ON-FARM RAINWATER MANAGEMENT BY THE FARMERS IN THE VIDARBHA REGION, INDIA – A CASE STUDY

GESTION DES EAUX DE PLUIE A LA PARCELLE PAR LES FERMIERS DE LA REGION DE VIDARBHA EN INDE – ETUDE DE CAS

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ABSTRACT

In Vidharbha region (India) rainfed agriculture faces the vagaries of monsoon and instability of yield. Soil compaction is common problem in rainfed farming. This can be further aggravated by presence of hard pan or plough pan in sub soil, which restrict infiltration and storage of water and root penetration. Modified land configuration like cultivation across the slope, contour cultivation, opening of furrows in alternate crop rows, ridges and furrows, square basins, green manuring etc., decrease soil bulk density and increase infiltration of rainwater in to soil, reduce runoff, soil and nutrient losses and there by increase the moisture storage in soil profile, root proliferation and enhance the productivity.

The results of the present study indicated that the modified land configurations enhanced the water use efficiency (kg/ha/mm) reduced the runoff, soil and nutrient losses, enhanced the soil moisture content in soil profile and increased the water and crop productivity significantly. Harvesting of runoff into farm ponds and utilization of this water body to provide one or two protective irrigations during the monsoon cultivation season (kharif season) and the winter cultivation season (rabi season) enhance the productivity and water use efficiency. On seeing the results, the participating farmers were convinced about the impact of the technologies for increasing water productivity. Their attitudes are changing towards adoption of water conservation methods.

Key words: *Rain water management, Vidarbha region of India, dry land agriculture, transfer of technologies, farmers' feedback*

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RESUME

Dans la région de Vidharbha (Inde), l'agriculture pluviale est affectée par les caprices de mousson et l'instabilité de rendement. Le compactage du sol est un problème commun de l'agriculture pluviale. Cela peut être aggravé de nouveau par la présence de la couche cimentée très résistante ou de la couche dure due au labourage dans le sous sol, qui limite l'infiltration et le stockage d'eau et la pénétration de la racine. La configuration modifiée de la terre - la culture en gradiens, la culture selon les courbes de niveaux, l'ouverture des sillons dans les rangées alternés de culture, des billons et des sillons, des bassins carrés, l'engrais vert etc, la réduction de la densité apparente, l'augmentation d'infiltration d'eau de pluie dans le sol et la réduction d'écoulement, des pertes nutritive et du sol, et par là l'augmentation d'humidité dans le profil du sol, la prolifération de la racine – augmente la productivité de la terre.

Les résultats de cette étude ont indiqué que les configurations modifiées de la terre ont augmenté l'efficience d'utilisation de l'eau (kg/ha/mm), réduit la l'écoulement et les pertes nutritives et du sol, augmenté la teneur en eau du sol ainsi que la productivité de l'eau et de la culture. La collecte d'écoulement dans les étangs à la parcelle et l'utilisation de ces cours d'eau pour l'une ou deux irrigations protectrices lors de la cultivation de mousson (saison kharif) et la cultivation hivernale (saison rabi) augmente la productivité et l'efficience d'utilisation de l'eau. Compte tenu des résultats, les fermiers sont convaincus de l'impact des technologies pour accroître la productivité de l'eau. Leur mentalité change vers l'adoption des méthodes de conservation d'eau.

Mots clés: *Gestion des eaux de pluie, région de Vidarbha (Inde), agriculture sur les terres sèches, transfert des technologies, commentaires des fermiers*

1. INTRODUCTION

Rainfed agriculture is the livelihood vocation of the marginal or subsistence farmers and increasingly seen as better alternative to irrigated agriculture as a result of its environmental friendliness and sustainability over long period. Improving productivity and stability of production of rainfed areas will be crucial in meeting the needs of the increasing population. India ranks first among the dryland agricultural countries in terms of both extent and value of produce. Out of every three hectares of cultivated land in India, nearly two hectares are under rainfed agriculture. Out of about 143 million hectares (Mha) of cultivated area in India, Dryland accounts for 91.0 Mha or 64% and in the foreseeable future also nearly 60% of our population will continue to depend on rainfed agriculture. Rainfed areas are not a homogenous region and vary in terms of soil type, rainfall, cropping pattern, literacy, land and labour productivity, therefore rainfed areas are highly diverse, ranging from resource-rich areas with good agricultural potential to resource-poor areas with a much restricted potential. Some resource-rich rainfed areas potentially are highly productive and have experience of adoption of improved technologies.

