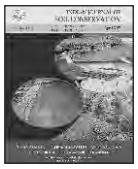
Vol. 45, No. 2, pp 214-222, 2017

Indian Journal of Soil Conservation

Online URL : http://indianjournals.com/ijor.aspx?target=ijor:ijsc&type=home



Augmentation of productivity and profitability through resource conserving technologies at cultivator's field in Central India

Dev Narayan[1,3], S.P. Tiwari[1] and H. Biswas[2]

[1]ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Datia- 475 661, Madhya Pradesh; [2] ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Bellary-583 104, Karnataka.

[3]E-mail: drdevnarayan@yahoo.com

ARTICLE INFO

Article history:

Received : January, 2016
Revised : September, 2016
Accepted : October, 2016

Key words:
Green manuring,
Integrated nutrient management,
Intercropping,
Micro-irrigation,
Resource conservation technologies,
Surface mulching,
Tillage

ABSTRACT

The productivity of crops in Bundelkhand region of central India is very low due to undulating terrain, low water holding capacity, low fertility, hostile climate and unfavorable edaphic conditions. To conserve natural resources for enhancing the productivity and profitability, five technologies during rainy season (1. Supplemental irrigation to soybean [*Glycine max* (L.) Merr.] through rain-gun during dry spells, 2. Integrated nutrient management (INM) in soybean, 3. Deep tillage in sorghum [*Sorghum bicolor* (L.) Monech]/soybean, 4. Intercropping of sorghum + black gram [*Vigna mungo* (L.) Hepper] and 5. Sorghum + surface mulching of sunnhemp (*Crotolaria juncea* L.) and another five technologies during winter season (1. Micro-irrigation to wheat (*Triticum aestivum* L. emend. Fiori and Paol.) through raingun, 2. INM in wheat, 3. Intercropping of chickpea (*Cicer arietinum*) + Indian mustard [*Brassica juncea* (L.) czernj and Cosson], 4. Wheat preceded by green manuring and 5. Indian mustard proceeded by green manuring) were demonstrated at farmer's field in 10 villages in 10 ha area covering 14-20 farmers per season during 2008-09 to 2009-10 in Datia, Madhya Pradesh. Results of 2 years revealed an increase in yield ranging from 7-20% in wheat, 36-60% in soybean, 27-42% in sorghum, 18% in Indian mustard and 16% in chickpea under demonstration plots as compared to those under conventional practices (CPs). Water use efficiency (WUE) increased from 26-47% over the CP during rainy season and from 19-64% during winter season over the CP. Monetary benefits over conventional practice ranged from ₹ 1,500-11,900 ha^{-1}.

1. INTRODUCTION

The Bundelkhand region ($23^0 10'$-$26^0 30'$ N and $78^0 20'$-$81^0 40'$E) with a geographical area of 7.07 M ha comprising six districts of Madhya Pradesh (Chhatarpur, Damoh, Datia, Panna, Sagar and Tikamgarh) and seven districts of Uttar Pradesh (Banda, Chitrakoot, Hamirpur, Jalaun, Jhansi, Lalitpur and Mahoba) in central India is reported as one of the most deprived regions of the country. It is characterized with undulating terrain, scarce vegetation cover, hostile climate, lack of irrigation facilities and unfavorable edaphic conditions (Tiwari and Narayan, 2010). About 70% of the total area in the region has been affected by varying degree of erosion hazards. Nearly 80% of total annual rainfall (830.0 mm) is received during monsoon season but water stress conditions are common even in rainy season (Narayan and Biswas, 2012a). Though the rainfall received is scanty and erratic but high intensity showers received during the monsoon season result into sizable runoff (runoff ranged between 50 to 60% of rainfall and soil loss between 8 to 9 t ha^{-1} at 2% slope on cultivated fallow land in red soils) and soil loss (Lakaria *et al.*, 2010). Bundelkhand region used to have one drought in 16 years in 18^{th} and 19^{th} centuries which increased by three times during the period 1968 to 1992 and the recent past several years have witnessed continuous drought situation in the region (Samra, 2008). Due to this situation the region is traditionally facing scarcity of water for drinking as well as agricultural purposes. About 53% area comes under rainfed agriculture and crop intensity is about 111%, consequently there exists a large proportion of cultivable waste and fallow

land (Tiwari and Narayan, 2010; Singh and Singh, 2010). In the region, red soils occupy more than 50% area on uplands but the productivity of these soils is very low due to low fertility and poor moisture retentivity. The crops experience water stress even in short dry spells during rainy season and the short monsoon season further aggravates the situation, consequently unstable yield and failure of crops are very common (Narayan and Biswas 2012a). On the other hand, black soils are found on low lands and pose the problem of drainage and workability. Under such situation, resource poor farmers are unable to harvest a good crop during the entire year; consequently, a large cultivable area is kept fallow in the region. To overcome these problems, various resource conserving technologies *viz.,* green manuring (Narayan and Lal, 2006), tillage and *in-situ* surface mulching (Narayan *et al.,* 2007; Narayan and Lal, 2009), INM (Biswas *et al*., 2012), intercropping (Narayan and Biswas, 2012b), rainwater harvesting and recycling (Narayan and Biswas, 2012a) and contour bunding (Narayan *et al*., 2014) *etc.* were developed through long field experiments at ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Datia, Madhya Pradesh for soil and water conservation and augmenting the productivity and profitability in the region. Some of the technologies were demonstrated at farmer's field for resource conservation and further increasing the production and returns.

