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LONG TERM EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL PHYSICAL INDICES UNDER PEARL MILLET – WHEAT CROPPING SYSTEM

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Abstract

This paper focuses on one of the objective of the study that was to examine the effect of integrated nutrient management (fertilizers and organic manures) on physical properties in soil. The investigation was conducted in soils at Hisar, Haryana. The result concluded that the increase in the value of both hydraulic conductivity and infiltration rate were observed when organic manures were applied in combination with nitrogen and phosphorus fertilizers. The highest value of 0.84 cm hr^{-1} for hydraulic conductivity was recorded in the treatment where fertilizers plus FYM was applied and was found statistically at par with the treatment where fertilizers plus pressmud was applied. In case of infiltration rate, supplying of nutrients through fertilizers along with FYM recorded the highest value of 1.30 cm hr^{-1} followed by pressmud amended treatment (1.10 cm hr^{-1}) and poultry manure amended treatment (0.98 cm hr^{-1}). The magnitude of increase for infiltration rate ranged from 40 to 86 % in organic manures amended treatment over the treatment where half the recommended dose of nitrogen and phosphorus fertilizers was applied. Although, bulk density was found to be invariant with respect to different treatments but a decrease was found in the treatment when FYM plus NP fertilizers were applied. It varied from 1.47 to 1.43 g cc^{-1} in the surface soil layer.

Key words : Fertilizers, hydraulic conductivity, manures, bulk density, infiltration rate.

Introduction

Soil is a fundamental requirement for crop production as it provides plants with water and nutrients. Therefore, soil quality in continuous cropping systems is very important for sustaining agricultural productivity.

The physical indicators of soil play an important role in determining its sustainability for crop production. The physical properties of soil such as bulk density, infiltration rate and hydraulic conductivity are some of the important parameters of soil quality measured under the study.

Soil Organic Carbon (SOC) is the most important indicator of soil quality and sustainability because of its effect on physical, chemical and biological properties of soil and long-term effect have shown the benefit of manures and adequate fertilization into the soil.

Various interpretations reflecting physical properties of soil was suggested by different authors. The present research focuses on long term continuous cropping experiments that can help in attaining sustainability.

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Materials and Methods

A long-term experiment on use of various combinations of organic manures and fertilizers was initiated in 1995 on a coarse loamy, Typic Ustochrepts using a pearl millet-wheat cropping sequence. The site is located between 29°16'N latitude and 75°75'E longitude in north-west part of India. The climate of the experimental area is semi-arid with a mean annual precipitation of 650 mm and mean annual temperature of 24.8°C. The pH (1:2) 8.10, electrical conductivity (EC) 0.36 dSm^{-1}, organic C 0.39 %. Available N, P and K were, respectively, 98.0, 12.6 and 217 mg kg^{-1} at the start of experiment. The average nutrient composition of farmyard manure (FYM), poultry manure and pressmud applied in the experiment during 2014 are given in table 1. The experiment was laid out with the following treatments in a randomized block design with three replications: 75 kg N +30 kg P_2O_5 ha^{-1}, 150 kg N + 60 kg

P_2O_5 ha^{-1}, 15 Mg FYM ha^{-1}, 15 Mg FYM + 150 kg N + 30 kg P_2O_5 ha^{-1}, 5 Mg Poultry manure ha^{-1}, 5 Mg Poultry manure + 150 kg N + 30 kg P_2O_5 ha^{-1}, 7.5 Mg Pressmud ha^{-1}, 7.5 Mg Pressmud + 150 kg N +30 kg P_2O_5 ha^{-1}. The organic manures (FYM, poultry manure, pressmud) were applied once in a year at the time of wheat sowing. The N and P were applied through urea and DAP, respectively. Surface soil samples were collected periodically in triplicate from each treatment to study the changes in P fractions after application of various organic manures during the wheat growth at 24 days interval from the date of sowing up to 120 days. Soil samples were air- dried, ground and sieved (2 mm) for further analysis. Soil samples were analysed for bulk density using core sampler method (Bodman, 1942), hydraulic conductivity using constant head method (Richards, 1954) and infiltration rate using double ring (Bertrand, 1965).

