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Influence of soil moisture conservation practices on soil properties under arid conditions of Rajasthan

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Abstract

A field experiment was conducted during 2004-09 to study the effect of soil water conservation practices viz., FYM mulch (@ 30 t/ha), cluster bean (*Cyamopsis tetragonoloba*) straw mulch (@ 8 t/ha), bui (*Aerva pseudotomentosa*) grass sraw mulch (@ 8 t/ha), sub-surface application of FYM (@ 12 t/ha) on soil properties. The soil samples were collected after the harvest of brinjal crop in January each year. The pooled data of five years were analysed for various soil physicochemical properties. Among various soil moisture conservation practices application of FYM mulch was found superior than others. It improved soil hydraulic conductivity from 29.35 in control to 27.12 cm h^{-1}, soil moisture content at field capacity from 3.30 to 3.88% w/w, wilting point from 1.20 to 1.54% w/w, organic carbon from 0.38 to 2.41 g kg^{-1}, available N from 78 to 120 kg ha^{-1}, P from 8.16 to 13.74 kg ha^{-1}, K from 430 to 621 kg ha^{-1}, available Fe from 4.1 to 7.1 mg kg^{-1}, Mn from 4.5 to 6.5 mg kg^{-1}, Cu from 0.13 to 0.34 mg kg^{-1} and Zn from 0.08 to 0.30 mg kg^{-1}.

Key words: *Soil properties, organic mulch, farmyard manure, sandy soil and arid region*

Introduction

Soil and water conservation are the two most important aspect for management of light textured sandy soils. These soils are characterized by high leaching rate of irrigation water and nutrient from the root zone of the crop. To improve the water and nutrient level in the soil the addition of farmyard manure (FYM) in the crop fields is a common practice because FYM directly adds much of organic carbon (Duiker and Lal, 1999) and other nutrients to the soil. The method of FYM application or other residues incorporation as organic mulch can play a great role in improving the micro-climate of soil and enhancing the supply of nutrients. These organic mulches also directly affect the microclimate around the plant and in the subsurface region of soil by modifying the radiation budget of the surface, add nutrient to the soil, improve moisture holding capacity and hydraulic conductivity of soil, reduce crusting by avoiding the direct impact of rain drops on the soil particle and decreasing the soil water loss (Gupta and Gupta, 1985; Gupta, 1989; and Singh *et al.*, 2006). The decrease in soil water evaporation results in more uniform soil moisture content and increasing the efficiency of irrigation water, which is of paramount importance in dry areas. Therefore, the present investigation was conducted to find out the influence of organic mulches on change in soil properties in arid condition.

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Material and methods

Field trials were conducted from July 2004 to June 2009 on very deep, coarse loamy sand Typic Torripsamments (sand 86%, silt 5%, clay 8%) at the research Farm of the Central Institute for Arid Horticulture, Bikaner, India, located between 27° 11' to 29° 3' N latitude and 71° 54' to 74° 12' E longitude with a mean annual rainfall of 250 mm with brinjal (eggplant) (*Solanum melongena* L.) as the test crop. The region is characterized by high wind velocity coupled with high evaporation rates, high temperature and solar radiation, low and irregular distribution of rainfall and generally experience water deficit during plant growth period. The soil was calcareous, alkaline in reaction single grain structure having bulk density 1.58 Mg m^{-3}; soil moisture retention capacity ranged from 3.30% w/w at field capacity and 1.20% at wilting point for 0.0 to 15.00 cm depths; saturated hydraulic conductivity 29.35 cm h^{-1}; pH (1:2.5 soil water suspension) 8.2; EC 0.07 dS m^{-1}; soil organic carbon (SOC) 0.38g kg^{-1}, total N 0.0021%; available N 78 kg ha^{-1}; available (Olsen) P_2O_5 8.16 kg ha^{-1}; and available K_2O 430 kg ha^{-1}; available Fe 4.1; Mn 4.5; Cu 0.13; and Zn 0.08 mg kg^{-1}.

The experiment was laid out in a randomized block design with three replications of four soil water conservation treatments, viz., FYM mulch, cluster bean (*Cyamopsis tetragonoloba*) straw mulch, bui (*Aerva pseudotomentosa*) grass straw mulch, sub-surface application of FYM at 20 cm depth and control. All the treatments were imposed after 15 days of transplanting in the month of July each year. The plot sizes were 5.0 m x 1.5 m. The FYM and straw mulches were applied@ 30 and 8 t ha^{-1}, respectively. The sub-surface application of FYM was done @ 12 t ha^{-1}. The N (Urea), P_2O_5 (di-ammonium phosphate) and K_2O (muriate of potash) were applied @ 80, 60 and 40 kg ha^{-1}, respectively.

After the harvest of brinjal crop in the month of January each year, the soil samples were collected from each treatment at 0-15 cm depth and analysed for pH, EC, $CaCO_3$, organic carbon, available N, P, and K following their standard methods as described by Jackson (1973). Available micronutrients i.e., Fe, Mn, Cu and Zn in soil samples were extracted with 0.005 M DTPA (Lindsay and Norvell, 1978) and analysed by atomic absorption spectrophotometer. Soil bulk density was determined using core method (Blake and Hartge, 1986) and moisture retention with a pressure plate method (Richards, 1954). The saturated hydraulic conductivity was determined by constant head method (Klute, 1965).