Agriculture in Maharashtra state and particularly in the Vidarbha region can be characterized by low irrigation (17% and 7%) and low rainfall. Approximately 85% of cultivated area (17.64 Mha in the state and 4.99 Mha in the Vidarbha region) is rainfed, and agricultural performance

is significantly influenced by the monsoon. Precipitation is concentrated over just a few months of the year and is highly variable in frequency, intensity, quantity and geographic coverage. Access to supplemental irrigation (canal or groundwater) is very limited in the low rainfall areas. Agriculture contributes only 30 per cent of Maharashtra's GDP, these drylands support 65% of the rural population and are the principal suppliers of cereals, pulses and oilseeds. The importance of rainfed agriculture in terms of rural employment, sustenance and livelihood cannot be over emphasized.

In Vidarbha, the rainfed farming faces the vagaries of monsoon with instability of yields, incomes and water use efficiency. In the present situation, it is important to involve the farmers and motivating them to enhance the rainwater use efficiency by reforming the cultivation practices, changing their attitude towards the scarce water resources and enhancing their skill and capacities towards *insitu* soil and water conservation, safe disposal of runoff, storage of runoff in farm ponds and recycling of water for protective irrigation during monsoon breaks.

Since major agriculture is rain dependent, the appropriate rainwater management play very vital role in sustainable rainfed farming. Impact of climate change is visible on Vidarbha agriculture where assured rainfall zone has become a distress zone due to changing behaviour of rainfall. Therefore, the only way for sustainable rainfed farming is to adopt rain water management technologies by the farmers in participatory mode. This paper indicates the impact of the farmers participatory action research programme in terms of improved land and water productivity which provides the water, food and livelihood security under climate change.

2. PARTICIPATION PROFILE

In the beginning farmers were reluctant to participate in the action research programme. Over a time period, through using communication skills, 529 research demonstrations were organized with the participation of 278 farmers from 106 villages in Akola, Amravati, Buldana, Washim, Yavatmal and Wardha district of Vidarbha region in Maharashtra.

Transfer of Technologies

Following technologies were demonstrated with the participation of farmers for *in-situ* recharge of rainwater and these were scientifically evaluated. Farmers' cultivation practices along the slope needed reform such that the rainfall get infiltrated into the soil profile and becomes available to the crop during prolonged monsoon breaks. This required the efforts and involvement of every farmer to go for *insitu* soil and water conservation. The following technologies were demonstrated with the participation of farmers on their fields.

i] *Kharif* and Semi-*rabi* :

- Deep cultivation
- Across the slope cultivation
- Opening of furrows in between alternate crop rows after 30 days of sowing
- Contour cultivation

- Opening of contour furrows in between alternate crop rows after 30 days of sowing
- Opening of tied furrows along the slope in between the crop rows.

ii] Cultivated fallow during *Kharif* in Vertisol :

- Across the slope cultivation
- Contour cultivation
- Adoption of square basin with and without green manuring.

iii] Rainfed *rabi* (Second crop) :

- Across the slope cultivation
- Contour cultivation

iv] Rainfed *kharif* and *rabi* with protective irrigation

- Sprinkler system
- Drip system

3. RESULTS

The benefits of adoption of the above cultivation practices over traditional practice of cultivation along the slope during kharif and semirabi season were discussed below,

i) Deep cultivation :

The soil moisture content was enhanced by 22.72, 19.14 and 26.93 per cent in cotton sole, soybean sole and intercrop of cotton+soybean (1:2) respectively over shallow cultivation. Data in Table 1 indicated that the yield levels in sole crop of cotton and soybean enhanced by 11.34 and 20.05 per cent respectively. However in intercropping system of cotton + soybean (1:2) the yield of cotton and soybean enhanced by 36.84 and 36.95 per cent, respectively, over the period of 12 years (1995-96 to 2009-10). Similarly the rain water use efficiency in sole crop of cotton and soybean was enhanced from 0.98 to 1.09 and 1.24 to 1.49 kg/ha/mm respectively. However in intercrop of cotton + soybean, it was enhanced from 0.54 to 0.74 kg/ha/mm in cotton and from 0.81 to 1.11 kg/ha/mm in soybean. From the results it is concluded that deep cultivation gives a better performance in terms of enhanced productivity and rainwater use efficiency in sole and intercropping system of cotton and soybean over shallow cultivation. This experiment was conducted at Agroecology and Environment Centre, Dr. P.D.K.V., Akola.

