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EFFECT OF FYM AND MINERAL NUTRIENTS ON PHYSIO-CHEMICAL PROPERTIES OF SOIL UNDER MUSTARD IN WESTERN ARID ZONE OF INDIA

GAJANAND JAT, K.K. SHARMA AND N. K. JAT*
Department of Soil Science & Agricultural Chemistry, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan), 303 329
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ABSTRACT

A field experiment was conducted at Jobner, Jaipur (Rajasthan) with mustard (Brassica juncea (L.) Czern and Coss) to evaluate the influence of application of FYM and mineral nutrients in different combinations on physio-chemical properties of soil after crop harvest. Treatments consisted of three levels of FYM (0, 5 and 10 t ha^{-1}) and five levels of mineral nutrients [M_o (without mineral nutrients), M_1 (S @ 40 kg ha^{-1}), M_2 (S @ 40 kg ha^{-1}+ zinc sulphate @ 25 kg ha^{-1}), M_3 (S @ 40 kg ha^{-1}+ ferrous sulphate @ 50 kg ha^{-1}), M_4 (S @ 40 kg ha^{-1}+ zinc sulphate @ 25 kg ha^{-1}+ ferrous sulphate @ 50 kg ha^{-1})] were applied to mustard (cv. Bio-902) as soil application using randomized block design with three replications. The results indicated that the saturated hydraulic conductivity, total porosity, moisture retention at 1/3 and 15 bar, organic carbon and available N, S, Zn and Fe content in soil at harvest stage of crop was significantly increased but bulk density of soil was decreased significantly with-increasing levels of FYM and whereas, available N, S, Zn and Fe content in soil significantly increased with the supplementation of mineral nutrients (S+Zn+Fe).
Keywords: FYM, mineral nutrients, mustard, physio-chemical properties of soil.

INTRODUCTION

In the India's agricultural economy, oilseeds are important next only to cereals in terms of acreage, production and value and account for about 1.5% of gross domestic product and 8% of value of all agricultural products (Hegde, 2009). Rapeseed and mustard are important oilseed crops and India is second in rapeseed and mustard production next to China and first in area. Rajasthan ranks first both in area and production of rapeseed and mustard in the country. Although it is a major oilseed crop but its productivity in the state (1306 kg ha^{-1}) is much lower than its realizable yield potential of 2200 to 2400 kg ha^{-1}. The role of organic materials in maintaining and increasing soil fertility is well established to sustain reasonable productivity. The fertility status of soils of semi-arid region of Rajasthan is low and whatever amount of organic matter is present is oxidized and lost very fast due to high temperature. The soils of this region are coarse textured and besides the major nutrients, deficient in S, zinc and iron due to continuous crop removal and use of high analysis NPK fertilizers. Since, S is involved in the synthesis of oil and is a constituent of S containing amino acids i.e. cysteine, cystine and methionine, zinc participates in the metabolism of plants as an activator of several enzymes and iron has an important role in synthesis of chlorophyll and flavor-proteins. Thus, the use of organic manure (FYM) and supplementation of soil fertility through mineral nutrients is essential not only to harvest higher yields of crops but to maintain the physical, chemical and biological properties of the soil. Therefore, the present investigation was undertaken to study the effect of different levels of FYM and combinations of S, zinc and iron on the physio-chemical properties of soil under mustard in western arid zone of India.

MATERIALS AND METHODS

A field experiment was carried out during rabi season of 2005-06 at the experimental farm (26°5' N latitude, 75°28' E longitude), S.K.N. College of Agriculture, Jobner located at an altitude of 427 m above MSL in Jaipur district of Rajasthan, representing western arid zone of India. The experimental site is characterized by sub-tropical climate, with extreme temperature during summer (up to 46 °C) and winter (as low as –3 °C) and low rainfall (400 mm and most which is received in rainy season from July to September). The soil is loamy sand, well drained, having pH (1:2.5) 8.1, EC 0.9 dS m^{-1}, organic carbon 0.18%, available N (N) 156.6 kg ha^{-1}, available phosphorus (P) 7.5 kg ha^{-1}, available potassium (K) 149.5 kg ha^{-1}, sulphur (S) 16.1 kg ha^{-1}, DTPA zinc (Zn) 0.43 mg kg^{-1} and iron (Fe) 4.3 mg kg^{-1} at the commencement of the experiment. Treatments consisted of three levels of FYM (0, 5 and 10 t ha^{-1}) and five levels of mineral nutrients [M_o (without mineral nutrients), M_1 (S @ 40 kg ha^{-1}), M_2 (S @ 40 kg ha^{-1}+ zinc sulphate @ 25 kg ha^{-1}), M_3 (S @ 40 kg ha^{-1}+ ferrous sulphate @ 50 kg ha^{-1}), M_4 (S @ 40 kg ha^{-1} + zinc sulphate @ 25 kg ha^{-1}+ ferrous

