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Soil Properties under Soybean and Cotton Cropping System Influenced by different Tillage Practices

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Abstract*—During kharif season the effect of five tillage systems, Conservation tillage (CnT), Conventional tillage (CvT), Conventional tillage + Sub soiling (CvT+SS), Shallow tillage by tractor (STT) & Shallow tillage by bullock (STB) drawn on soil properties has been studied in field experiment at the research farm of Agronomy, Dr. P.D.K.V. Akola. These tillage treatments were evaluated for clay soil with split plot design under soybean and cotton cropping system (cotton + blackgram).*

The soil properties such as moisture content, porosity, Penetration resistance (cone index), Infiltration rate, saturated hydraulic conductivity and Mean weight diameter at various depth and periodical intervals. In soybean & cotton + blackgram cropping system, the moisture content at depth 30-45 cm were found significantly higher values was recorded from 60 DAS till 120 DAS in CvT+SS treatment. At the depth of 15-30 cm highest porosity (53.86%) was observed in treatment of (CvT+SS) at 30 DAS and lowest value of porosity (33.60%) at 150 DAS in CnT treatment. Penetration resistance at depth of 25 cm as lowest value was recorded in CvT+SS treatment in 226.18 KPa at 30 DAS. Infiltration rate was measured at the time of sowing and harvesting. The highest rate of infiltration at sowing (3.33 cm/h) and (2.17 cm/h) at harvesting was recorded under tillage treatment 'CvT+SS'. The lowest value of hydraulic conductivity (16.90 mm/h) and Mean weight diameter (0.27 mm) was recorded in CnT treatment.

Keywords: *subsoiler, Infiltration rate; Conservation tillage; conventional tillage; hydraulic conductivity.*

1. INTRODUCTION

Tillage has been part of most agricultural systems throughout history because tillage can be used to achieve many agronomic objectives such as soil conditioning, weed/pest suppression, residue management, incorporation/mixing segregation, land forming, shaping. More specific tillage objectives include seed bed formation, stale seed bed formation, compaction alleviation, fracturing of soil crusts, severing/ desiccation of weeds, maceration of biofumigant cover crops, stimulation of soil biology, and harvesting of root crops. Soil temperature, water content, bulk density, porosity, penetration resistance, and aggregate distribution are some of the physical properties affected by tillage systems. Soil physical properties changes affected by different soil tillage treatments could influence yield level of crops (Sharma A.R., *et al*. 2008). Since tillage strongly influences the physical properties of soil, it is important to apply such type of technology that will make it possible to sustain physical properties at a level suitable for normal growth of agricultural crops.

Cotton and soybean are major crops in Maharashtra as well as in Vidarbha region. A tillage method plays an important in seedbed preparation for cotton and soybean and received little attention in Vidarbha. Farmers in this region believe in the value of deep tillage plowing although they have no scientific evidence to support this belief. Limited research has generally shown benefits of shallow and minimum tillage practices over deep and conventional tillage. At this time, a wide range of tillage methods are being used in Vidarbha region without evaluating their effects on soil physical or engineering properties and crop yield. There is a need to standardize the package of practices for higher yield of cotton and soybean. Therefore, the present investigation was planned to determine the effect of different tillage practices with engineering parameter or soil physical properties on cotton and soybean production.

In order to investigate the cumulative effect of various tillage practices viz.; conservational, conventional, shallow and deep tillage on the major crops of Vidarbha region with special reference to local agro-climatic conditions, a field experiment was conducted with the following objectives.

1. To evaluate the various engineering parameters of soil as influenced by various tillage practices.
2. To find out the economically viable tillage operation.

2. MATERIALS AND METHODS

Field experiment was carried out during *Kharif* season of 2010-11 at the research farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola. Total rainfall received during the *Kharif* season of 2010-11 was 924.8 mm as against the normal value of 689.5 mm. The experimental plot topography was fairly uniform and leveled. The soil was clayey in texture with the percentage of sand, silt and clay 34.38, 11.00 and 54.20 respectively. Soybean crop (Variety JS-335) and cotton + blackgram (Variety AKH-8828 + TAU-1 was undertaken to see the effect of various tillage operations.

