

INFLUENCE OF TILLAGE METHODS AND MULCHES ON SOIL MOISTURE AND YIELD OF GRAM AND WHEAT UNDER RAINFED CONDITION

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ABSTRACT

Influence of tillage methods in association with mulches was studied on the conservation of soil moisture, its utilization and the yield of gram and wheat crops raised on a vertisol under rainfed condition. In gram, sub-soiling + gypsum, and sub-soiling + saw dust treatments, respectively, retained soil moisture 17.5 to 21.5% and 16 to 20% higher than light harrowing + no mulch, and no-tillage + no mulch treatments. In wheat, soil moisture was 9.4 to 9.9% and 8.2 to 8.8% higher under deep ploughing + gypsum, and sub-soiling + gypsum treatments compared to light harrowing + no mulch and no-tillage + no mulch treatments, respectively. Soil moisture utilization by gram and wheat was better in deep ploughing + gypsum treatments. The highest grain yields of gram (1.66 t ha^{-1}) and wheat (1.52 t ha^{-1}) were obtained with sub-soiling + gypsum and deep ploughing + gypsum treatments. Deep tillage (sub-soiling and deep ploughing) and gypsum proved superior to other tillage and mulches on soil for moisture conservation, its efficient use and grain yields of the gram and wheat.

INTRODUCTION

Conservation of moisture in the soil profile after withdrawal of monsoon is vital for seed germination, plant growth and grain yield of crops raised on stored moisture in a traditional dry farming system.

A combination of tillage and mulches can benefit soil organic matter content, bulk density and erodibility properties besides improved soil and moisture conservation (Packer et al., 1984) and reduced runoff (Khybri et al., 1984, Bhatnagar et al., 1984). On the other hand, contrary to the above reports, Pande and Bhan (1964) obtained higher gram yield with no-tillage than with mould-board ploughing. Van Doren et al. (1976) reported higher grain yield of corn with no tillage compared to conventional tillage on a well drained soil.

MATERIAL AND METHODS

The experiment was conducted at Indore ($22^{\circ}43'N$ and $76^{\circ}45'E$). An average annual rainfall of 1000 mm is normally received from the middle of June to the last week of September. Winters, mostly dry, have the mean maximum temperature of

22-31°C and the mean minimum temperature from 6-11°C. The soil of the experimental site was chromic vertisol, 1-m deep, with AC horizon, containing 60% clay, predominantly montmorillonite, 28% silt and 12% sand underlain by a permeable strata of weathered basalt of varying colour. Soil moisture constant values at 0.3 bar and 15 bar were 34% and 16%, respectively. Value of bulk density with respect to 0-15, 15-30, 30-45, 45-60, 60-75, 75-90 and 90-120 cm soil depth were 1.15, 1.19, 1.23, 1.30, 1.28 and 1.27 g cc⁻¹, respectively. Soil pH is 8.0 and electrical conductivity (EC) 0.22 dSm⁻¹. Infiltration (under saturation condition) and permeability of the soil were low.

The experiments were conducted on two major crops of the region, gram (cv U-24) and wheat (cv PKD-1) sown in 10m x 4m plots in a split plot design with 3 replicates for each treatment.