Table 1 : Average composition of various organic manures used.

Organic manure	Organic C	N	P	K
	%			
FYM	40.5	1.27	0.86	1.60
Poultry manure	37.2	2.26	1.40	0.66
Pressmud	48.9	3.20	1.20	0.70

Results and Discussion

The soil bulk density (0-15 cm and 15-30 cm) measured at the harvest of wheat is presented in table 2. It can be seen from the table that there was no significant difference amongst various treatments and comparable contents of soil bulk density were recorded under different treatments. Amongst all treatments, the highest decrease to the tune of 1.43 g cc^{-1} was recorded in FYM at the rate of 15 Mg along with N at the rate of 150 kg plus P at the rate of 30 kg ha^{-1}. The value (1.44 g cc^{-1}) recorded for the treatment with pressmud plus NP fertilizers and poultry manure plus NP fertilizers were found to be at par. Though our study showed the non significant difference amongst the various treatments at both the soil depths but regular incorporation of organic manures with or without fertilizers improved the soil aggregation. This result correlates to the findings of Antil *et al*. (2011) and thereby decreased the bulk density, which in turn increased the saturated hydraulic conductivity and infiltration rate of the soil. The results also correlates to the findings of Yaduvanshi *et al*. (2013) that use of organic manures (FYM or green manure) with inorganic fertilizers significantly improved the bulk density of the 0-15 cm soil layer over inorganic fertilizers treatments that is due to increase in organic carbon, which results in more pore space and good soil aggregation.

Application of fertilizers alone also decreased the bulk density. This could be attributed to the increased biomass production with consequent increase in organic matter content of soil (Selvi *et al*., 1997).

The decrease was observed more pronounced in upper soil layers than in the lower layer, which might be due to the decreased effect of organic materials on soil organic carbon content. This correlates to the findings of Bairwa (2012).

In case of soil hydraulic conductivity as influenced by long-term application of organic manures with or without fertilizers is presented in table 2. Results revealed that increased hydraulic conductivity at both surface and sub-surface soil was observed by the application of organic manures alone or in combination of NP fertilizers over NP fertilizers alone. Higher values of hydraulic conductivity indicated that long-term application of organic manures along with fertilizers had improved the soil structure due to decreased soil bulk density as depicted above.

Amongst the various combinations of organic manures and fertilizers, combination of NP fertilizers with FYM and combination of NP fertilizers with pressmud increased the soil hydraulic conductivity to 0.84 cm hr^{-1} and was statistically at par followed by combination of NP fertilizers with poultry manure (0.76 cm hr^{-1}).

This might be due to improved soil structure, increased organic carbon content and decreased soil bulk density. Yadav and Kumar (2009) also showed that the regular incorporation of organic materials along with chemical fertilizers before puddling of rice improved the soil aggregation and thereby decreased the bulk density, which in turn increased the saturated hydraulic conductivity.

Similar findings have been shown by Kumar *et al.* (2012), who concluded that long-term application of organic materials along with fertilizers had significantly increased the saturated hydraulic conductivity of 0-10, 10-20 and 20-30 cm soil depths and was found highest under the treatment with FYM. Under the treatments with fertilizers alone had also increased the hydraulic conductivity, which might be due to higher root biomass accumulated over the years under fertilized treatments.

Similarly, Sonune *et al*. (2012) reported the significant increase in bulk density and better aggregation, which resulted in increased hydraulic conductivity due to integrated use of FYM and chemical fertilizers.

Table 2 : Long-term effect of fertilizers and organic manures on soil physical properties at different soil depths after 19 cylces of pearl millet-wheat cropping sequence.