**Project Directorate for Farming Systems Research, Modipuram, Meerut (U.P.) 250 110*

sulphate @ 50 kg ha^{-1})] were applied to mustard (cv. Bio-902) as soil application using randomized block design with three replications. The recommended dose of N (40 kg ha^{-1}) was applied in two equal splits, half as basal and the remaining half was top dressed at the time of first irrigation through urea after adjusting the quantity supplied through diammonium phosphate. The whole quantity of P (40 kg ha^{-1}), K (30 kg ha^{-1}), Zn (25 kg ha^{-1}) and Fe (50 kg ha^{-1}) was applied through diammonium phosphate, muriate of potash, $ZnSO_4.7H_2O$ and $FeSO_4.7H_2O$, respectively and was drilled as basal at 8-10 cm depth along with half N prior to sowing. S was applied @ 40 kg ha^{-1} through elemental S (85%) about three weeks (21 days) before sowing. The quantity of S added through $ZnSO_4.7H_2O$ and $FeSO_4.7H_2O$ was adjusted @ 40 kg S ha^{-1}in respective treatments. The sowing was done in lines 30 cm apart manually by 'Kera' method. Usual crop husbandry operations were followed to raise a good crop. After crop harvest the soil samples were analyzed using standard laboratory procedures like Singh (1980) for bulk density and saturated hydraulic conductivity, respectively; Richards (1954) and Richards (1974) for total porosity and moisture retention, respectively; Piper (1950) for organic carbon, Subbiah and Asija (1956), William's and Steinbergs (1959) and Lindsay and Norvell (1978) for available N, S and Zn & Fe, respectively.

RESULTS AND DISCUSSIONS

Soil physical properties

Effect of FYM

Bulk Density: The bulk density of the surface soil (0-15 cm) at harvest stage of the mustard crop decreased significantly with increasing levels of FYM (Table 1). The maximum bulk density (1.51 Mg m^{-3}) was obtained under the control (F_0) while minimum was observed under application of F_2 (FYM @ 10 t ha^{-1}). However, in 15-30 cm soil layer the effect of FYM was found non-significant. The decrease in bulk density of the soil might be due to increase in humic substances of soil which resulted in increase of porosity and water holding capacity of soil (Babulkar et al., 2000). Similar findings were also recorded by Sharma and Sharma (1993).

Saturated Hydraulic Conductivity (SHC) and total Porosity: The SHC of different soil layers increased significantly with increasing levels of FYM (Table 1). The maximum SHC in 0-15 and 15-30 cm soil layers (9.05, 7.91 cm h^{-1}) was found under the treatment F_2 (FYM @ 10 t ha^{-1}) and the minimum (7.05, 6.01 cm h^{-1}) under control (F_0). The application of FYM @ 5 and 10 t ha^{-1} increased the SAC of 0-15 and 15-30 cm soil layers to the extent of 1.33, 1.32 and 2.00, 1.90 cm h^{-1}, respectively as compared to control (F_0). Total porosity of the surface soil (0-15 cm) increased significantly with increasing levels of FYM. The minimum total porosity (41.9%) was obtained under the control (F_0) which increased by 0.6 and 1.8% under application of F_1 (FYM @ 5 t ha^{-1}) and F_2 (FYM @ 10 t ha^{-1}) levels of FYM, respectively. However, in 15-30 cm soil layer the effect of FYM was found non-significant on total porosity. Incorporation of FYM @ 10 t ha^{-1} resulted in an improvement in soil porosity, saturated hydraulic conductivity in surface and sub-surface layers and ultimately increased moisture retention in soil profile, while, decreased soil bulk density. The higher percolation rate with lapse of time under FYM treated plots might be due to an increase in root biomass, better soil aggregation and improvement in mechanical composition of the soil as well as greater proliferation (Bhattacharya et al., 2004).

