of agriculture, their conservation is utmost essential. This is because even in India, about 50 per cent of the geographical area is prone to only water erosion, which wash away about 5334 million tones of soil (16.4 t/ha/year) and 5.37 to 8.40 million tones of nutrients per year. This situation is quite alarming because the soil of semi-arid region in India characterized by high activity and mix mineralogy rendered themselves difficult to manage particularly during the extreme stages of sorption and disruption cycles of moisture content, in addition to their inherently low fertility particularly with reference to essential plant nutrients (Samra et al., 1998).

In the present situation, involving farmers and motivating them to undertake more responsibilities to enhance the water use efficiency both in rainfed and irrigated farming. Working to gether as a group for the benefits and welfare of all, envisages changes in their attitudes, mind sets and enhancing their skill and capacities.

How much water do we really need in rainfed and irrigated agriculture? Related to this question, how should be managed in rainfed and irrigated agriculture in future? These questions have several answers depending on objectives of society. Yet even if we can clarify our desires, we cannot adequately answer the questions of what kind of and how much water we need in rainfed and in irrigated agriculture.

A major reason for this lack of foresight is that farmers do not know how to manage the rainwater in rainfed agro-ecosystem for food production, like wise what the contribution of surface and ground water to food production are the relations between water use and food security and even what the present use and future potential of rainfed agriculture. Farmers do not know the potential of promising locally created rain water as well as irrigation water management solutions for producing food in rainfed agriculture or in the area of water stress. And yet no adequate information technologies employed to discriminate information or solutions to these problems. Hence, onward the crucial management of our water potential is need of the day because,

i) Annual receipts of rainfall may remain same or may even decline if the deforestation continues with the present rate.

ii) Demands for water will be increasing tremendously for drinking and living conditions, as well as for expanding industrial complexes and

iii) Substantial improvement in productivity and stability of farming shall have to come from increasing utilization of water at least for protective irrigation in rainfed agro-ecosystem.

In situ recharge of rainwater needs reforms in cultivation practices in such a fashion that maximum rainfall gets infiltrated in to the soil profile and it becomes available to the crop during prolonged monsoonic break. This requires the participatory involvement of every farmer to adopt the effective cultivation practices to enhance the water use efficiency means to boost the water and crop productivity. Soil water being the very scarce resources and to make farmers water wise all out efforts have been undertaken for integrated rain water management by demonstrating the technologies on farmers field in Western Vidarbha region.

Objectives

This study was conducted to provide communicating knowledge to the farmers about, **"More Crop per drop of Water"** which solve water crises in agriculture by way of

- Enhancing the water use efficiency
- Reducing the runoff, soil and nutrient losses.
- Enhancing the soil moisture content in soil profile

Participation Profile

In the beginning farmers were reluctant to adopt the modern cultivation practices and advanced irrigation systems like sprinklers and MIS. Participating farmers were exposed to on station demonstrations at University Model Watershed and organized group meetings at various villages, Krishi Melawas at tahsil places as well as at village level as a result some farmers shown their willingness to participate in the FPARP.

Participatory rain water management through farmers participatory action research programme means by involving the farmers in the research have more diffused impact by changing the thinking about how water is and should be manage in agriculture. Major role of the FPARP is in providing and communicating knowledge about water management in agriculture will solve the water crisis. Ministry of Water Resource Govt. of India provided the financial support to implemented this programme. University has implement the programme. In six district with more concentration in saline tract of Amravati, Akola and Buldana district.

During 2008-09

Kharif - 74 demonstration in 29 villages from 5 districts with participation of 65 farmers.

Semi Rabi - 27 demonstration in 27 villages from 2 districts with participation of 27 farmers.

Rabi - 103 demonstration in 44 villages from 5 districts with participation of 88 farmers.

During 2009-10

Kharif - 143 demonstration in 44 villages from 6 districts with participation of 99 farmers.

Semi rabi - 29 demonstration in 11 villages from 2 districts with participation of 29 farmers.

Rabi – During Rabi proposed about 153 demonstration in 51 villages from 5 districts with participation of 150 farmers.