Experimental design and treatment details

Treatment	Details of Treatments	Depth of operation
CnT	Conservation tillage (1Pass by tractor mounted blade harrow before sowing)	8-10 cm.
CvT	Conventional tillage (1 Ploughing + 1 harrowing by tyne cultivator+1Pass by tractor mounted blade harrow)	25 cm.
CvT+SS	Conventional tillage + Sub soiling (1 Sub-soiling + 1 Ploughing + 1pass by tyne cultivator+1 Harrowing by tractor mounted blade harrow)	55-60 cm
STT	Shallow tillage by tractor (1 shallow tillage by tyne cultivator + 1 Harrowing by blade harrow)	15 cm
STB	Shallow tillage by bullock drawn plough (1shallow tillage by indigenous plough + 1harrowing by bullock drawn blade harrow)	12-15 cm

Conservation Tillage

Conventional Tillage

Subsoiling

Shallow tillage by bullock

Soybean crop

Cotton + Blackgram

3. MEASUREMENT OF VARIOUS PARAMETERS

Moisture content:

Moisture was estimated by direct method, Gopher make soil digital moisture meter (Made in Newziland) was used for estimating the soil moisture from the depth of 15, 30 and 45 cm.

Porosity of soil

The porosity of soil was determined from the relation of dry bulk density and particle density. The relation between the dry bulk density and porosity is:

$$\text{Porosity (\%)} = [\ 1 - \frac{\text{Bulk density}}{\text{Particle density}} \times 100\ ]$$

Where particle density of soil = 2.65 g/cm^3

Penetration resistance (cone index) of soil:

The penetration resistance of soil was taken by using single-tube and dial gauge proven ring type cone penetrometer (Recommended by ASAE 1995).

$$\text{Penetration resistance of soil (CI)(kg/cm}^2\text{)} = \frac{\text{Force applied (kg)}}{\text{Base area (cm}^2\text{)}}$$

Penetration resistance = kg /cm^2 × 98.066 = kPa.

Infiltration rate

Double ring infiltrometer (A.M.Michael, 1999) was used for measurement of infiltration because of its reliability and accuracy.

Saturated hydraulic conductivity:

Hydraulic Conductivity was determined in the laboratory with a Constant Head Permeameter (Disturbed soil) as suggested by Richards, 1954. The hydraulic conductivity (K) was calculated by the formula:

$$K = \frac{Q \times L}{H \times A \times T}$$

where, K = hydraulic conductivity (cm/sec) L= Length (cm)

A= Cross-sectional area (sq.cm) H= difference in pressure head (cm)

T= time (min)

Mean weight diameter:

Calculating the mean weight diameter of aggregates (MWD) the following equation was used (Van Bavel, 1958):

$$MWD = \sum_{i=1}^{n} X_i \times W_i$$

Where X is the average diameter of the openings of 2 consecutive sieves, and W the weight ratio of aggregates remaining on the ith sieve.

4. RESULTS AND DISCUSSION

The observations and results obtained during the experimental work of the present study are presented.

Moisture content (%) at depth of 30-45 cm

Treatment where subsoiler was used (CvT+SS) proved statistically superior over-all the remaining treatments in terms of soil moisture content at the time of sowing. This treatment was followed by conventional tillage treatment (CvT), where as the lowest moisture content at sowing was recorded with treatment ‘CnT’. During the early growth period and crop maturity stage (i.e. up to 120DAS) consistently higher moisture was retained by treatment ‘CvT+SS’, which was significantly superior over other tillage treatments. Treatment ‘CvT’ recorded second highest position, while treatment ‘STT’ recorded the lowest moisture status during 20, 40, 60, 100 and 120DAS.

At the time of sowing moisture content differed significantly due to various cropping systems. Significantly highest moisture status at 20, 80, 100 and 120DAS was recorded with cotton + blackgram cropping system. Whereas, soybean recorded highest moisture at sowing, 40 and 140DAS.

Table 1: Effect of tillage on moisture content (%) at depth of 30-45 cm.