Table 1. Effect of shallow and deep cultivation on yield of cotton and soybean

Sr. No	Year	Rainfall (mm)	Yield, q/ha							
			Shallow cultivation				Deep cultivation			
			Soy-bean sole	Cotton sole	Cotton + Soybean Cultivation		Soy-bean sole	Cotton sole	Cotton + Soybean Cultivation	
					Cotton	Soy-bean			Cotton	Soy-bean
1	1995-96	565.00	12.21	4.76	2.02	8.63	13.79	5.29	2.79	9.47
2	1996-97	695.50	21.59	6.92	5.09	5.39	27.76	7.42	5.68	18.36
3	1997-98	757.50	17.33	5.33	3.34	8.34	19.66	5.87	3.8	9.78
4	1998-99	796.70	7.48	6.61	3.76	4.88	9.35	7.33	4.57	6.13
5	1999-00	982.00	18.41	11.58	6.55	13.56	21.21	11.85	17.73	15.41
6	2000-01	545.40	6.21	7.34	3.5	3.87	6.63	7.5	5.28	4.89
7	2004-05	440.10	6.54	6.52	2.99	3.99	7.04	7.04	3.49	4.05
8	2005-06	718.40	6.99	9.09	7.57	5.42	9.96	9.33	7.87	6.33
9	2006-07	1028.70	3.51	7.75	7.06	2.66	5.72	9.06	7.53	4.42
10	2007-08	818.60	1.68	10.86	1.36	7.79	1.72	13.82	1.38	10.61
11	2008-09	534.80	1.86	3.6	1.81	2.4	2.01	4.4	1.97	2.56
12	2009-10	578.60	1.36	2.82	1.29	1.71	1.41	3.7	1.32	1.99
Total		846113	100.27	65.9	41.88	56.74	121.12	70.69	58.74	78.84
Avg.		705.10	8.76	6.93	3.86	5.72	10.52	7.72	5.28	7.83
Increase in yield (%) over shallow cult.,							20.05	11.34	36.84	36.95
Rainfall WUE (kg/ha/mm)			1.24	0.98	0.54	0.81	1.49	1.09	0.74	1.11

ii) Across the slope cultivation :

The soil moisture content was enhanced by 11.82 to 38.35 per cent in Cotton, Soybean and Green gram. Similarly during semi *rabi* in Sunflower soil moisture content was enhanced by 9.22 to 36.95 per cent at 15 to 60 cm depth. Data in Table 2 indicate that the yield levels were enhanced by 20.83 to 36.25 per cent in Cotton, Green gram, Soybean and Hy. Jowar. In the intercrop of Green gram + Pigeonpea, the yields of Green gram enhanced by 25 per cent and Pigeonpea by 50 per cent. Similarly in Soybean + Pigeonpea, the yield was increased by 20.83% in Soybean and by 50% in Pigeonpea. In Sunflower during semi rabi the yield was increased by 25%. Rain water use efficiency (WUE) improved from 0.55 – 2.67 to 0.74 – 3.26 kg/ha/mm, in Cotton, Soybean, Green gram, Black gram, and Hy. Jowar. In intercrop of Green gram+Pigeonpea the rain WUE enhanced from 0.59 to 0.74-0.89 kg/ha/mm. In Soybean+Pigeonpea, it enhanced from 1.78 - 0.59 to 2.15 – 0.89 kg/ha/mm respectively and in Sunflower during semi *rabi* the rain WUE improved from 1.48 to 1.85 kg/ha/mm.

Table 2. 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	Opening of tied furrows	Across the slope	Opening of alternate furrows	Con tour cultivation	Opening of alternate contour furrows	Conventional method	Opening of tied furrows	Across the slope	Opening of alternate furrows	Contour cultivation	Opening of alternate contour furrows
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
Green gram	3.75	-	05.00 (33.33)	-	6.25 (66.68)	-	0.55	-	0.74	-	0.92	-
Black gram	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	-
Green gram + Pigeonpea	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 + Pigeonpea	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

iii) Opening of furrows in between alternate crop rows after 30 days of sowing :