TECHNOLOGIES DEMONSTRATED

Following technologies were demonstrated during 2008-09 with the participation of farmers for *in-situ* recharge of rainwater. Traditional cultivation practices needs reforms in such a fashion that the rainfall gets infiltrated in to the soil profile and becomes available to the crop during prolonged monsoonic break. This requires efforts and involvement of every farmer to go for

Kharif and Semirabi :

- Across the slope cultivation
- Raise beds across the slope cultivation
- Contour cultivation
- Contour raise beds cultivation
- Intermittent opening of furrow in crop rows sown along the slope
- Agro-Horticulture systems
- Continues contour trenches on degraded land (CCT's)

Cultivated fallow in Kharif (Vertisol) :

- Across the slope cultivation
- Contour cultivation
- Square basin with and without green manuring crop e.g. Dhaincha

Rainfed rabi (Second crop) :

- Along the slope (control)
- Across the slope
- Contour cultivation

Rainfed kharif and rabi with protective irrigation

- Sprinkler
- Drip
- Flow Irrigation (Control)

Irrigation rabi :

- Sprinkler irrigation system
- Flow irrigation (conventional)

Horticultural crop :

- Drip irrigation (online & inline)
- Flow irrigation

IMPACT OF TECHNOLOGIES

Kharif and Semirabi season (2008-09)

1. Across the slope cultivation :

The soil moisture content enhanced by 11.82 to 38.35 per cent in Cotton, Soybean and Mung. Similarly during semirabi in Sunflower soil moisture content enhanced by 9.22 to 36.95 per cent at 15 to 60 cm depth.

Data in Table 1 indicated that the yield levels enhanced by 20.83 to 36.25 per cent in Cotton, Mung, Soybean and Hy. Jowar. In intercrop Mung + Tur, the yields of Mung enhanced by 25 per cent and Tur by 50 per cent. Similarly in Soybean + Tur, the yields enhanced by 20.83 per cent in Soybean and by 50 per cent in Tur and in Sunflower during semi rabi the yields enhanced by 25 per cent.

Rain water use efficiency (WUE) enhanced from 0.55 – 2.67 to 0.74 – 3.26 kg/ha-mm, in Cotton, Soybean, Mung, udid, and Hy. Jowar. In intercrop Mung+Tur the rain WUE enhanced from 0.59 to 0.74-0.89 kg/ha-mm. In Soybean+Tur enhanced from 1.78 - 0.59 to 2.15 – 0.89 kg/ha-mm respectively and in Sunflower during semi rabi rain WUE enhanced from 1.48 to 1.85 kg/ha-mm.

2. Raise bed across the slope cultivation :

The soil moisture content enhanced by 14.59 to 44.09 per cent in Cotton, Soybean and Hy. Jowar.

Data in Table 1 indicated that the yields enhanced by 25 to 40.62 per cent in Cotton, Soybean and Hy. Jowar and in intercrop Soybean + Tur, the yields of Soybean enhanced by 25 per cent and Tur by 56.25 per cent. The rain WUE enhanced from 1.18 – 2.67 to 1.67 – 3.41 kg/ha-mm in Cotton, Soybean and Hy. Jowar and in intercrop Soybean + Tur, the rain WUE enhanced from 1.78 – 0.59 to 2.22 – 0.92 kg/ha-mm in Soybean and Tur respectively.

3. Contour cultivation :

The soil moisture content enhanced by 21.78 to 74.71 per cent in Cotton, Soybean and Mung crops at 15 to 60 cm depth and data in Table 6 indicated that the yield enhanced by 38.88 to 87.50 per cent in Cotton, Mung, Soybean and Hy. Jowar.. In intercrop Mung + Tur the yields enhanced by 62.50 to 75 per cent and in Soybean + Tur by 45.83 to 50 per cent . In Sunflower during semi rabi moisture content enhanced by 41.08 to 77.71 per cent at 15 to 60 cm depth and the yields enhanced by 50 per cent.

Rain water use efficiency (WUE) enhanced from 0.65 – 2.67 to 0.92 – 3.71 kg/ha-mm in Cotton, Soybean, Mung and Hy. Jowar. In inter crop Mung+Tur the rain WUE enhanced from 0.59 to 0.96 in Mung and from 0.59 to 104 kg/ha-mm in Tur. Similarly in Soybean+Tur WUE enhanced from 1.78 – 0.59 to 2.60 – 0.89 kg/ha-mm respectively. In Sunflower during semi rabi rain WUE enhanced from 1.48 to 2.22 kg/ha-mm.