Combined treatments of tillage methods (main treatments) and mulches (sub-treatments) were given for each crop. Pre-monsoon tillage treatments were no-tillage (direct drilling); light harrowing (shallow tillage) using blade harrow 'bakhar' (10 ± 2 cm deep); deep ploughing with 6-bottom reversible mouldboard plough (30 ± 2 cm deep); and sub-soiling with a single row sub-soiler (4 ± 52 cm deep and at 90 cm intervals). In no-tillage plots, weeds were managed by pre-sowing application of glyphosate (2.5 l ha⁻¹). Each tillage treatment was associated with the mulch of gypsum (2.5 t ha⁻¹), vertical mulch of sand (15 t ha⁻¹), vertical mulch of saw dust (5 t ha⁻¹), and no mulch (control). Gypsum was incorporated into the soil and vertical mulching of sand and saw dust was done manually. The rate of fertilizer for gram was 12 kg N ha⁻¹ and 30 kg P ha⁻¹ whereas for wheat it was 62.5 kg N ha⁻¹, 62.5 kg P ha⁻¹ and 37.5 kg K ha⁻¹. Gram was sown on 14 October 1978 in rows 30 cm apart and wheat on 27 October 1978 in rows 30 cm apart. A local seeding machine was used for drilling the seed as well as fertilizer. An additional dose of N 37.5 kg ha⁻¹ as urea was applied to wheat as top dressing in two equal splits after 4 weeks of germination and at flowering stage.

Soil moisture was determined gravimetrically on volume basis for 3 spots in each plot for the soil depth of 0-15 cm, 15-30 cm, 30-45 cm, 45-60 cm, 60-75 cm, 90-105 cm and 105-120 cm at sowing, grain growth stage, initiation of flowering, and at harvesting of the two crops. Moisture utilization was computed by the depletion of soil moisture from sowing to harvest.

Plot grain yields of the crops were determined by harvesting of 9.5 m x 3.5 m area (leaving the border rows on each side) and statistically analysed.

RESULTS AND DISCUSSION

Soil moisture conservation

Data on pre-sowing soil profile moisture in different treatments are set out in Table 1. Combined treatments of deep tillage (sub-soiling and deep ploughing) and mulches showed trend of increased moisture conservation. In the gram crop, sub-soiling + gypsum mulch significantly increased the soil moisture content over other treatments except sub-soiling + saw dust mulch treatment. Sub-soiling + saw dust and sub-soiling + sand mulch treatments did not differ significantly. In wheat, deep ploughing + gypsum retained significantly higher soil moisture than other treatments except sub-soiling + gypsum and deep ploughing + saw dust treatments.

Among the four tillage treatments, the highest soil moisture content for the gram crop was observed in sub-soiling, followed by deep ploughing, whereas for wheat, deep ploughing followed by sub-soiling treatments showed highest moisture regime. These results are similar to those reported by Hadas et al. (1977) and Stibbe et al. (1977) who concluded that the tillage operations saved more water in soil profile, improved winter weed control and enabled deeper and greater root system proliferation than disking or no tillage in dry soil.

Any mulching on the soil further increased the soil moisture content significantly. Similar results were obtained by Gupta and Gupta (1984) and Jones et al (1969). However, gypsum was more effective in soil moisture conservation than sand and saw dust mulch.

Soil moisture use

The consumptive soil moisture use by gram was higher under deep ploughing + gypsum mulch (17.5 cm), followed by that under sub-soiling + gypsum mulch, sub-soiling + saw dust mulch, and deep ploughing + sand mulch (Table 2). wheat also used moisture better in deep ploughing + gypsum mulch, but followed by deep ploughing + sand mulch and deep ploughing + saw dust mulch. The minimum moisture use by gram was in no-tillage + no mulch treatment (13.4 cm); however, in case of wheat, minimum moisture use took place in light harrowing + no mulch treatment (18.1 cm), followed by no-tillage no mulch treatment (18.4 cm). The greater moisture use in deep tillage (sub-soiling and deep ploughing) with mulches, compared to the other treatments could be attributed to increased moisture conservation and possibly, better root development.