2. MATERIALS AND METHODS

Technology demonstrations were conducted during 2008-09 to 2009-10 at farmer's field in 10 villages (Bargain, Bhiti, Garhi, Govindpur, Maheba, Murera, Nayagaon, Rahuri, Sitapur, and Sonagir) under centrally sponsored scheme "Farmers Participatory Action Research Programme (FPARP)" on "More crop per drop of water" funded by Ministry of Water Resources, Government of India, in Datia, Madhya Pradesh. The climate of Datia is semi-arid with an average annual rainfall of 830.0 mm and nearly 80% of the total precipitation is received during monsoon period (from middle of June to September) with long dry spells causing frequent crop failure. A rainfall of 371.6 and 644.2 mm was recorded during crop growth period of rainy season crops in 2008 and 2009, respectively; however, a rainfall of 15.4 and 54.4 mm was recorded during crop growth period of winter season crops in 2008-09 and 2009-10, respectively at meteorological observatory, ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Datia (25^{0}40' N, 78^{0}28'E and 342.42 m above msl). Minimum and maximum temperature, evaporation and rainfall distribution in crop growth period during 2008-09 and 2009-10 have been depicted in Fig. 1. Five technologies during rainy season and another five technologies during winter season, as given below (Table 1 and Table 2) were demonstrated in above 10 villages in about 10 ha area covering 14-20 farmers per season:

Rainy Season

1. Supplemental irrigation to soybean ('J S 335') through rain-gun (gear operated rain-gun capable of providing 2.5 cm irrigation in 4 hours and covering about 0.4 ha area from one point. Rain-gun operateable with 5 H.P. pump which are commonly available at farmer's field) was provided during dry spells (common occurrence in the region) for efficient utilization of limited ground water, energy and labour. Furthermore, rain-gun can effectively be used on undulating land.

2. Organics (vermi-compost @ 1 t ha^{-1}) in conjunction with recommended dose of in-organic fertilizers (INM) were applied for higher soil moisture conservation and

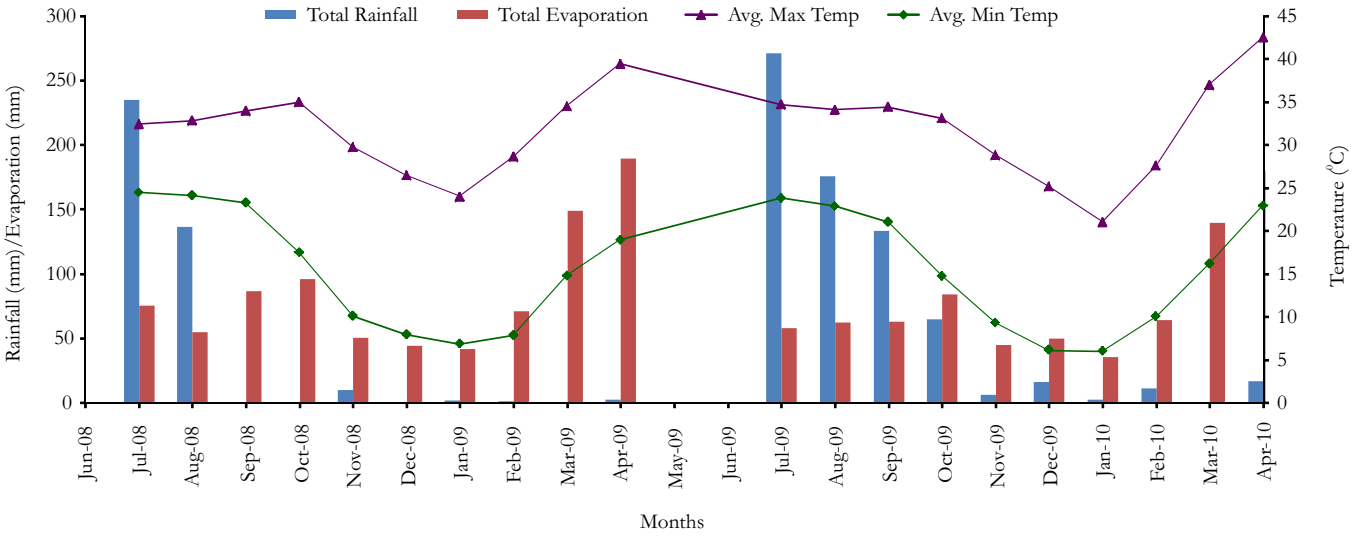


Fig. 1. Minimum and maximum temperature, evaporation and rainfall distribution in different months during crop growth period in 2008-09 and 2009-10