Results and discussion

Soil properties

Physical properties

There was no change in texture, structure, bulk density and particle density of soil due to application of soil water conservation practices. However, a significant change in porosity, water holding capacity and hydraulic conductivity of soil was recorded (Table 1). FYM mulch and FYM subsurface incorporation treatments were found significantly effective in increasing the soil moisture retention capacity both at field capacity and wilting point. Pertaining to the status of hydraulic conductivity of soil, all the treatments recorded significant improvement in hydraulic conductivity as compared to control. The results are in consonance with the findings of Blevin *et al.* (1983). They reported that straw mulching had no effect on bulk density of soil. Mulching studies conducted in the inter-row spaces of cowpea (*Vigna ungiculata*, Cv. FS-68) with native weeds @ 6 t ha^{-1} increased the infiltration rate by 10-20% and moisture retention (at -0.01 MPa) by 6.0-20 per cent (Gupta, 1986).

Table 1. Physical properties of soils (0-15 cm) after five years of experimentation (Pooled data of five years from 2004 to 2009).

Treatments	Bulk density Mg m^{-3}	Particle density Mg m^{-3}	Porosity (%)	Soil moisture at F.C. w/w (%)	Soil moisture H.C. w/w (%)	Sat. at W.P. cm h^{-1}
FYM mulch	1.57	2.77	44.04	3.88	1.54	27.12
Cluster bean straw mulch	1.58	2.77	42.96	3.35	1.15	28.45
Grass straw mulch	1.58	2.77	42.96	3.30	0.91	28.76
FYM incorporation	1.58	2.77	42.96	3.58	1.46	28.10
Control	1.58	2.78	43.16	3.30	1.20	29.35
CD at 5%	NS	NS	0.368	0.067	0.184	0.315

Chemical properties

Soil water conservation practices could not bring significant changes in values of pH and EC as compared to control (Table 2). However, $CaCO_3$ content was significantly higher in the treated plots as compared to control. A slight decline in the value of pH may be attributed to the production of organic acids, phenolic and carboxylic compounds and secretions of growing biomass.

The SOC of these soils is generally low both at surface and subsurface horizons (Table 2). The low content of organic carbon (0.36 to 2.42 g kg^{-1}) in these soils is due to limited biological activity and rapid decomposition of biomass under prevailing arid climatic conditions (Gupta, 1989). The effects were positive and appreciably higher in the FYM mulch treatment. SOC were recorded significantly higher in all the treated plots as compared to the control. The highest SOC (2.42 g kg^{-1}) was recorded in FYM mulch treatments. The result is in agreement with the findings of Duiker and Lal (1999). They reported a positive linear effect of organic mulch application rate on soil organic carbon concentration.

Table 2 presents the pooled data for available N, P and K content in soil. A comparison of available N and P contents of the treated plots with control plots clearly indicates that application of organic mulches results in significant increase in nutrient status of the soils under the present agroclimatic conditions. FYM mulch registered maximum content of available N (120 kg/ha) and P (13.74 kg/ha) of the soils as compared to control showing N and P values of 78 kg/ha and 8.16 kg/ha, respectively. Increase in available N, P and K due to FYM mulching is due to direct addition of NPK through FYM to the available nutrients pool in the soil. The decomposition of organic matter is accompanied by the release of appreciable quantities of carbon dioxide which, when dissolved in water, forms carbonic acid, which is capable of decomposing certain primary minerals (Tolanur and Badanur, 2003). Further, the beneficial effect of FYM on the available K is also due to the reduction of potassium fixation and release of K due to the interaction of organic matter with clay. Significantly higher available N and P were recorded with straw mulching as compared to control. This may be attributed to the reduction in soil temperature due to straw mulching influencing the biological processes (Hartfield and Prueger, 1996) and enhances soil N mineralization (Tian *et al.*, 1993). It has been shown that in calcareous soils, CO_2 production plays an important role in increasing the phosphate availability.

Table 2. Chemical properties of soils of 0-15 cm depth after five years of experimentation (Pooled data of five years from 2004 to 2009).

Treatments	pH	EC (dS m^{-1})	$CaCO_3$ (%)	Org. C g kg^{-1}	Avail. N (kg ha^{-1})	Avail. P_2O_5 (kg ha^{-1})	Avail. K_2O (kg ha^{-1})	Fe	Mn	Cu (mg kg^{-1})	Zn
FYM mulch	8.30	0.08	2.0	2.42	120	13.74	621	7.1	6.5	0.34	0.30
Cluster bean straw mulch	8.20	0.10	2.2	0.68	88	11.56	393	5.0	5.3	0.25	0.20
Grass straw mulch	8.21	0.12	1.8	0.57	89	10.50	352	4.5	4.6	0.24	0.18
FYM incorporation	8.26	0.07	2.5	0.68	95	11.72	453	5.6	5.5	0.28	0.21
Control	8.20	0.07	1.0	0.38	78	8.16	430	4.1	4.5	0.13	0.08
CD at 5%	NS	NS	0.660	0.05	9.320	1.425	9.591	0.218	0.675	0.026	0.041

The data on DTPA extractable micronutrients (Fe, Mn, Cu and Zn) are given in table 2. The initial status of available Zn and Cu contents indicated that soils were deficient in these nutrients because of their coarse texture. Treatments were found to be significantly effective in increasing the available micronutrient status of soil. An increase in micronutrients status was observed in all the treated plots as compared to control. However, Mn was at par in grass mulch treatment and control.

It was concluded that based on improvement in physico-chemical properties of soil FYM mulch was proved to be the best treatment. Cluster bean straw mulch may be another option for improved soil properties.

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