4. Contour raise bed cultivation :

The moisture content enhanced by 25.46 to 90.97 per cent in Cotton, Soybean and Mung. Data in Table 1 indicated that the yields enhanced by 58.33 per cent in Soybean and 93.78 per cent in Cotton. In intercrop, Soybean + Tur yields of Soybean enhanced by 54.16 per cent and Tur by 75 per cent.

Rain water use efficiency (WUE) in cotton enhanced from 1.18 to 2.30 kg/ha-mm and in Soybean enhanced from 1.78 to 2.82 kg/ha-mm. In intercrop, Soybean + Tur, the rain WUE enhanced from 1.78 to 2.74 kg/ha-mm in Soybean and 0.59 to 1.04 kg/ha-mm in Tur.

5. Intermittent opening of furrows in crop rows sown along the slope

When the farmers do not have any other option to cultivate his land along the slope in such cases it is recommended to open intermittent furrows in crop rows at the time of first hoeing.

The soil moisture content enhanced by 0.74 to 7.29 per cent in Cotton, Soybean and Mung. During semirabi soil moisture content enhanced by 0.96 to 7.60 per cent in Sunflower crop.

Data in Table 1 indicated the yields enhanced by 4.16 to 14.28 per cent in Cotton, Soybean, Hy. Jowar and Udid and the rain WUE enhanced from 1.78 to 1.85 kg/ha-mm in Soybean and 1.04 to 1.18 kg/ha-mm in Udid and from 2.67 to 2.82 kg/ha-mm in Hy. Jowar.

Rainfed rabi in Deep black soils :

1. Cultivated fallow during kharif :

In across the slope cultivation the soil moisture content enhanced by 16.43 to 36.47 per cent at 15 to 60 cm depth. The data in Table 2 indicated that the yields enhanced by 33.33 per cent and rain WUE from 0.89 to 1.18 kg/ha-mm in Gram. However data in Table 3 indicated that the Safflower yields enhanced by 25 per cent and rain WUE from 1.78 to 2.22 kg/ha-mm.

Data in Table 2 indicated the contour cultivation with opening of contour furrows at 20 m HI enhanced yields of Gram by 50 per cent and rain WUE from 0.89 to 1.33 kg/ha-mm and development of Square basin lay out (20 m x 20 m) prior to rainy season enhanced the yields of Gram by 66.66 per cent and rain WUE from 0.89 to 1.48 kg/ha-mm.

2. Green manuring during kharif :

Data in Table 2 indicated that the across the slope cultivation with Green manuring in kharif enhanced the yield of Gram in rabi by 16.66 per cent and rain WUE from 0.89 to 1.04 kg/ha-mm. Similarly the contour cultivation with green manuring in kharif enhanced the soil moisture content by 60.85 to 82.45 per cent, yields of Gram by 33.33 per cent and rain WUE from 0.89 to 1.18

kg/ha-mm and development of square basin lay out (20 x 20 m) with Green manuring in kharif enhanced the soil moisture content by 43.48 to 64.06 per cent and yields of Gram by 37.50 per cent and rain WUE from 0.89 to 1.22 kg/ha-mm. (Table 2)

3. Gram in rabi as a second crop after Mung in kharif :

The soil moisture content enhanced by 30.27 to 45.57 per cent at 15 to 60 cm depth. Data in Table 4 indicated that the yields of Gram enhanced by 16.66 per cent and rain WUE enhanced from 0.89 to 1.04 kg/ha-mm.

The contour cultivation enhanced the soil moisture content by 58.78 to 84.85 per cent at 15 to 60 cm depth. The yield of Gram by 33.33 per cent and rain WUE from 0.89 to 1.18 kg/ha-mm.

4. Safflower in rabi as a second crop after Mung in kharif :

Data in Table 4 indicated the across the slope cultivation enhanced the yields of Safflower by 11.11 per cent and rain WUE from 1.33 to 1.48 kg/ha-mm respectively.