Table: 1
No. of technology demonstrations conducted and area covered during 2008-09 and 2009-10

S.No.	Technology	Crop	No. of demonstrations			Area (ha)		
			2008-09	2009-10	Total	2008-09	2009-10	Total
1	Micro irrigation with rain-gun	Soybean	7	5	12	3	2	5
		Wheat	6	6	12	2	2	4
2	INM	Soybean	2	3	5	2	2	4
		Indian mustard	2	2	4	2	2	4
		Wheat (INM-vermi-compost)	7	8	15	3	3	6
		Wheat (Green manuring-wheat)	2	2	4	1	1	2
3	Deep tillage	Soybean	2	2	4	2	1	3
		Sorghum	-	2	2	-	1	1
4	Intercropping	Sorghum + black gram	2	3	5	2	2	4
		Chickpea + Indian mustard	2	2	4	2	2	4
5	*In-situ* surface mulching	Sorghum	1	-	1	1	-	1
		Total	33	35	68	20	18	38

improved soil health in soybean. The yield was compared with untreated plots.

3. Deep tillage was carried out for *in-situ* soil moisture conservation in sorghum ('CHS 14') and soybean. Deep tillage (ploughing with mould board plough + 2 pass harrow + planking) was done during summer season before sowing of rainy season crops, and the yield obtained was compared with traditional tillage (2 pass harrow + planking).

4. Intercropping of sorghum + black gram ('Azad 2') was done in 1:2 ratios for better surface cover and efficient soil moisture utilization. Intercropping yield (sorghum equivalent) was compared with yield of sole sorghum.

5. One row of sunnhemp was grown in between two rows of sorghum for *in-situ* surface mulching for soil moisture conservation. Sunnhemp was cut down from the ground after 25 days of sowing and bio-mass was uniformly spread as mulch on the ground surface in between two rows of sorghum. The yield was compared with untreated plots.

Winter Season

1. In view of limited availability of ground water, five irrigations through sprinkler (rain-gun) were applied to wheat ('GW 273') at critical stages of crop growth for increasing the WUE. Results were compared with flood irrigation plots.

2. Recommended dose of inorganic fertilizers (100 kg N and 60 kg P_2O_5 and 40 kg K_2O ha^{-1}) was applied in conjunctioncwith vermi-compost @ 1 t ha^{-1} in wheat for improved soil moisture conservation and soil health. The results were compared with untreated plots.

3. The chickpea is usually grown in pure stand (farmer's practice) and many times it failed because of infestation of wilt and attack of pod borer. In order to minimize the risk of crop failure, increase the productivity as well as net profit per unit area and per unit time besides increasing the WUE, intercropping of Indian mustard ('Pusa Bold') in chickpea ('JG 322') was done in a ratio of 8:1.

4. The sunnhemp was grown during rainy season for green manuring and it was turned down in the soil by mould board plough after 7 week of sowing. Wheat was grown during winter season adopting recommended package of practices. Yield was compared with that obtained under farmer's practice (fallow - wheat).

5. The sunnhemp was grown during rainy season for green manuring and it was turned down in the soil by mould board plough after 7 week of sowing. The Indian mustard ('Pusa bold') was grown during winter season adopting recommended package of practices. Yield was compared with that obtained under farmer's practice (fallow-Indian mustard).

Sunnhemp at incorporation contained 0.95, 0.17 and 1.32% of N, P_2O_5 and K_2O, respectively. The N, P_2O_5 and K_2O contents in the vermi-compost were 1.8-2.1, 1.5-1.8 and 0.6-0.8%, respectively.

The quantity of irrigation water applied at each irrigation under farmer's practice and through sprinkler (rain-gun) was measured (Misra and Ahmed, 1987). Soil-moisture at sowing and at harvest from 0-60 cm soil profile, irrigation applied and effective rainfall received during crop growth period was taken into account for computing the seasonal consumptive use and further WUE. WUE was worked out using following formula:

$$WUE = Y/U$$

Where, WUE = Water use efficiency (kg grain ha^{-1} mm); Y = Crop yield (kg ha^{-1}); U = Seasonal consumptive use (mm).