The soil moisture content was increased by 14.59 to 44.09 per cent in Cotton, Soybean and Hy. Jowar. Data in Table 2 indicated that the yields increased by 25 to 40.62 per cent in Cotton, Soybean and Hy. Jowar and in intercrop of Soybean + Pigeonpea, the yield of Soybean enhanced by 25 per cent and Pigeonpea 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 of Soybean + Pigeonpea, the rain WUE enhanced from 1.78 – 0.59 to 2.22 – 0.92 kg/ha/mm in Soybean and Pigeonpea, respectively.

iv) Contour cultivation :

The soil moisture content increased by 21.78 to 74.71 per cent in Cotton, Soybean and Green gram crops at 15 to 60 cm depth and the data in Table 2 indicate that the yield increased by 38.88 to 87.50 per cent in Cotton, Green gram, Soybean and Hy. Jowar. In intercrop of Green gram + Pigeonpea the yields enhanced by 62.50 to 75 per cent and in Soybean + Pigeonpea by 45.83 to 50 per cent. In Sunflower during semi *rabi* moisture content increased by 41.08 to 77.71 per cent at 15 to 60 cm depth and the yields increased by 50%..

Rain water use efficiency (WUE) enhanced from 0.55 – 2.67 to 0.92 – 3.71 kg/ha/mm in Cotton, Soybean, Green gram and Hy. Jowar. In inter crop Green gram+Pigeonpea the rain WUE enhanced from 0.59 to 0.96 kg/ha/mm in Green gram and from 0.59 to 104 kg/ha/mm in Pigeonpea. Similarly in Soybean+Pigeonpea 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.

v) Opening of contour furrows in between alternate crop rows after 30 days of sowing :

The moisture content increased by 25.46 to 90.97 per cent in Cotton, Soybean and Green gram. The yields increased by 58.33% in Soybean and 93.78% in Cotton. In intercrop of Soybean + Pigeonpea, yields of Soybean increased by 54.16% and Pigeonpea by 75%. Rain water use efficiency (WUE) in cotton improved from 1.18 to 2.30 kg/ha-mm and in Soybean from 1.78 to 2.82 kg/ha/mm. In intercrop of Soybean + Pigeonpea, the rain WUE improved from 1.78 to 2.74 kg/ha/mm in Soybean and 0.59 to 1.04 kg/ha/mm in Pigeonpea. (Table 2).

vi) Opening of tied furrows along the slope in between the crop rows

When the farmers do not have any other option than to cultivate the land along the slope. it is recommended to open tied furrows in crop rows after 30 day of sowing. The soil moisture content increased by 0.74 to 7.29 per cent in Cotton, Soybean and Green gram. During semi*rabi*, soil moisture content enhanced by 0.96 to 7.60 per cent in Sunflower crop. Data in Table 2 indicate that the yields increased by 4.16 to 14.28 per cent in Cotton, Soybean, Hy. Jowar and Black gram 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 Black gram 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 soil moisture content increased by 16.43 to 36.47 per cent at 15 to 60 cm depth, yields increased by 33.33% and rain WUE from 0.89 to 1.18 kg/ha/mm in Chickpea. However data in Table 4 indicte that Safflower yields increased by 25% and rain WUE from 1.78 to 2.22 kg/ha/mm. Data in Table 3 indicated that contour cultivation with opening of contour furrows at 20 m HI increased yields of Chickpea by 50% and rain WUE from 0.89 to 1.33 kg/ha/mm. Similarly, formation of Square basins (20 m x 20 m) prior to commencement of rains enhanced the yields of Chickpea by 66.66% and rain WUE from 0.89 to 1.48 kg/ha/mm.

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

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

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

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

Av. Rainfall 673mm

2. Green manuring with and without square basin during *kharif* :

Across the slope cultivation with Green manuring in *kharif* increased the yield of Chickpea in *rabi* by 16.66% and rain WUE from 0.89 to 1.04 kg/ha/mm. Contour cultivation with green manuring in *kharif* improved the soil moisture content by 60.85 to 82.45 per cent, yields of Chickpea by 33.33% and rain WUE from 0.89 to 1.18 kg/ha-mm. Similarly, formation of square basins (20 x 20 m) with Green manuring in *kharif* enhanced the soil moisture content by 43.48 to 64.06 per cent, yields of Chickpea by 37.50% and rain WUE from 0.89 to 1.22 kg/ha/mm (Table 3).