Above cultivation practices are useful in increasing time of concentration of runoff water, minimizes runoff and soil loss. Rainfall water infiltrates into the soil and spread laterally. Soils that absorb water slowly require these practices since it gives more area for the water to soak in. The inter cropping involves growing together two crops of similar maturity but dissimilar in height, canopy and effective root depth. The vacant space in between the rows can successfully be utilized for growing short duration compact and quick growing crops like sorghum, black gram, soybean etc. Intercropping system was originally practiced as an insurance against crop failure under rain fed condition. The main objective of intercropping is higher productivity per unit area in addition to stability in production, intercropping system utilizes resources efficiently and their productivity is increased. In arid and semi arid regions most of the farmers mix the two or more crops together. These combination of intercropping and reforms in cultivation practices results in minimum runoff and soil loss with enhanced yield levels and water use efficiency (kg/ha-mm) as compared to sole crops and conventional cultivation practices.

Rainfall Harvesting :

In deep black soils and specially in saline tract of Vidarbha region in Amravati, Buldana and Akola districts collection of runoff in to the farm ponds or community tanks is most important and need of the day to provide the protective irrigation at least to some part of the holding of the farmer.

- **Protective Irrigation :**

Application of protective irrigation in deep black soil by sprinkler and MIS of 50 mm depth for raising crops during non rainy periods enhancing the water and crop productivity with higher water use efficiency.

1. **Protective irrigation in Kharif**

Data in Table 5 indicated the two protective irrigations through drip system from farm pond water enhanced yields of Cotton by 51.37 per cent and WUE from 1.61 to 2.13 kg/ha-mm.

One protective irrigation through sprinklers from Purna river enhanced yields of Soybean by 24.13 per cent and WUE from 2.15 to 3.48 kg/ha-mm and one protective irrigation through drip (pepsi) system from farm pond enhanced yield of Tur by 66.66 per cent and WUE from 0.89 to 1.38 kg/ha-mm.

2. **Protective irrigation in Rabi**

Data in Table 5 indicated the one protective irrigation through sprinkler from farm pond enhanced the yields by 55 per cent and WUE from 1.48 to 2.14 kg/ha-mm in safflower.

Two protective irrigations through sprinklers from Purna River to Gram (second crop after Soybean) enhanced the yield by 166.66 per cent and WUE from 0.55 to 1.38 kg/ha-mm and one protective irrigation through sprinkler from river and open well to (second crop after Mung) Gram enhanced the yields by 42.85 per cent with WUE from 1.04 to 1.38 kg/ha-mm.

During the longer dry spell between two storms there is a adverse effect on the crops and productivity levels dropped down drastically due two moisture stress. During this period crops needs the protective irrigation in rainfed farming. By providing one or two protective irrigations the yield levels were observed enhanced by 40 to 166 per cent and water use efficiency from 0.55 to 1.38 kg/ha-mm. this indicates provision for protective irrigation is the way to make the rainfed farming sustainable by way by improved land and water productivity means, “More Crop per Drop of Water”.

CONCLUSION

From the results It is conducted that the adoption of cultivation practices like across the slope, contour etc. 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 rainfed agroecosystem.

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Table 1 : Impact of in-situ soil and water practices rain water use efficiency (kg/ha/mm) in deep black soil under rainfed condition.

Crop	Av. Yield qha^{-1}						Av. Rainwater use efficiency (kg/ha/mm)					
	Conventional method	Intermittent furrow opening	Across the slope	Raised bed across the slope	Contour cultivation	Raisebed cultivation	Conventional method	Intermittent furrow opening	Across the slope	Raised bed across the slope	Contour cultivation	Contour raisebed cultivation
Cotton	8.00	08.50 (6.25)	10.90 (36.25)	11.25 (40.62)	15.00 (87.50)	15.50 (93.78)	1.18	-	1.60	1.67	2.22	2.30
Soybean	12.00	12.50 (4.16)	14.50 (20.83)	15.00 (25.00)	18.00 (50.00)	19.00 (58.33)	1.78	1.85	2.15	2.22	2.67	2.82
Mung	3.75	-	05.00 (33.33)	-	6.25 (66.68)	-	0.55	-	0.74	-	0.92	-
Udid	7.00	8.00 (14.28)	-	-	-	-	1.04	1.18	-	-	-	-
Hy. Jowar	18.00	19.00 (5.55)	22.00 (22.22)	23.00 (27.77)	25.00 (38.88)	-	2.67	2.82	3.26	3.41	3.71	-
Mung+ Tur	4.00	-	5.00 (25.00)	-	6.50 (62.50)	-	0.59	-	0.74	-	0.96	-
	4.00	-	6.00 (50.00)	-	7.00 (75.00)	-	0.59	-	0.89	-	1.04	-
Soybean + Tur	12.00	-	14.50 (20.83)	15.00 (25.00)	17.50 (45.83)	18.50 (54.16)	1.78	-	2.15	2.22	2.60	2.74
	4.00	-	6.00 (50.00)	6.25 (56.25)	6.00 (50.00)	7.00 (75.00)	0.59	-	0.89	0.92	0.89	1.04
Sunflower	10.00	-	12.50 (4.16)	-	15.00 (50.00)	-	1.48	-	1.85	-	2.22	-