Table: 2
Detail of different technologies and farmer's practice

S.No.	Cropping season			
	Rainy season		Winter season	
	Technology	Farmer's practice	Technology	Farmer's practice
1	Supplemental irrigation to soybean through rain-gun in dry spells during pod filling	Rainfed soybean	Micro-irrigation to wheat through rain-gun for efficient utilization of limited ground water	Flood irrigation
2	Integrated nutrient management (INM) in soybean: Application of organics (vermi-compost fertilizer @ 1 t ha^{-1}) along with in-organic fertilizer (20 kg N and 50 kg P_2O_5 and 40 kg K_2O ha^{-1}) for improved soil moisture conservation and soil health	Soybean without	INM (vermi-compost @ 1 t ha^{-1} with in organic fertilizer, 100 kg N and 60 kg P_2O_5N and 60 kg P_2O_5 ha^{-1}) in wheat (with recommended seed rate *i.e.* 100 kg ha^{-1}) for improved soil moisture conservation and soil health	Imbalanced dose of fertilizers (80 kg N and 40 kg K_2O ha^{-1}) coupled with high (almost double of recommended *i.e.* 200 kg ha^{-1}) seed rate
3	Deep tillage in sorghum/soybean for *in-situ* soil moisture conservation	Shallow tillage with *desi* plough	Intercropping of chickpea + Indian mustard (8:1) for better surface cover and efficient soil moisture utilization	Sole chickpea
4	Intercropping of sorghum + black gram (1:2) for better surface cover and efficient soil moisture utilization	Sole sorghum	Wheat preceded by green manuring (Green manuring-wheat) for efficient soil moisture utilization and soil health	Fallow-wheat
5	Sorghum + *in-situ* surface mulching of sunnhemp (1.86 t ha^{-1}, on air dry weight basis) for soil moisture conservation	Sorghum traditionally sown and managed	Indian mustard preceded by green manuring (Green manuring-Indian mustard) for efficient soil moisture utilization and soil health	Fallow-Indian mustard

Both the approaches (traditional vs improved) were compared with respect to crop yields, WUE, additional net returns and benefit-cost ratio (B:C ratio) at the end of the season. Economic analysis was done considering prevalent market rate of inputs and produce.

The extension gap, technological gap and technological index were also calculated (Samui *et al.*, 2000) as given below:

Technology gap = Potential yield - Demonstration yield; Extension gap= Demonstration yield-Farmers yield; Technology index = (Potential yield - Demonstration yield)/ Potential yield.

A potential yield for various crops recorded at the Research Farm to the tune of 25, 20, 60, 20, 22 and 25 q ha^{-1} for soybean, sorghum, wheat, Indian mustard, sorghum + black gram (sorghum equivalent) and chickpea + Indian mustard (chickpea equivalent), respectively, was taken into account for calculating extension gap, technological gap and technological index.

3. RESULTS AND DISCUSSION

A rainfall of 371.6 and 644.2 mm was received during the growth period of rainy season crops in 2008 and 2009, respectively (Fig.1). However, a rainfall of 15.4 and 54.4 mm was recorded during growth period of winter season crops in 2008-09 and 2009-10, respectively. The distribution of received rainfall during both the years was uneven and erratic. There was no rain after 28th August during rainy season in 2008 and only 15.4 mm rainfall was received during winter season (2008-09). Dry spells of 6 to 21 days were experienced during rainy season 2009 and a rainfall of 54.4 mm was recorded in winter season of 2009-10.

Yield

Results of 2 years revealed that all resource conservation technologies demonstrated at farmer's field were helpful in increasing production and returns over farmer's practice (Table 3). During 2008-09, grain yields of different rainy season crops increased from 22 to 82% and yield of winter season crops increased from 5 to 8% under various resource conservation technologies over farmer's practice. However, during 2009-10, yield of various rainy season crops increased from 28 to 44% and yield of winter season crops increased from 8 to 22% under different technology demonstrations over farmer's practice. The magnitude of increase in yield of different crops recorded higher during rainy season than winter season crops under various resource conservation technologies during both the years that indicated more necessity of adoption of resource conservation technologies during rainy season than winter season. As there was no rainfall received after 28th August till the harvest of rainy season crops during 2008 and from September 11 to

Table: 3
Yield of various crops under different practices during 2008-09 and 2009-10 and mean of 2 years

Technology	Crop	Year	Seed yield (kg ha^{-1})		
			Traditional practice	Technology	Percent increase over traditional practice
Micro irrigation with rain-gun	Soybean	2008-09	1175	2136	81.8
		2009-10	1378	1915	39.0
		Mean	1277	2026	60.4
	Wheat	2008-09	4720	4970	5.3
		2009-10	4112	4442	8.0
		Mean	4416	4706	6.7
INM (Vermi compost + recommended dose of inorganic fertilizers)	Soybean	2008-09	1575	2140	35.9
		2009-10	1397	2017	44.4
		Mean	1486	2079	40.1
	Indian mustard	2008-09	1563	1834	17.3
		2009-10	1515	1800	18.8
		Mean	1539	1817	18.1
	Wheat	2008-09	4450	4980	11.9
		2009-10	3486	4127	18.4
		Mean	3968	4554	15.2
Green manuring	Wheat	2008-09	4280	5060	18.2
		2009-10	3750	4585	22.3
		Mean	4015	4823	20.3
Deep tillage	Soybean	2008-09	-	-	-
		2009-10	1425	1938	36.0
		Mean	1425	1938	36.0
	Sorghum	2008-09	1025	1250	22.0
		2009-10	1350	1785	32.2
		Mean	1188	1518	27.1
Intercropping	Sorghum + black gram	2008-09	725	928	28.0
		2009-10	566	725	28.1
		Mean	646	827	28.1
	Chick pea + Indian mustard	2008-09	1678	1885	12.3
		2009-10	1635	1954	19.5
		Mean	1657	1920	15.9
In-situ surface mulching	Sorghum	2008-09	688	975	41.7
		2009-10	-	-	-
		Mean	688	975	41.7