Type of manure	Dose(Mg ha^{-1})	Fertilizers (kg ha^{-1})		Bulk density (g cc^{-1})		Hydraulic conductivity (cm hr^{-1})		Infiltration rate (cm hr^{-1})	
		N	P_2O_5	0-15	15-30	0-15	15-30	0-15	15-30
No manures	0	75	30	1.45	1.57	0.60	0.32	0.70	0.67
	0	150	60	1.47	1.53	0.51	0.38	0.87	0.79
FYM	15	0	0	1.44	1.48	0.75	0.46	0.97	0.90
	15	150	30	1.43	1.47	0.84	0.54	1.30	1.00
Poultry manure	5	0	0	1.46	1.48	0.68	0.44	0.95	0.88
	5	150	30	1.44	1.47	0.76	0.50	0.98	0.93
Pressmud	7.5	0	0	1.45	1.48	0.68	0.48	0.96	0.78
	7.5	150	30	1.44	1.48	0.84	0.52	1.10	0.98
LSD (p=0.05)				**NS**	**NS**	**0.19**	**0.06**	**0.31**	**0.15**

Irrespective of the treatments, the rate of increase of hydraulic conductivity in sub-surface layer was less as compared to the surface layer and the influence of organic manures on hydraulic conductivity diminished with increased soil depth. This might be attributed to more accumulation of organic manures and in turn more organic carbon content leading to better aggregation in the surface as compared to the sub-surface.

Infiltration rate is the rate at which water enters into the soil. Organic manures when applied in conjunction with fertilizers had significant (p=0.05) effect on infiltration rate at both soil depths (table 2). However, the effect was less with the application of organic manures alone. Minimum values were recorded in case of NP fertilized treatments. The increase in infiltration rate may attribute to the increase in micropores and macropores in the soil resulting from better aggregation by cementing of soil particles together due to higher Soil Organic Matter and favourable living conditions for soil organisms.

Also, due to improvement in pore size distribution favourable for water infiltration in the soil. Similar finding has been suggested by Bairwa (2012).

Also, Yadav and Kumar (2009) showed that the regular incorporation of organic materials along with chemical fertilizers before puddling of rice improved the soil aggregation and thereby decreased the bulk density, which in turn increased the saturated hydraulic conductivity and infiltration rate of the soil.

At surface soil, the highest (1.30 cm hr^{-1}) was recorded by long-term application of fertilizers supplemented with FYM with an increase of about 34% over the treatment where FYM applied alone. The value recorded under FYM amended treatment was very close to the value recorded under pressmud plus NP fertilizers treatment, *i.e.* 1.10 cm hr^{-1} with an increase of about 15 % over only pressmud applied treatment followed by poultry manure + NP fertilizers treatment with an increase of about 3.16% over only poultry manure applied treatment.

It was observed that application of 100% recommended dose of fertilizers alone also increased infiltration rate by 24% over the treatment where 50% recommended dose of fertilizers was applied. Although the infiltration rate slightly decreased in sub-surface soil layer but the trend followed was similar to that observed in surface soil layer.

The surface soil recorded comparatively high infiltration rate than sub-surface soil. This might be due to more accumulation of organic manures and in turn more organic carbon content leading to better aggregation in the surface as compared to the sub-surface.

Conclusion

The conclusions above shows that upon addition of organic manures there is slow but continuous release of nutrients which affects the crop production.

Hydraulic conductivity of soil depends upon soil pores, which are influenced by soil texture, structure and organic matter.

In case of infiltration rate, the magnitude of increase for infiltration rate ranged from 40 to 86% in organic manures amended treatment over the treatment where half the recommended dose of nitrogen and phosphorus fertilizers was applied.

The increase in the value of both hydraulic conductivity and infiltration rate were observed when organic manures were applied in combination with nitrogen and phosphorus fertilizers. Therefore, addition of organic manures has the potential to improve the soil physical properties.

Soil bulk density indicates the soil physical condition in terms of compaction or looseness of soil and plays an important role in plant growth by affecting the soil porosity, water retention, water movement and root penetration and development. Although, bulk density was found to be invariant with respect to different treatments but was found to improve in the organic manures amended treatments.

It is essential that the experiment should be repeated over time at the same experimental area due to the residual effect of treatments on the succeeding crop to formulate fertilizer recommendations to crops. The management of soils in a sustainable manner through proper nutrient management is essential in preserving and conserving of soil.

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