3. Chickpea in *rabi* as a second crop after Green gram in *kharif* :

Across the slope cultivation improved the soil moisture content by 30.27 to 45.57 per cent at 15 to 60 cm depth, increased yields of Chickpea by 16.66% and rain WUE from 0.89 to

1.04 kg/ha/mm. Data in Table 5 indicate that contour cultivation improved the soil moisture content by 58.78 to 84.85 per cent at 15 to 60 cm depth, yields of Chickpea by 33.33% and rain WUE from 0.89 to 1.18 kg/ha/mm.

Table 5. Effect of various cultivation practices on yield of Chickpea and Safflower in deep black soil under rainfed condition.

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

4. Safflower in *rabi* as a second crop after Green gram in *kharif* :

Data in Table 5 indicate that across the slope cultivation increased Safflower yield by 11.11% and rain WUE from 1.33 to 1.48 kg/ha/mm.

5. Rain water Harvesting :

In deep black soils especially in saline tract of Purna river valley in Amravati, Buldana and Akola districts of Vidarbha region, collection of runoff in farm ponds or community tanks is most important to provide the protective irrigation at least to some part of the farmers' holdings.

■ Protective Irrigation

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

1. Protective irrigation in *Kharif*

Data in Table 6 indicate that two protective irrigations through drip system from farm pond water increased cotton yield by 51.37% 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% and WUE from 2.15 to 3.48 kg/ha/mm and one protective irrigation through drip system from farm pond enhanced yield of Pigeon pea by 66.66% and WUE from 0.89 to 1.38 kg/ha/mm.

Table 6. Impact of protective irrigation

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
Pigeonpea	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
Chickpea (Second crop after soybean in kharif)	Sprinkler irrigation	River (purna)	02	03.75	10.00	166.66	0.55	1.38
Chickpea (Second crop after Green gram in kharif	Sprinkler irrigation	River and Farm pond	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.

2. Protective irrigation in *Rabi*

Data in Table 6 indicate that one protective irrigation through sprinkler from farm pond enhanced the yields by 55% and WUE from 1.48 to 2.14 kg/ha/mm in safflower. Two protective irrigations through sprinklers from Purna River to Chickpea (second crop after Soybean) enhanced the yield by 166.66% 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 of after Green gram) Chickpea enhanced the yields by 42.85% and WUE from 1.04 to 1.38 kg/ha/mm.

4. FARMERS FEED BACK

Drought is a common feature in Vidarbha region and about 89% of total cultivated land is under rainfed agriculture. Further the scope for increasing the irrigation potential appears to be very limited. Under such circumstances now the farmers participating in this programme gave their feedback as given below:

i) Efficient utilization of Water is the only way of boosting agricultural production.

ii) Rainwater management in rainfed agriculture/water conservation is of great importance and should receive top priority in rainfed farming.

iii) Water resources development by way of increasing the moisture content in the soil profile, conserving the soil and nutrient stimulate all further development under rainfed farming.

iv) Reforms in cultivation practices and such as deep cultivations and across the slope cultivation, opening of furrows in between the alternate crop rows after 30 days of sowing, contour cultivation including the opening of contour furrows in alternate crop rows, opening of tied furrows in between the crop rows sown along the slope, timely implementation of agricultural operations, adoption of improved varieties etc. are components of the integrated package of rainfed agriculture.

v) Improvement in the rainfed agriculture is only possible by linking the farming with attempts of in-situ soil and water conservation cultivation practices.

vi) Providing the means of higher and prolonged residual soil moisture conservation is the key to ward off the problems of farmers due to uncertain rainfall.

vii) Demonstrated technologies are easy to adopt, affordable and they reduce the runoff, soil and nutrient losses and improve soil moisture content.

viii) Finally the farmers are of the opinion that the adoption of these technologies enhanced the productivity in *kharif* season by way of providing the required moisture to the crop during prolonged monsoon break by conserving the rainwater or by providing protective irrigation from the farm ponds.

ix) Few farmers expressed the view that additional credit from banks and subsidy on priority to the ay be provided to those who wish to adopt these technologies.

x) Large scale demonstration should be conducted at each village to disseminate these useful technologies to larger groups.

5. CONCLUSIONS

From the results It is conducted that, i) the adoption of cultivation across the slope, contour cultivation etc., along with opening of furrow in between the crop rows and other practices like protective irrigation improve the soil moisture, yield levels and rainwater use efficiency. ii) Involvement of farmers in research through the FPARP indicated a better diffusion of technological information to the farmers, which help their mind set and attitude to change for the improved technologies in lieu of the traditional cultivation methods.

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