October 1 during 2009 when most of the rainy season crops were in reproductive phase. Various soil and water conservation practices followed under technology demonstrations helped in conserving and retaining higher soil moisture content in soil over farmer's practices that, in turn, resulted in better reproductive growth and higher yield of different crops. The seed yield of soybean increased under micro irrigation provided through rain gun during pod filling because it improved the availability of soil moisture in root zone which helped the seed development during prevailing water stress condition. Narayan and Biswas (2012a) also reported increase in yield of soybean under supplemental irrigation provided during pod filling in dry spells. Similarly, INM, green manuring, deep tillage and *in-situ* surface mulching and intercropping were found helpful in conserving higher rainwater, retaining it for longer duration and ensuring its availability to crop during dry spells under demonstration plots over farmer's practice. The findings of present study are in accordance with earlier findings of Biswas *et al.* (2012), Narayan and Lal (2006), Narayan and Lal (2009) and Narayan and Biswas (2012b) about increase in yield under combined use of inorganic fertilizers and organic manures (INM), green manuring, improved tillage and *in-situ* surface mulching and intercropping, respectively.

Water Use Efficiency

WUE of different crops increased under various improved technologies over farmer's practice during rainy season as well as winter season during both the years (Table 4). During 2008-09, WUE of different rainy season crops increased from 22.0 to 81.8% and winter season crops from 5.3 to 18.8% under various resource conservation technologies over farmer's practice. During 2009-10, WUE of various rainy season crops increased from 28.1 to 44.4% and winter season crops from 8.0 to 22.3% under different technologies over farmer's practice. Mean results of two years also followed the similar results. The magnitude of increase in WUE of different crops recorded higher during rainy season than

Table: 4
Water use efficiency of various crops under different practices during 2008-09 and 2009-10 and mean of 2 years

Technology	Crop	Year	Water use efficiency (kg grain ha^{-1}mm)		
			Traditional practice	Technology	Per cent increase over traditional practice
Micro irrigation with rain-gun	Soybean	2008-09	3.04	4.72	55.3
		2009-10	2.57	3.57	38.9
		Mean	2.81	4.15	47.1
	Wheat	2008-09	11.60	19.90	71.6
		2009-10	10.00	15.60	56.0
		Mean	10.80	17.75	63.8
INM (Vermi compost + recommended dose of inorganic fertilizers)	Soybean	2008-09	3.23	4.63	43.3
		2009-10	2.61	3.76	44.1
		Mean	2.92	4.20	43.7
	Indian mustard	2008-09	7.90	9.58	21.3
		2009-10	10.44	12.54	20.1
		Mean	9.17	11.06	20.7
	Wheat	2008-09	11.20	13.2	17.9
		2009-10	7.78	9.39	20.7
		Mean	9.49	11.30	19.3
Green manuring	Wheat	2008-09	12.00	15.2	26.7
		2009-10	8.55	9.99	16.8
		Mean	10.28	12.60	21.8
Deep tillage	Soybean	2008-09	-	-	-
		2009-10	3.68	5.20	41.3
		Mean	3.68	5.20	41.3
	Sorghum	2008-09	2.91	3.53	21.3
		2009-10	2.52	3.33	32.1
		Mean	2.72	3.43	26.7
Intercropping	Sorghum + black gram	2008-09	2.13	2.71	27.2
		2009-10	1.06	1.35	27.4
		Mean	1.60	2.03	27.3
	Chick pea + Indian mustard	2008-09	8.32	9.79	17.7
		2009-10	11.30	13.63	20.6
		Mean	9.81	11.71	19.1
In-situ surface mulching	Sorghum	2008-09	1.85	2.56	38.4
		2009-10	-	-	-
		Mean	1.85	2.56	38.4

winter season crops under various resource conservation technologies during both the years that further indicated the importance of adoption of resource conservation technologies during rainy season over winter season. Narayan and Biswas (2012a) also reported increase in WUE of different rainy season and winter season crops with supplemental irrigation during dry spells/water stress conditions. The findings of present study also corroborate the findings of Narayan and Lal (2009) about increase in WUE under improved tillage and *in-situ* surface mulching.