Av. Rainfall 673 mm (Rainfall of Akot taluka - 612 mm and Daryapur taluka - 735 mm)
* Figure in parenthesis indicated the increase in yield (%) over conventional method cultivation along the slope

Table 2 : Effect of various cultivation practices on yield of Gram in deep black soil under rainfed

Cultivation practices	Yield (qha^{-1})	Increase over conventional method, (%)	Water use efficiency (kg/ha/mm)
Cultivated fallow (Unsown in kharif)			
Along the slope cultivation (control)	6.00	-	0.89
Across the slope cultivation	8.00	33.33	1.18
Contour cultivation with opening of furrow at 20 m HI	09.00	50.00	1.33
Square basin lay-out 20m×20m in kharif	10.00	66.66	1.48
Green manuring (Dhaincha) during kharif			
Along the slope cultivations (control)	6.00	--	0.89
Across the slope cultivations	7.00	16.66	1.04
Contour cultivation	8.00	33.33	1.18
Square basin lay-out	8.25	37.50	1.22

Table 3 : Effect of various cultivation practices on yield of Safflower in deep black soil under rainfed condition

Cultivation practices	Yield qha^{-1}	Increase over conventional method, (%)	Water use efficiency (kg/ha/mm)
Along the slope cultivations (control)	12.00	-	1.78
Across the slope cultivation	15.00	25.00	2.22

Av. Rainfall 673mm

Table 4 : Effect of various cultivation practices on yield of Gram and Safflower in deep black soil under rainfed

Cultivation practices	Yield qha^{-1}	Increase over conventional method, (%)	Water use efficiency (kg/ha/mm)
Second crop after mung in kharif			
Along slope cultivations (control)	6.00	-	0.89
Across the slope cultivations	7.00	16.66	1.04
Contour cultivation	8.00	33.33	1.18
Safflower as a second crop after mung in kharif	9.00	-	1.33
Along slope cultivation of safflower (control)	10.00	11.11	1.48
Across the slope sowing cultivation of safflower			

Table 5 : Effect of protective irrigation on yield of various crops cultivated across the slope during kharif in deep black soil (Saline Tract)

Crop	Irrigation system	Water source	No. of Protective Irrigation	Yield qha^{-1}		Increase over rainfed (%)	Water use efficiency kg/ha/mm	
				rainfed (control)	With protective irrigation		rainfed (control)	With protective irrigation
Cotton	Drip irrigation	Farm pond	02	10.90	16.50	51.37	1.61	2.13
Soybean	Sprinkler irrigation	River (purna)	01	14.50	18.00	24.13	2.15	3.48
Tur	Pepsy Drip irrigation	Farm pond	01	06.00	10.00	66.66	0.89	1.38
Safflower	Sprinkler irrigation	Farm pond	01	10.00	15.50	55.00	1.48	2.14
Gram (Second crop after soybean in kharif)	Sprinkler irrigation	River (purna)	02	03.75	10.00	166.66	0.55	1.38
Gram (Second crop after Mung in kharif	Sprinkler irrigation	River and open well	01	07.00	10.00	42.85	1.04	1.38

*** Av. Rainfall 673 mm location Daryapur (735 mm) and Akot (612mm) per irrigation depth 50 mm.**