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Effect of inorganic fertilizers and organic manures on biological properties of soil for wheat grown on Normal and Saline Sodic Inceptisol

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Abstract
The present study entitled, "Effect of inorganic fertilizers and organic manures on biological properties of soil for wheat grown on normal and saline sodic Inceptisol" was conducted at PGI Research farm, Department of Soil Science and Agriculture Chemistry, Post Graduate Institute, M.P.K.V., Rahuri during *Rabi* 2021-2022. Plant analysis for N, P and K uptake was carried out after harvesting of wheat for normal and saline sodic plots. The results showed that, among all the organic manures, better results were observed in the treatment T_7 *i.e* GRDF (120:60:40 $N:P_2O_5:K_2O$ kg ha^{-1}) + 10 t FYM ha^{-1} with respect to microbial population, yield and uptake of NPK by wheat in normal and saline sodic soil.

Keywords: Fertilizers, organic, manures, Saline Sodic Inceptisol

Introduction
Soil is a living system and it is necessary to manage it in agriculture to improve sustainability. Soil health is commonly used term to indicate the capacity of soil to function as a vital living system to sustain biological productivity, promote environmental quality and maintain plant and animal health (Doran and Zeiss, 2000). It is a dynamic and natural body that play crucial role in food security, climate change mitigation and other essential ecosystem services (Smith, 2000). The stagnation in production and productivity of food grains for the past few years has become a matter of concern and is posing a serious threat to our national food security.

Wheat (*Triticum aestivum* L.) is also referred to as "King of cereals", that was originated in South West Asia. It is the world's most important and widely cultivated food crop. Wheat straw is also a good source of feed for cattle and also used in manufacturing of papers, straw boards and other pulp products. Wheat is a good reserve of carbohydrates, minerals and proteins. Wheat procures more attraction in the food market due to its better nutrition values as compared to rice. Wheat contains 68-70 grams of carbohydrate, 12.6 grams of protein, 1.5 grams of total fats, 12.2 grams of dietary fibre and 3.2 mg of iron present in 100 grams of winter wheat. It's contribution of world edible dry matter goes up to 28 per cent and up to 60 per cent of daily calorie intake in several developing countries.

Soil biological activities are widely recognized as an important aspect in nutrient cycling, plant nutrient availability, as well as in the development and maintenance of soil structure and contributing to soil health. Studies of soil biological activities are important as they indicate the potential of soil to support biochemical processes which are essential for the maintenance of soil fertility (Dkhar and Mishra, 1983). The microbial biomass has been used as an index of soil fertility, which depends on nutrient fluxes (Hassink *et al*., 1991). The plant residues affect quantity and quality of organic matter input influences microbial biomass (Wardle, 1992). The biomass itself constitutes the part of soil organic matter and serves as most dynamic pool (Jenkinson, 1988). All the biological reactions are carried out by enzymes. Microbial population is influenced by addition of organic materials which in turn favourably augment beneficial population and their activities *viz*., mineralization of organic residues, organic matter decomposition and availability of nutrients. The nutrition of plants is certainly dependent on composition of soil flora in the rhizosphere. The soil enzymes are the mediators and catalysts of most soil processes, and hence have potential to provide an integrative assessment of soil health.

The soil enzymes increases the rate of reaction of plant that helps in release of nutrients to the plant. Soil enzymes play an important role in agriculture because it catalyses general vital reactions essential for the life processes of soil microorganism, stabilization of soil structure by acting as cementing agent, decomposition of organic wastes, organic matter formation leading to formation of stable aggregates and nutrient cycling.

Agriculture intensification due to heavy use of chemicals has created negative impact on soil and the environment that serves as threat to sustainability (Tilman *et al*., 2011). The overuse of fertilizers not only decreases the fertilizer use efficiency, but also leds to degradation of environment through nutrients runoff and biodiversity loss (Li *et al*., 2015 and Zhang *et al.,* 2012). Mineral fertilizer application decreases the soil pH (Cai, *et al*., 2015) that alters the nutrient availability. The mineral fertilizer fastens the rate of mineralization of soil organic carbon (SOC), that leads to depletion of SOC (Ju *et al*., 2009). Inorganic use of mineral fertilization creates negative impact on the microbial diversity by altering the bacterial and fungal population (Zhang *et al*., 2012). The higher mineral fertilizer application can lead to increase in nitrogen (N) loss as compared to manure application (Martínez *et al*., 2017).

Integrated nutrient supply is the systematic approach to nutrient management due to combined application of organic and inorganic sources that improves the soil fertility and crop productivity (Shree *et al.,* 2014). Mohanty *et al.* (2013), reported a remarkable increase in supply and management strategies for enhancing soil quality, input use efficiency and crop productivity is extremely important for food and nutritional security in Indian agriculture (Swarup, 2010). In India, during the past three decades, intensive agriculture which involves high yielding varieties has led to heavy withdrawal of nutrients from the soil. The organic material holds great promise as a source of multiple nutrients and ability to improve soil characteristics. Soil fertility management plays a vital role in increasing the production of crop. This involves adequate and balanced nutrient supply. Moreover, integrated nutrient management promotes balanced and judicious use of inorganic fertilizers in conjunction with organic manures. Thus, the logical way emerging to manage soil productivity and fertility is integrated use of inorganic and organic sources to address the concern of excess or depletion of nutrients.