Economics

Improved technologies were more remunerative over CPs in registering higher profit during rainy season and winter season in both the years (Table 5). During 2008-09, additional net returns of different rainy season crops increased from ₹ 1,387 to ₹ 12,706 ha^{-1} and winter season crops from ₹ 2,355 to ₹ 11,193 ha^{-1} under various resource conservation technologies over farmer's practice. However, during 2009-10, net additional returns of various rainy season crops increased from ₹ 2,753 to ₹ 11,147 ha^{-1} and winter season crops from ₹ 2,878 to ₹ 9,410 ha^{-1} under different technologies over farmer's practice. Mean results of 2 years indicated that additional net returns of soybean increased to the tune of ₹ 11,927; 8,132 and 10,593 ha^{-1} under micro irrigation through rain-gun, INM and deep tillage, respectively, over farmer's practice. Additional net returns of sorghum increased by ₹ 2,070 ha^{-1} under deep tillage and ₹ 1,499 ha^{-1} under *in-situ* surface mulching of sunnhemp over traditional practice. Intercropping of sorghum + black gram registered the higher additional net returns to the tune of ₹ 5,353 ha^{-1} over sole cropping of sorghum. Additional net returns of wheat cultivation increased by ₹ 2,797; 5,409 and 10,302 ha^{-1} under micro irrigation, INM (vermicompost) and INM (green manuring-wheat), respectively, over CP. Additional net returns of Indian mustard increased by ₹ 4,316 ha^{-1} under INM over farmer's practice. Intercropping of chickpea + Indian mustard

Table: 5
Additional net returns and B:C ratio under various crops in different practices during 2008-09 and 2009-10 and mean of 2 years

Technology	Crop	Year	Additional net returns under technology over traditional practice (₹ ha^{-1})	B:C ratio	
				Traditional practice	Technology
Micro irrigation with rain-gun	Soybean	2008-09	12,706	2.51	3.26
		2009-10	11,147	2.40	3.09
		Mean	11,927	2.46	3.17
	Wheat	2008-09	2,716	3.99	4.07
		2009-10	2,878	2.43	3.44
		Mean	2,797	3.71	3.76
INM (Vermi compost+recommended dose of inorganic fertilizers)	Soybean	2008-09	7,640	2.68	2.68
		2009-10	8,623	2.46	2.52
		Mean	8,132	2.57	2.60
	Indian mustard	2008-09	4,804	3.18	3.51
		2009-10	3,828	3.21	3.13
		Mean	4,316	3.19	3.32
	Wheat	2008-09	5,921	3.07	3.24
		2009-10	4,897	2.57	2.58
		Mean	5,409	2.82	2.91
Green manuring	Wheat	2008-09	11,193	2.95	3.66
		2009-10	9,410	2.77	3.17
		Mean	10,302	2.86	3.41
Deep tillage	Soybean	2008-09	-	-	-
		2009-10	10,593	2.51	3.13
		Mean	10,593	2.51	3.13
	Sorghum	2008-09	1,387	1.35	1.44
		2009-10	2,753	1.84	1.87
		Mean	2,070	1.60	1.66
Intercropping	Sorghum + black gram	2008-09	4,067	2.51	2.67
		2009-10	6,639	2.28	2.66
		Mean	5,353	2.39	2.66
	Chick pea + Indian mustard	2008-09	2,355	3.38	3.22
		2009-10	5,624	3.35	3.63
		Mean	3,990	3.37	3.42
In-situ surface mulching	Sorghum	2008-09	1,499	1.00	1.15
		2009-10	-	-	-
		Mean	1,499	1.00	1.15

increased additional net returns to the tune of ₹ 3,990 ha^{-1} over sole cropping of gram.

Data further indicated the positive effect of technology demonstration over the farmer's practices in registering higher B:C ratio under demonstrations. In general, higher B:C ratio was obtained under improved technologies over CPs during rainy season and winter season in both the years (Table 5). Mean results of 2 years indicated highest increase of 29.2% in B:C ratio under micro irrigation through rain gun followed by 24.8% under deep tillage in soybean. An increase of 19.2, 14.4, 11.6, 4.2, 4.0, 3.1, 1.7, 1.2, 1.0% in B:C ratio under improved technologies over farmer's practice was recorded in green manuring-wheat, *in-situ* surface mulching in sorghum, INM in Indian mustard and wheat, intercropping of Indian mustard in gram, micro-irrigation in wheat through rain-gun and INM in soybean, respectively.

The yield of wheat under micro-irrigation with rain-gun might have increased over traditional practice (flooding) because of no stagnation of irrigation water in the field and better aeration that led to higher crop growth and yield. Saving on water, energy and labour under micro-irrigation helped in increasing WUE and additional net returns and B:C ratio over traditional practice of flood irrigation. Deep tillage in sorghum and soybean might have helped in recycling of nutrients and conservation of soil moisture for a longer period which helped the crop in dry spell, better moisture availability that, in turn, resulted higher yield, WUE and additional net returns over traditional practice *i.e.* shallow tillage (Narayan and Lal, 2009). Intercropping of sorghum + black gram during rainy season might have helped in reducing soil erosion and improving soil moisture status through higher canopy cover that might have resulted in higher yield, WUE and profit over sole cropping of sorghum. Similarly, intercropping of chickpea + Indian mustard increased the productivity as well as net profit besides higher WUE by minimizing the risk of crop failure on account of infestation of wilt and attack of pod borer in sole cropping of chickpea.