Table 1: Effect of FYM and mineral nutrients on physical properties of soil at harvest of mustard

Treatment	Bulk density (Mg m^{-3})		Saturated hydraulic conductivity (cm h^{-1})		Total porosity (%)		Moisture retention capacity (%)			
	Soil depth (cm)									
							1/3 bar		15 bar	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
FYM (t ha^{-1})										
F_0	1.51	1.54	7.05	6.01	41.9	40.5	11.1	12.3	2.5	3.0
F_1	1.49	1.53	8.38	7.33	42.5	40.9	11.6	12.9	2.7	3.2
F_2	1.48	1.52	9.05	7.91	43.1	41.4	11.8	13.2	2.8	3.3
SEm+	0.005	0.012	0.121	0.113	0.17	0.47	0.08	0.09	0.03	0.03
CD (P=0.05)	0.01	NS	0.35	0.32	0.5	NS	0.2	0.3	0.1	0.1
Mineral nutrients (kg ha^{-1})										
M_0	1.49	1.53	7.91	6.84	42.4	40.8	11.2	12.6	2.6	3.1
M_1	1.49	1.53	8.15	7.07	42.5	40.9	11.4	12.7	2.6	3.1
M_2	1.49	1.53	8.23	7.16	42.5	40.9	11.5	12.9	2.7	3.2
M_3	1.49	1.53	8.24	7.17	42.5	41.9	11.6	12.9	2.7	3.2
M_4	1.49	1.53	8.26	7.19	42.6	41.2	11.6	13.0	2.7	3.2
SEm±	0.006	0.016	0.16	0.16	0.22	0.61	0.11	0.13	0.04	0.04
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non-significant

Moisture Retention: Moisture retention at 1/3 and 15 bar of different soil layers increased significantly with increasing levels of FYM (Table 1). The maximum moisture retention at 1/3 and 15 bar in 0-15 cm soil layer (11.8, 2.8 %) and in 15-30 cm soil layer (13.2, 3.3 %) was found under the treatment F_2 (FYM @ 10 t ha^{-1}) and the minimum moisture retention at 1/3 and 15 bar in 0-15 cm (11.1, 2.5%) and in 15-30 cm soil layer (12.3, 3.0%) under control (F_0). The application of FYM @ 5 and 10 t ha^{-1} increased the moisture retention at 1/3 of 0-15 and 15-30 cm soil layers to the extent of 4.5 and 6.3 and 4.9 and 7.3 %, respectively as compared to control (F_0). Similarly, the application of FYM @ 5 and 10 t ha^{-1} also increased the moisture retention of soil at 15 bar in 0-15 and 15-30 cm layers to the extent of 8.0 and 12.0 and 6.7 and 10.0 %, respectively over that of control (F_0). FYM enhanced the water retention capacity of soil which might be ascribed to the micro-pores while high rate of water transmission may be associated with the macro-pores of soil as influenced by high organic carbon and better soil aggregation (Mishra and Sharma, 1997). The increase in water retention as a result of FYM application is expected from the aggregation resulting in favourable pore geometry of the soil (Bhattacharya et al., 2004).

Effect of Mineral Nutrients

Application of mineral nutrients on bulk density, saturated hydraulic conductivity, total porosity and moisture retention at 1/3 and 15 bar of both the soil layers at harvest stage of mustard crop were found non-significant.

Table 2: Effect of FYM and mineral nutrients on soil chemical properties at harvest

Treatment	Org. carbon (g ha^{-1})	Avail. N (kg ha^{-1})	Avail. S (kg ha^{-1})	Avail. Zn (mg kg^{-1})	Avail. Fe (mg kg^{-1})
FYM (t ha^{-1})					
F_0	1.74	114.1	14.7	0.40	4.21
F_1	2.24	121.9	21.9	0.43	4.37
F_2	2.39	126.9	22.3	0.45	4.52
SEm+	0.032	1.43	0.28	0.007	0.053
CD (P=0.05)	0.120	4.1	0.8	0.02	0.14
Mineral nutrients (kg ha^{-1})					
M_0	2.10	115.6	14.2	0.39	4.16
M_1	2.11	121.4	20.7	0.41	4.28
M_2	2.16	122.2	21.1	0.45	4.31
M_3	2.13	121.9	20.9	0.44	4.52
M_4	2.19	123.7	21.4	0.45	4.55
SEm±	0.042	1.84	0.36	0.01	0.064
CD (P=0.05)	NS	5.4	1.1	0.03	0.19

