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Impact of deep cultivation on run-off, soil and nutrient conservation in rainfed conditions

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ABSTRACT : A field experiment was conducted on cropping systems for *in situ* soil and moisture conservation during the *Kharif* season of 2012-13 at Agro-ecology and Environment Centre, Dr. P.D.K.V., Akola. The main objective was to estimate *in situ* soil and moisture conservation and to study the effect on crop growth and productivity. The experiment consisted of two crops *viz.*, cotton (variety-AKA-7) and soybean (variety- JS-335) with eight treatments of cropping systems and cultivation practices. Data pertaining to the growth and yield of soybean (JS-335) and cotton (AKA-7) indicated the favorable effects of 30 cm deep cultivation in medium deep soil under sole and intercropping systems. Results on growth parameters revealed that the performance of soybean crop in terms of plant height, no. of branches, no. of pods, grain yield, straw yield and WUE under 30 cm deep cultivation was found better in both, sole (T_5) and intercropping systems (T_7) over shallow cultivation (T_2 and T_4). The performance of the cotton crop in terms of plant height, no. of branches and picked bolls per plant, seed cotton, stalk yield and WUE under deep cultivation was found better in both, sole (T_6) and intercropping systems (T_7) over T_3 and T_4 under shallow cultivation. The maximum soil moisture content up to the depth of 60 cm was observed 11.08 to 17.86 per cent in T_7 followed by T_6 (10.96 to 17.17 %) and minimum in T_5 (10.76 to 16.98 %).Over the treatment of T_2, T_3 and T_4, respectively. The maximum increase in soil moisture content was observed 10.12 to 15.94 per cent in T_5 followed by T_6 (8.25 to 12.29 %) and T_7 (9.48 to 10.79 %) over the treatment of T_2, T_3 and T_4, respectively.

KEY WORDS : Cropping system, Growth, Intercropping, Moisture, Water use efficiency

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There are always strong links between measures for soil conservation and measures for water conservation, and this applies equally in semi-arid areas. Many measures are directed primarily to one or the other, but most contain an element of both. Reduction of surface run-off by structures or by changes in land management will also help to reduce erosion. Water and soil are essential resources for sustainable agriculture development of a country and foundation stone for agricultural production. The maintenance of soil health is important for higher productivity on sustainable basis to meet the demand of growing population. Resource degradation is also an important problem for semiarid areas and water erosion is common, affecting 126 Mha in India (Maji *et al*., 2010). Tillage increases soil degradation and erosion (Cerda *et al*., 2009), reducing soil productivity and soil organic carbon (SOC) (Lal, 2004), whereas reduced or no till practices can increase SOC in the surface soil layer (Sainju *et al*., 2006; Lopez- Bellido *et al*., 2010). Good farming practices and fertilizer application can facilitate crop and root development; and this in turn can improve soil C balance by increasing the crop residue available for return to the soil (Kirkby *et al*., 2011; Gregorich *et al*., 1996; Dalal *et al.*, 2011). Soil erosion by water has been recognized as a serious threat to sustainable agriculture. Estimates shows that about 155 mha of total geographical area (329 mha) of our country suffer from soil erosion. The existing soil loss data show that soil erosion take place at an average rate of 16.35 tonnes ha^{-1} yr^{-1} totaling of all India 5334 m tonnes ha^{-1} yr^{-1} and it contains nutrients equivalent to 8.4 m tonnes of N, P, K. If soil erosion takes place at this rate, entire 15 cm of soil will loss within 138 years (Anonymous, 2002).

Soil and water are our most precious natural resources and maintaining the soil in stage of high productivity on sustainable basis is important for meeting food demand of our growing population. Several soil and water conservation practices have been recommended to minimize soil erosion and to increase the moisture content in soil. Further, the

pressure on land accelerated soil erosion through degrading the soil which leads to reduced soil fertility. Cropping system is the kind and sequence of crops grown on a given area of soil over a long period of time. It may be regular rotation of different crops in which the crops follow a definite order of appearance on land or it may consist of only one crop grown year after year on the same area. 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).