Green manuring of sunnhemp during rainy season prior to sowing of Indian mustard and wheat minimized soil erosion, increased the higher rainwater conservation, reduced infestation of weeds and improved fertility of the soil which in turn increased the crop growth, yield, WUE and net returns over traditional practice of fallow-wheat cropping system. INM (NPK + vermi-compost) in wheat improved soil health, particularly water holding capacity through better soil aggregation that in turn increased crop growth, yield and net returns besides WUE over traditional practice-no application of organics) (Chaudhary *et al*., 2003; Dass *et al*., 2008). *In-situ* surface mulching in sorghum conserved higher soil moisture for a longer period through reduced surface evaporation that might have helped in assuring moisture availability to the crop during grain filling period after cessation of rain that resulted in higher yield, WUE and profit over farmer's practice (no mulching) (Chaudhary *et al*., 2003).

Extension Gap, Technology Gap and Technology Index

Mean results of 2 years indicated that extension gap under various technologies ranged between 808 to 181 kg ha^{-1} (Table 6). The highest extension gap (808 q ha^{-1}) was recorded for green manuring-wheat technology followed by 749 kg ha^{-1} for micro irrigation through rain-gun in soybean, whereas lowest extension gap of 181 kg ha^{-1} was recorded in intercropping of sorghum + black gram. Extension gap emphasized the need to educate the farmers through various techniques for adoption of improved agricultural production reverse the trend of wide extension gap. The mean technological gap *i.e.* the difference between potential yield and yield of demonstration plot (yield) ranged between 183 to 1447 kg ha^{-1} for different crops under various technologies (Table 6). Technology gap imply researchable issues for realization of potential yield, while the extension gap imply what can be achieved by the transfer of existing technologies (Table 6). The mean technological index ranged between 9.15 to 62.43% in different crops under various technologies. The technological index revealed the feasibility of the demonstration technology. As such, variation in technology index during the study period (2008-09 and 2009-10) for individual crop may be attributed to variation in the weather condition. The results are in accordance

Table: 6
Technology gap, extension gap and technology index under different crops and practices during 2008-09 and 2009-10 and mean of 2 years

Technology	Crop	Year	Technology gap (kg ha^{-1})	Extension gap (kg ha^{-1})	Technology index
Micro irrigation with rain-gun	Soybean	2008-09	364	961	14.56
		2009-10	585	537	23.40
		Mean	475	749	18.98
	Wheat	2008-09	1030	250	17.20
		2009-10	1558	330	26.00
		Mean	1294	290	21.57
INM Vermi compost + recommended dose of inorganic fertilizers	Soybean	2008-09	360	565	14.40
		2009-10	483	620	19.30
		Mean	422	593	16.86
	Indian mustard	2008-09	166	271	8.30
		2009-10	200	285	10.00
		Mean	183	278	9.15
	Wheat	2008-09	1020	530	17.00
		2009-10	1873	641	31.20
		Mean	1447	586	24.11
Green manuring	Wheat	2008-09	940	780	15.70
		2009-10	1415	835	23.60
		Mean	1178	808	19.63
Deep tillage	Soybean	2008-09	-	-	-
		2009-10	562	513	22.50
		Mean	562	513	22.48
	Sorghum	2008-09	750	225	37.50
		2009-10	215	435	10.80
		Mean	483	330	24.13
Intercropping	Sorghum + black gram	2008-09	1272	203	57.80
		2009-10	1475	159	67.00
		Mean	1374	181	62.43
	Chick pea + Indian mustard	2008-09	615	207	24.60
		2009-10	546	319	21.80
		Mean	581	263	23.22
In-situ surface mulching	Sorghum	2008-09	1025	287	51.30
		2009-10	-	-	-
		Mean	1025	287	51.25

with the findings of Joshi *et al.* (2012), Katare *et al.* (2011) and Samui *et al.* (2000).

During the last year of the study, farmers themselves brought about 50 ha area under green manuring-wheat, 27 ha under micro-irrigation through rain-gun in wheat, 25 ha under intercropping of chickpea + Indian mustard, 20 ha under INM in wheat, 16 ha under deep tillage in sorghum, 15 ha under micro-irrigation through rain-gun in soybean, 10 ha under deep tillage in soybean, 8 ha under INM in soybean, 7 ha under INM in soybean, 5 ha under intercropping of sorghum + black gram and 3 ha under *in-situ* surface mulching in sorghum. It indicated usefulness of the various resource conservation technologies over existing practices.

4. CONCLUSIONS

Resource conserving technologies developed at ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Datia, Madhya Pradesh were demonstrated at farmer's field in 10 villages during 2008-09 to 2009-10 in Datia, during rainy and winter seasons. Results of 2 years revealed an increase in yield ranging from 7-20% in wheat, 36-60% in soybean, 27-42% in sorghum, 18% in Indian mustard and 16% in chickpea under demonstration plots as compared to those under CPs. WUE increased from 26-47% over the CP during rainy season and from 19-64% during winter season over the CP. Monetary benefits over CP ranged from ₹ 1,500-11,900 ha^{-1}. Results of demonstration of resource conserving technologies at farmer's field clearly indicated that improved technologies were helpful over farmer's practices in increasing yield, WUE and additional net returns. Study suggested that the productivity and profitability could be enhanced considerably at farmer's field by adopting suitable resource conserving technologies during various seasons in Bundelkhand region in central India.