NS = Non-significant

Soil chemical properties

Effect of FYM

Organic Carbon: Organic carbon status of the soil at harvest stage of the crop increased significantly with increasing levels of FYM application (Table 2). The maximum organic carbon (2.38 g kg^{-1}) was observed under F_2 (FYM @ 10 t ha^{-1}) and the minimum (1.74 g kg^{-1}) under control (F_0). The application of FYM @ 5 and 10 t ha^{-1} increased the status of organic carbon of soil to the extent of 28.7 and 36.7 %, respectively as compared to control (F_0). It might be perhaps due to addition of FYM which directly adds organic carbon and helps to stimulate the growth and activity of micro-organisms. Higher production of biomass might have also increased the organic carbon content of soil (Babulkar et al., 2000). Similar findings were also observed by Yaduvanshi (2001).

Effect of Mineral Nutrients

The effect of mineral nutrient supplementation was found non-significant on organic carbon content of soil.

Effect of FYM

Available Nutrients (N, S, Zn & Fe): A perusal of the data (Table 2) reveals that available N, S, Zn and Fe content of soil increased significantly with increasing levels of FYM. The maximum available N (126.9 kg ha^{-1}), S (22.3 kg ha^{-1}), Zn (0.45 mg kg^{-1}) and Fe (4.52 mg kg^{-1}) were observed under F_2 (FYM @ 10 t ha^{-1}) and the minimum were under control (F_0). The application of FYM @ 10 t ha^{-1} increased the available N, S, Zn and Fe content of soil to the extent of 11.2, 51.7, 12.7 and 7.4 %, respectively as compared to control (F_0). The significant increase in available nutrient content of the soil after harvest of the crop may ascribe to the beneficial role of FYM in mineralization of native as well as applied nutrients which enhanced the available nutrient pool of the soil. The favorable conditions for microbial as well as chemical activities due to addition of FYM integrated with other nutrients augmented the mineralization of nutrients and ultimately increased the available nutrient status of the soil. These results are in agreement with those of Tiwari et al. (2002).

Effect of Mineral Nutrients

The available N, S, Zn and Fe content of soil was also influenced significantly due to mineral nutrients application (Table 2). The maximum available N, S, Zn and Fe content of soil was observed under treatment M_4 and the minimum under M_0. The application of M_4 (S @ 40 kg ha^{-1} + zinc sulphate @ 25 kg ha^{-1} + ferrous sulphate @ 50 kg ha^{-1}) increased the available N, S, Zn and Fe content of soil to the extent of 7.0, 50.7, 15.4 and 9.4 %, respectively as compared to M_0 (without mineral nutrients). A significant increase in available N in soil due to application of S has also been reported by Patel (1992). The higher S content in soil could be attributed to a greater mineralization of organic S and release of SO_4^{2-} ions on its gradual oxidation. Similar results were also reported by Tiwari et al. (1992). Increase in the available Zn in soil with application of S might be due to ameliorative effect of S and improved physio-chemical properties of soil. Liberation of acids from applied S and its consequent dissolution effect might be one of the reasons for increased availability of Zn in the soil. Increased availability of Zn with S addition has been also observed by Akbari (1990). Application of Zn increased the available N content in soil. It might be due to synergistic effect of Zn on N content in soil. Application of Zn increased the DTPA-Zn content in soil, possibly higher solubility, diffusion and mobility of the applied inorganic Zn fertilizer might be the reason leading to increased Zn status of soil. The results were confirmed by Chatterjee et al. (1983). The application of iron significantly increased the available Fe status of soil at harvest stage of crop (Table 2). The higher solubility, diffusion and mobility of the applied inorganic Zn and Fe fertilizer might be the reason for increased Fe status in soil.

Conclusion

The results of above study can be concluded that in a soil which is deficient in available S, Zn and Fe, the application of FYM significantly improves the physical and chemical properties of soil. However, inorganic fertilizers application could not influence the physical properties and organic carbon of soil but had significant effect on residual fertility of soil.

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