Soil moisture is a prime constraint in increasing crop production and soil acts as a filter for the moisture storage. This natural situation needs to be utilized to the maximum extent before one think of storing the water elsewhere. Hence, the present investigation was carried out with the objective to estimate *in situ* soil and moisture conservation and to study the effect on crop growth and productivity at Agro-ecology and Environment Centre (Watershed Farm), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

METHODOLOGY

The present study was carried out at cropping systems for *in situ* soil and moisture conservation during the *Kharif* season of 2012-13, Agro-ecology and Environment Centre, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Climate of the agro-ecology and environment centre (watershed farm) :

Akola is situated at latitude 20.70 North and longitude 77.070 East. It is an altitude of 925 ft. (282m) above sea level. Agro-ecologically the watershed area lies in sub region (Eastern Maharashtra Platue, hot, moist, semi-arid, with medium black soil, medium to high available water holding capacity. The climate is semi dried monsoonic characterized by three distinct seasons *viz.*, summer with hot and dry weather from March to May, monsoon, warm and rain from June to October and winter, dry mild from November to February. The mean monthly temperature of Akola is 20.5^0 C to 30.5^0 C with recorded minimum and maximum temperature of 12^0 C to 45^0 C, in the month of December and May, respectively. Akola district falls in assured rainfall zone of Maharashtra having an average annual rainfall of 750mm. (Anonymous, 2013).

Details of study :

The study was conducted with eight treatments using two crops *viz.*, cotton variety AKA-7 and soybean variety JS-335. Details of each treatment pertaining to the study are given below.

Treatment details :

T_1 : Cultivated fallow
T_2 : Soybean sole with shallow cultivation up to 20 cm
T_3 : Cotton sole with shallow cultivation up to 20 cm
T_4 : Cotton + soybean (1:2) with shallow cultivation up to 20 cm
T_5 : Soybean sole with deep cultivation up to 30 cm
T_6 : Cotton sole with deep cultivation up to 30 cm
T_7 : Cotton+soybean (1:2) with deep cultivation up to 30 cm
T_8 : Un-cultivated fallow.

Other details :

The soil of the experimental site was medium deep black having land slope of 1.8 per cent. The micro run-off plot size was 33 m × 2m which is equal to 66 m^2. Tanks in which surface run-off water collected were having size 2.0 m in length, 2.0 m width and 1.2 m depth and having capacity 4.8 m^3. Both the crops were sown on 2nd July 2012. The harvesting of soybean was carried out on 12th October 2012 and two pickings of cotton were carried out on 7th November 2012 and 30th November 2012. The total rainfall during the season was 674.0mm. Other cultural practices were followed as per the recommended package of practices.

Run-off sample collection and analysis :

The surface run-off samples of respective treatments were collected in tanks and total run-off, soil loss and nutrients losses were estimated by using standard methods.

Soil loss :

The soil samples from the run-off were collected during the season. After each storm the run-off samples were collected manually. Stirred 100 ml run-off water each from individual sample was taken into aluminium box. The weight dry soil from 100 ml run-off water was determined by weighing. The soil loss in total run-off volume was expressed in t ha^{-1}:

$$\text{Soil loss} = \frac{\text{Cumulative run - off volume (ml)} \times \text{Soil loss in ml}}{100}$$

Nutrient losses :

Nutrient losses from various treatments plots were calculated by chemical analysis conducted in Soil Testing Laboratory Agro-ecology and Environment Centre, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Available N content in soil was determined by Alkaline permanganate method given by Subbiah and Asija (1965). Available phosphorus content in soil was determined by Olsen's method given by Jackson (1967). Available potassium content in soil was determined by Flame photometer using 1N ammonium acetate given by Jackson (1967).

Soil sampling for moisture determination :

Soil samples were collected using screw augar for four depth's *viz.*, 15cm, 30cm, 45cm and 60 cm, respectively. Soil moisture per cent was determined gravimetrically as described by Piper (1966).

Water use efficiency :

Water use efficiency was calculated with the help of following formula :

$$\text{Water use efficient (kg ha}^{-1}\text{ mm)} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Total water applied (mm)}}$$

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth and productivity :

Data pertaining to the growth and yield of soybean (JS-335) and cotton (AKA-7) presented in Table 1a and Table 1b indicated the favorable effects of 30 cm deep cultivation in medium deep soil under sole and intercropping systems. Results on growth and productivity revealed that the performance of soybean crop in terms of plant height, no. of branches, no. of pods, grain yield, straw yield and WUE under 30 cm deep cultivation was found better in both, sole (T_5) and intercropping systems (T_7) over shallow cultivation (T_2 and T_4).