Grain yield

The maximum yield of gram was obtained in sub-soiling + gypsum (1.66 t ha^{-1}), followed by deep ploughing + gypsum (1.64 t ha^{-1}) (Table 3). The percentage

Table 1. Total pre-sowing soil profile moisture (cm) upto 120 cm in different tillage and mulch treatments

Tillage methods	Gram				Wheat					
	No mulch	Gypsum	Sand	Saw dust	Mean	No mulch	Gypsum	Sand	Saw dust	Mean
No-tillage	38.6	40.1	40.4	40.0	39.8	43.6	45.7	44.7	44.4	44.6
Light harrowing	39.9	42.6	41.3	40.8	41.2	43.8	45.0	44.8	44.1	44.4
Deep ploughing	41.7	43.0	44.2	42.1	42.8	45.4	47.9	44.9	47.1	46.3
Sub-soiling	43.3	46.9	46.0	46.3	45.6	44.7	47.4	46.0	45.8	46.0
Mean	40.9	43.2	43.0	42.3	43.3	44.4	46.5	45.1	45.4	45.3
Tillage	SEM \pm 0.07				LSD (0.05) 0.24				LSD (0.05) 0.25	
Mulching	0.06				0.17				0.17	
Between two mulches at the same level of tillage	0.12				0.34				0.34	
Between two tillage means at different levels	0.35				1.09				1.10	

Table 2. Soil moisture use (cm) by gram and wheat crops in different tillage and mulch treatments during growth period

Tillage methods	Gram				Wheat					
	No mulch	Gypsum	Sand	Saw dust	Mean	No mulch	Gypsum	Sand	Saw dust	Mean
No-tillage	13.4	14.5	15.0	14.4	14.3	18.4	19.4	19.5	18.4	18.9
Light harrowing	15.9	16.2	16.0	15.3	15.9	18.1	20.7	20.5	19.6	19.7
Deep ploughing	14.8	17.5	16.6	15.4	16.1	19.4	22.6	22.5	22.2	21.7
Sub-soiling	15.7	16.1	17.3	16.7	16.5	19.6	21.5	21.6	20.4	20.8
Mean	15.0	16.1	16.2	15.5	15.7	18.9	21.1	21.0	20.0	20.3
	SEm ±		LSD (0.05)			SEm ±		LSD (0.05)		
Tillage	0.07		0.23			0.09		0.32		
Mulching	0.10		0.28			0.10		0.28		
Between two mulches at same level of tillage	0.20		0.57			0.19		0.56		
Between two tillage means at different levels of mulches	0.59		1.74			0.58		1.78		

Table 3. Grain yield (t ha⁻¹) of gram and wheat under different tillage and mulch treatments

Tillage methods	Gram				Wheat					
	No mulch	Gypsum	Sand	Saw dust	Mean	No mulch	Gypsum	Sand	Saw dust	Mean
No-tillage	1.29	1.35	1.37	1.40	1.35	1.04	1.24	1.20	1.19	1.17
Light Harrowing	1.40	1.44	1.52	1.43	1.44	1.17	1.31	1.26	1.23	1.14
Deep ploughing	1.39	1.64	1.60	1.52	1.54	1.26	1.52	1.41	1.50	1.42
Sub-soiling	1.46	1.66	1.60	1.46	1.55	1.31	1.48	1.42	1.50	1.43
Mean	1.38	1.52	1.52	1.45	1.47	1.91	1.39	1.32	1.35	1.31
	SEM ±					SEM ±				
	0.13					0.06				
	LSD (00.5)					LSD (0.05)				
	0.45					0.22				
Tillage	0.11					0.07				
Mulching	0.22					0.15				
Between two mulches at same level of tillage	0.63					0.45				
Between two tillage means at different level of mulches	2.05					1.33				

increases in yield over no-tillage + gypsum and no-tillage + no mulch treatments were 23.6-29.1 and 21.6-27, respectively. In wheat, 29-47% and 28-45% higher grain yield was obtained with deep ploughing + gypsum and sub-soiling + gypsum treatments over light harrowing + no mulch and no-tillage + no mulch treatment, respectively. Average grain yields from no-tillage treatments were significantly lower than from light harrowing, deep ploughing and sub-soiling treatments.

Average yields of gram and wheat under mulch treatments were significantly higher than those under no mulch treatments. Increase in grain yield by mulching may be attributed to improved soil moisture conditions.

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