Treatments	Moisture Content (%) at the depth 30-45cm at periodical intervals.								
Tillage treatment (T)	**At sowing**	**20 DAS**	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**120 DAS**	**140 DAS**	**160 DAS**
CnT	24.23	36.08	36.16	36.49	36.50	36.58	36.41	33.28	32.98
CvT	26.08	36.48	36.61	36.79	36.78	36.79	36.73	34.67	32.56
CvT+SS	27.06	36.71	36.95	37.03	37.38	37.44	37.61	35.15	33.22
STT	24.99	35.38	35.47	35.72	35.87	35.96	35.72	33.38	32.24
STB	25.99	35.86	35.59	36.00	36.31	36.38	35.95	33.68	32.23
F' Test	s	s	s	s	s	s	s	s	s
SE (m) +/-	0.001	0.003	0.002	0.003	0.004	0.006	0.009	0.010	0.012
CD at 5%	0.002	0.008	0.007	0.011	0.013	0.017	0.028	0.032	0.037
Cropping System(C)									
S	25.76	36.11	36.31	36.22	36.57	36.63	36.50	34.06	32.44
CB	25.49	36.13	36.00	36.48	36.87	36.93	36.72	33.86	32.71
F' Test	s	s	s	s	s	s	s	s	s

SE (m) +/-	0.001	0.002	0.003	0.002	0.004	0.005	0.007	0.005	0.009
CD at 5%	0.002	0.006	0.008	0.006	0.011	0.013	0.019	0.015	0.026

Porosity (per cent) at 15-30 cm.

Data with respect to porosity at the depth 15-30 cm as observed under various treatment under study is depicted in Fig. 1

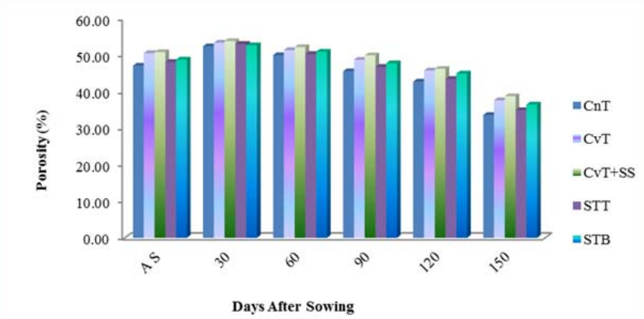

Fig. 1 Effect of tillage on Porosity of soil at 15-30 cm depth

Overall porosity decreased with depth and with the duration. At the time of sowing, the highest porosity (50.785 per cent) was recorded in treatment ‘CvT+SS’ which was followed by treatment ‘CvT’ where the porosity was 50.527 per cent. Significantly lowest porosity was recorded with treatment ‘CnT’ (47.100 per cent). During the periodical stages of 30, 60,90, 120 and 150DAS statistically superior treatment was found to be ‘CvT+SS’ which recorded the highest porosity while treatment ‘CnT’ was found to be less responsive towards the per cent porosity.

Penetration Resistance at 25 cm depth

Reading of penetration resistance (kPa) at the depth of 25 cm were taken one week before sowing and at the time of sowing ; and thereafter at an interval of 30 days up to harvest of the main crop. Data are presented in Table 2.

Table 2: Effect of tillage on Penetration Resistance (kPa) at 25 cm depth

Treatments	**Penetration Resistance (Cone Index)**					
Tillage Treatment (T)	**At sowing**	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**	**150 DAS**
CnT	445.32	412.73	433.96	486.05	526.36	614.19
CvT	319.53	249.31	318.38	356.65	424.80	460.58
CvT+SS	299.12	226.18	270.07	316.49	364.85	395.09
STT	413.79	385.53	419.13	437.76	515.03	538.93
STB	342.99	312.44	355.22	395.29	469.56	510.33
F' Test	s	s	s	s	s	s
SE (m) +/-	0.04	0.01	0.04	1.49	0.00	0.01
CD at 5%	0.12	0.03	0.11	4.59	0.01	0.03
Cropping System(C)						
S	362.67	315.94	357.90	395.25	458.51	502.44
CB	364.53	318.23	360.07	400.06	460.41	504.18
F' Test	s	s	s	s	s	s
SE (m) +/-	0.03	0.01	0.03	1.16	0.01	0.01
CD at 5%	0.09	0.02	0.09	3.34	0.02	0.02

Though the soil compaction intensified at the depth of 25 cm, the compaction or soil strength was compensated by the increased depth of soil manipulation under treatment ‘CvT+SS’. Hence treatment ‘CvT+SS’ (299.12 kPa) proved significantly superior over other tillage treatments by recording the lower values of cone index which was followed by treatment ‘CvT’(445.32). The highest cone index value (445.32kPa) was recorded in treatment ‘CnT’. Treatments ‘STT’ and ‘STB’ where found to be intermediate.