ACKNOWLEDGEMENTS

The authors are extremely grateful to Ministry of Water Resources, Government of India for providing financial help for taking this study under FPARP on "More Crop Per Drop", Director, ICAR-Indian Institute of Soil and Water Conservation, Dehradun for providing necessary facilities during the course of investigation, two anonymous reviewers for providing their valuable comments for improvement on this manuscript and staff of the Journal for providing necessary help in publication of present manuscript.

REFERENCES

Biswas, H., Narayan, D. and Lakaria, B.L. 2012. Effect of integrated nutrient management on soil properties and performance of anola (*Emblica officinalis* Gaertn) based agri-horti system in Bundelkhand region. *Ind. J. Soil Cons.,* 40(2):141-146.

Chaudhary, R.S., Dass, A. and Patnaik, U.S. 2003. Organic farming for vegetable production using vermi-compost and FYM in Kokriguda watershed of Orissa. *Ind. J. Soil Cons.*, 31(2): 203-206.

Dass, Anchal, Lenka, N.K., Sudhishri, S. and Patnaik, U.S. 2008. Integrated nutrient management for production, economics and soil improvement in winter vegetables. *Int. J. Veg. Sci.,* 14(2): 104:120.

Joshi, N.S., Bariya, M.K. and Kunjadia, B.B. 2014. Yield gap analysis through Front Line Demonstration in wheat crop. *Int. J. Scientific Res. Pub.,* 4(9): 1-3.

Lakaria, B.L., Narayan, D., Katiyar, V.S. and Biswas, H. 2010. Evaluation of different rainy season crops for minimizing runoff and soil loss in Bundelkhand region. *J. Ind. Soc. Soil Sci.*, 58(2): 252-255.

Katare, S., Pandey, S.K. and Mustafa, M. 2011. Yield gap analysis of Rapeseed-mustard through front line demonstrations. *Agric. Update,* 6(2): 5-7.

Misra, R.D. and Ahmed, M. 1987. Manual on Irrigation Agronomy. Oxford and IBH Publishing Co., New Delhi, pp. 224-247.

Narayan, D. and Biswas, H. 2012a. Augmenting crop production through rain water harvesting and recycling in red soils of Central India. *Ind. J. Soil Cons.,* 40(1): 52-59.

Narayan, D. and Biswas, H. 2012b. Soybean based intercropping systems for sustainable production under rainfed condition in Bundelkhand region. In. Conservation of natural resources for food and environment security. Dubey, S.K., Dubey, R.K., Singh, A.K., Panda, P.K., Kala, S. and Sharda, V.N. (eds.), Satish Serial Publishing House, Delhi, pp. 323-328.

Narayan, D., Biswas, H. and Kumar, Pramod. 2014. Conservation measures for resource conservation and enhancing yield of sorghum (*Sorghum bicolor* L.) in red soils of Bundelkhand region in central India. *Ind. J. Soil Cons.*, 42(1): 62-67.

Narayan, D. and Lal, B. 2006. Effect of green manuring on soil properties and yield of wheat under different soil depths in Alfisols in Central India. *Bulletin of National Institute of Ecology,* 17: 141-146.

Narayan, D. and Lal, B. 2009. Rain water conservation and yield of sorghum as influenced by tillage and cover management practices in red soils. *Ind. J. Agron.,* 54(3): 438-443.

Narayan, D., Tiwari, A.K., Lal, B. and Katiyar, V.S. 2007. Influence of tillage and sunnhemp mulching on runoff, soil loss and sorghum yield. *Ind. J. Agric. Sci.,* 77(6): 387-389.

Samra, J.S. 2008. Report on Drought Mitigation Strategy for Bundelkhand Region of Uttar Pradesh and Madhya Pradesh. Inter ministerial Team, New Delhi, 143 p.

Samui, S.K., Maitra, S., Roy, D.K., Mandal, A.K. and Saha, D. 2000. Evaluation of front line demonstration on groundnut. *J. Ind. Soc. Coastal Agric. Res.*, 18(2): 180-183.

Singh, A.K. and Singh, Lakhan. 2010. Problems and priorities of Bundelkhand region of Uttar Pradesh. *In*: Extension strategy for Bundelkhand region. Kokate, K.D., Singh, A.K., Mehta, A.K., Singh, Lakhan, Singh, Atar and Prasad, R. (eds.), Zonal Project Directorate, Zone IV (ICAR), Kanpur, pp. 129-136.

Tiwari, S.P. and Narayan, D. 2010. Soil and water conservation measures for Bundelkhand region. *In*. Extension strategy for Bundelkhand region. Kokate, K.D., Singh, A.K., Mehta, A.K., Singh, Lakhan, Singh, Atar and Prasad, R. (eds.), Zonal Project Directorate, Zone IV (ICAR), Kanpur, pp. 48-57.