The performance of the cotton crop (Table 1b) in terms of plant height, no. of branches and picked bolls per plant, seed cotton yield, stalk yield and WUE under deep cultivation was found better in both, sole (T_6) and intercropping systems (T_7) over T_3 and T_4 under shallow cultivation.

***In situ* soil and moisture conservation :**

Data pertaining to the surface runoff and soil loss recorded from various cropping systems under different cultivation practices presented in Table 2 indicated the favorable effect of deep cultivation (30 cm) in medium deep soils.

Runoff and soil loss :

During this season surface runoff and soil loss observed in cultivated fallow land (T_1) was 0.52 per cent and 0.69 t ha^{-1} and 0.42 per cent and 0.52 t ha^{-1}, respectively in (T_8).

The maximum reduction in runoff was observed 6.13 per cent in T_5 followed by 4.26 per cent in T_6 and 4.25 per cent in

Table 1a : Growth and yield of soybean (JS-335) as influenced by shallow and deep cultivation under different cropping systems

Treatments	Growth parameter		Yield parameter					Grain yield, WUE (kg/mm/ha)
	Height (cm)	No. of branches plant^{-1}	No. of pods	Grain yield, kgplot^{-1}	Straw yield, kgplot^{-1}	Grain yield, q ha^{-1}	Straw yield, ha^{-1}	
Shallow cultivation (20 cm)								
T_2	27.8	2.8	18.10	2.12	2.94	3.21	4.43	0.65
T_3	–	–	–	–	–	–	–	–
T_4	25.6	2.2	14.90	1.76	2.12	2.67	3.22	0.54
Deep cultivation (30 cm)								
T_5	32.40	3.2	24.8	2.86	3.06	4.34	4.64	0.88
T_6	–	–	–	–	–	–	–	–
T_7	29.10	2.6	16.30	1.98	2.48	2.99	3.76	0.61

Table 1b : Growth and yield of Cotton (AKA-7) as influenced by shallow and deep cultivation under different cropping systems

Treatments	Growth parameter		Yield parameter					Seed cotton, WUE (kg/mm/ha)
	Height (cm)	No. of branches plant^{-1}	No. of picked boll plant^{-1}	Wt. of seed cotton yield, kgplot^{-1}	Cotton stalk yield, kg plot^{-1}	Seed cotton yield, qha^{-1}	Stalk yield qha^{-1}	
Shallow cultivation (A_1)								
T_2	–	–	–	–	–	–	–	–
T_3	41.2	4.5	2.12	1.476	5.12	2.24	7.76	0.46
T_4	39.0	3.2	1.98	1.394	4.962	2.12	792	0.43
Deep cultivation (A_2)								
T_5	–	–	–	–	–	–	–	–
T_6	44.5	6.3	2.36	1.586	6.18	2.41	9.36	0.49
T_7	40.10	4.1	2.08	1.456	5.02	2.21	7.60	0.45

T_7 under 30 cm deep cultivation over shallow cultivation (up to 20 cm) in treatment T_3, T_4 and T_2, respectively. Mittal *et al.* (1996) had observed minimum runoff and soil loss with green gram + red gram intercropping. On an average intercrops reduced runoff by 11 and 15 per cent and soil loss by 20 and 23 per cent over pure red gram.

Similarly the maximum reduction in soil loss was observed 5.78 per cent in T_7, followed by 4.96 per cent in T_5 and 4.24 per cent in T_6 under deep cultivation over shallow cultivation in treatments T_3, T_4 and T_2, respectively.

A prominent reduction in soil loss was due to the fact that under cropping system with deep cultivation, velocity of flowing water was reduced by obstruction and soil particles could get longer period to settle on the ground surface.

The results indicated that under inter cropping recorded higher productivity in 30 cm deep cultivation with more reduction in runoff and soil loss.

Nutrient loss :

Data pertaining to the nutrient losses given in Table 3 indicated the favorable effect of deep cultivation in medium deep soil under sole and intercropping system. Data revealed

Table 2 : Effect of cropping systems on surface runoff and soil loss as influenced by the cultivation practices