The highest values of cone index obtained at the depth of 25 cm may have been due to the reduction in soil moisture content and higher value of bulk density. Fluctuation in the value of cone index was noted to be inversely proportional to the values of moisture content during the growth period of the crop. At the time of harvest, the lowest cone index; as such at higher depth reflects breakage of compacted subsoil layer and improved infiltration that usually accompanies sub-soiling. While the increase in cone index value with decrease in depth of tillage could have been attributed to increased bulk density, increased soil strength and reduced moisture content.

Arun Kumar et al., (2006) reported that the soil cone index is a engineering property which affects soil compaction and plant root development. They reported the value of cone index varies directly with bulk density and depth, and inversely with moisture contents.

Infiltration rate of soil

Soil property in respect of rate of infiltration was found to be varying at the time of sowing. Data obtained from various tillage treatments regarding infiltration rate of field are presented in the Fig. 2.

The highest rate of infiltration (3.33 cm/h) was recorded under tillage treatment ‘CvT+SS’. This was followed by treatment ‘CvT’ with rate of infiltration as 2.94 cm/h. The lowest rate of infiltration (2.31 cm/h) was recorded in treatment ‘CnT’. In case of final infiltration rate which was recorded at the time of crop harvest, the overall values decreased in all the tillage treatments. Still, under all the circumstances of higher soil compaction, treatment ‘CvT+SS’ and ‘CvT’ were found to be better than other tillage treatments by recording infiltration rate of 2.17 cm/h and 1.96 cm/h, respectively. The lowest infiltration rate was recorded in treatment 'CnT' (0.98 cm/h). Both the shallow tillage treatments (STT and STB) found similar in terms of rate of infiltration (1.44 and 1.48 cm/h).

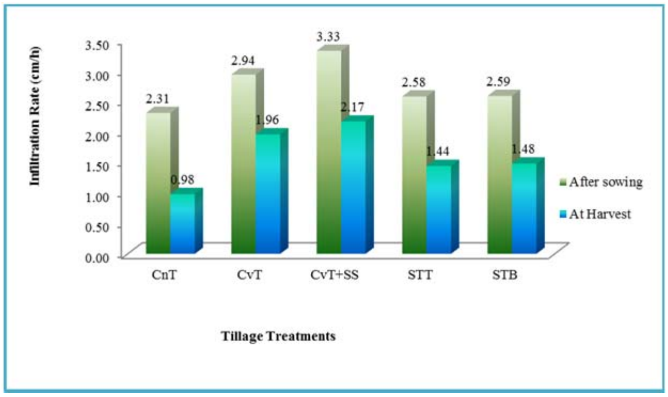

Fig. 2: Effect of tillage on Infiltration Rate of soil

Hydraulic conductivity

As the depth of tillage increased, the proportionate increase in hydraulic conductivity of the soil was observed (Table 3). The highest hydraulic conductivity to an extent of 38.6 mm/h was recorded in treatment 'CvT+SS'. As against this, the hydraulic conductivity found minimum (16.9 mm/h) under the conservation tillage treatment (CnT), which received very shallow tillage treatment up to the depth of 8 cm. As the improvement in soil porosity and decrement in soil bulk density was recorded due to increased tillage depth, its reflection might have obtained by recording the higher hydraulic conductivity under the treatment 'CvT+SS'.

Table 3: Effect of tillage on Mean Weight Diameter and Hydraulic Conductivity of soil

Treatments	Mean Weight Diameter (mm)	Hydraulic conductivity (mm/h)
CnT	0.27	16.90
CvT	0.28	28.70
CvT+SS	0.30	38.60
STT	0.29	20.90
STB	0.28	29.90
Mean	0.28	27.00

Mean weight diameter

High value of mean weight diameter (0.30 mm) were obtained in treatment 'CvT+SS', while the lowest mean weight diameter (0.27 mm) was recorded under the conservation tillage treatment (CnT). Other tillage treatments recorded intermediate values of mean weight diameter. The mean weight diameter represents the state soil aggregation and their high values are found to be beneficial representing grater soil aggregation thereby increasing the infiltration and decreasing the bulk density and soil resistance.

When subsoiler was used in treatment 'CvT+SS', it might have influenced with value of bulk density, porosity and resistance positively causing high soil aggregation and there by increased mean weight diameter.

5. CONCLUSION

Improvement in the soil parameter like moisture content, porosity, penetration resistance, infiltration rate hydraulic conductivity and mean weight diameter was observed in a very deep tillage treatment where subsoiler was used, where as treatment of conservation tillage did not influenced these engineering parameters to an appreciable extent.

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