Sr. No.	Parameters	T_1 Cultivated fallow	Treatments: Shallow cultivation (20 cm) T_2 Soybean sole	T_3 Cotton sole	T_4 Cotton+ soybean	Deep cultivation (30 cm) T_5 Soybean Sole	T_6 Cotton sole	T_7 cotton + Soybean	T_8 un-cultivated fallow
1.	Runoff volume (m^3)	0.21	0.198	0.188	0.188	0.186	0.18	0.18	0.17
2.	Runoff depth, (mm)	3.18	3.00	2.85	2.85	2.82	2.73	2.73	2.57
3.	Runoff per cent (rainfall causing runoff)	5.09	4.80	4.56	4.56	4.52	4.38	4.37	4.12
4.	Runoff per cent (seasonal rainfall)	0.52	0.49	0.47	0.47	0.46	0.452	0.45	0.42
5.	Reduction in runoff over shallow cultivation (%)	–	–	–	–	6.13	4.26	4.25	–
6.	Soil loss, (kg $plot^{-1}$)	4.60	4.125	4.050	3.995	3.920	3.885	3.770	3.450
7.	Soil loss, (t ha^{-1})	0.69	0.625	0.614	0.605	0.594	0.58	0.57	0.522
8.	Reduction in soil loss over shallow cultivation %	–	–	–	–	4.96	4.24	5.78	–

Table 3 : Effect of cropping systems on nutrient loss kg ha^{-1} as influenced by the cultivation practices

Treatments		N (kg ha^{-1})	Reduction over shallow cultivation, (%)	P (kg ha^{-1})	Reduction over shallow cultivation, (%)	K (kg ha^{-1})	Reduction over shallow cultivation, (%)
Shallow cultivation	T_2	2.88	–	0.696	–	2.76	–
	T_3	2.14	–	0.648	–	2.04	–
	T_4	2.87	–	0.262	–	2.56	–
Deep cultivation	T_5	2.54	11.80	0.656	5.74	2.42	12.32
	T_6	1.45	32.24	0.268	58.64	1.96	39.21
	T_7	2.24	21.95	0.198	24.42	1.98	22.65

Table 4 : Effect of cultivation practices on soil moisture content in medium soils

Treatments		Soil moisture (%) 15 cm	30 cm	45 cm	60 cm	Increase in moisture over T_2, T_3 and T_4 (%) 15 cm	30 cm	45 cm	60 cm
Cultivated fallow	T_1	7.86	10.36	12.45	14.96	–	–	–	–
	T_2	9.28	11.86	13.12	15.42	–	–	–	–
Shallow cultivation	T_3	9.76	12.12	13.45	15.86	–	–	–	–
	T_4	10.12	12.76	13.86	16.12	–	–	–	–
	T_5	10.76	13.08	14.12	16.98	15.94	10.28	7.62	10.12
Deep cultivation	T_6	10.96	13.24	14.64	17.17	12.29	9.24	8.84	8.25
	T_7	11.08	13.84	14.98	17.86	9.48	8.46	8.08	10.79
Uncultivated fallow	T_8	8.14	10.76	12.92	15.12	–	–	–	–

that the maximum reduction in nutrient loss was observed in sole soybean (T_6) followed by intercropping system (T_7) and sole cotton (T_5) over shallow cultivation practices in T_3, T_2 and T_4, respectively. Kale *et al.* (1992) indicated that 1 per cent slope intercropping system showed minimum run off and soil loss (118.7mm and 2.47t/ha, respectively) followed by sole cropping (132.9 mm and 3.03 t/ha, respectively) as compared to 1.25 per cent slope reduced NPK losses to the extent of 48.9, 45 and 92.3 per cent over sole cropping at 1.25 per cent slope.

Soil moisture :

During this year soil moisture content (Table 3) indicated the favorable effect of deep cultivation in medium deep soil under sole and intercropping systems over T_2, T_3 and T_4 in shallow cultivation.

The maximum soil moisture content up to the depth of 60 cm was observed 11.08 to 17.86 per cent in T_7 followed by T_6 (10.96 to 17.17 %) and minimum in T_5 (10.76 to 16.98 %). Over the treatment of T_2, T_3 and T_4, respectively. The maximum increase in soil moisture content was observed 10.12 to 15.94 per cent in T_5 followed by T_6 (8.25 to 12.29 %) and T_7 (9.48 to 10.79 %) over the treatment of T_2, T_3 and T_4, respectively.

Conclusion :

This study revealed that, deep cultivation up to 30 cm depth favorably influenced the run-off, soil and nutrient losses as well as soil moisture and yields under intercropping of cotton+soybean and sole cropping of cotton and soybean over shallow cultivation up to 20 cm depth. Therefore, it is concluded that, the deep cultivation only up to 30 cm depth.

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