Material and Methods

The present investigation was carried out at Post Graduate Institute, Research Farm of Department of Soil Science and Agricultural Chemistry, MPKV, Rahuri (MS). Both the experimental site *viz*. normal and saline sodic plot was uniform and nearly levelled, medium deep black soil and belongs to the soil order Inceptisol.

The experiment consists of eight treatments *viz*., T_1: RDN (50% N) + 50% N through FYM, T_2: RDN (50% N) + 50% N applied through vermicompost, T_3: RDN (50% N) + 50% N applied through poultry manure, T_4: (50% N) + 50% N applied through press mud compost, T_5: (50% N) + 50% N applied through goat manure, T_6: (50% N) + 50% N applied through urban compost, T_7: GRDF (120:60:40 N:P_2O_5:K_2O kg ha^{-1}) + 10 t FYM ha^{-1} and T_8: absolute control. These treatments were replicated thrice in randomized block design. The soil samples were collected and analyzed at 0, 30, 60 DAS and at harvest for soil biological properties.

In terms of climate, the experimental site falls under semi-arid tropics having an average rainfall of 519 mm per year. It was observed that the mean maximum temperature ranged between 24.7 and 39.7 °C while, the mean minimum temperature ranged between 12.0 and 24.9 °C. The relative humidity during morning and evening ranged between 52 to 93 per cent and between 12 to 54 per cent, respectively. The temperature prevailing during sowing and growth period was favourable for crop growth. In general, the climatic conditions were favourable for crop growth and there was no serious incidence of pest and disease.

The soil of the experimental field of both the plots *viz*. normal and saline-sodic were clayey in texture, Bulk density of normal soil was 1.34 (Mg m^{-3}) and for saline sodic soil 1.49 was (Mg m^{-}. The soil was slightly alkaline in reaction having pH (8.34) in normal soil and (8.42) in saline sodic soil. The EC of normal soil 0.28 dSm^{-1} and for saline-sodic soil 1.02 dSm^{-1}, organic carbon content was (0.41%) and (0.45%) respectively and $CaCO_3$ content was (6.23%) and (9.35%) respectively. The fertility status of soil initially showed low available N (184.2 and 192.1 kg ha^{-1}) for normal soil and saline-sodic soil respectively and available P for normal soil (14.28 kg ha^{-1}) and for saline-sodic (13.21 kg ha^{-1}) respectively. Whereas, the soils were high in available K (387.2 kg ha^{-1}) for normal soil and (359.4 kg ha^{-1}) for saline-sodic soil. The soil was sufficient in micronutrients content (Fe, Mn, Zn and Cu). The heavy metals were in traces. Initial fungal population recorded in normal soil was 7.09 (cfu x 10^4 g^{-1} soil) while in saline sodic soil it was, 6.22 (cfu x 10^4 g^{-1} soil). Initial bacterial population recorded in normal soil was 10.66 (cfu x 10^7 g^{-1} soil) and in saline sodic soil it was 15.00 (cfu x 10^7 g^{-1} soil). Initial actinomycetes count recorded in normal soil and saline sodic soil was 4.90 and 7.30 (cfu x 10^6 g^{-1} soil) respectively.

Observations Recorded

The data pertaining to initial and periodic analysis of biological parameters *viz*., fungi(cfu x 10^4 g^{-1} soil), bacteria (cfu x 10^7 g^{-1} soil) and actinomycetes population (cfu x 10^6 g^{-1} soil), urease (mg NH4+ - N 100 g^{-1}), acid and alkaline phosphatase (µg PNP g^{-1} soil hr^{-1}), dehydrogenase (µg TPF g^{-1} soil hr^{-1}) and β-Glucosidase enzyme (PNP g^{-1} soil hr^{-1}), grain and straw yield (q ha^{-1}), and N, P and K (kg ha^{-1}) uptake were recorded during the experiment.

Result and discussion

The application of GRDF (120:60:40 N:P_2O_5:K_2O kg ha^{-1}) + 10 t FYM ha^{-1} (T_7) recorded significantly the highest total fungal population of normal soil at 30 DAS, 60 DAS and at harvest (13.66, 28.00, 24.00 cfu x 10^4 g^{-1} soil,) respectively. In saline sodic soil at 30 DAS, 60 DAS and at harvest respectively, the highest total fungal population (11.90, 25.00 and 19.66 cfu x 10^4 g^{-1} soil respectively) was recorded in the treatment T_7.

The application of GRDF (120:60:40 N:P_2O_5:K_2O kg ha^{-1}) + 10 t FYM ha^{-1} (T_7) recorded significantly the maximum increase in bacterial population of normal soil at 30 DAS, 60 DAS and at harvest (26.33, 32.33, 27.00 cfu × 10^7 g^{-1} soil, respectively) whereas in saline sodic soil at 30 DAS, 60 DAS and at harvest (31.00, 42.00, 35.00 cfu x 10^7 g^{-1} soil) was the significantly the highest recorded bacterial population. The population count of bacteria was found to be more in saline sodic soil as compared to normal soil.

The treatment T_7 *i.e* GRDF (120:60:40 N:P_2O_5:K_2O kg ha^{-1}) + 10 t FYM ha^{-1} recorded significantly the highest (20.00, 35.16, 23.33 cfu x 10^7 g^{-1} soil, respectively) actinomycetes population in normal soil at 30 DAS, 60 DAS and at harvest respectively. The saline sodic soil at 30 DAS, 60 DAS and at harvest (23.66, 38.86, 26.33 cfu x 10^7 g^{-1} soil respectively) recorded the highest actinomycetes population in the treatment T_7.

The urease activity was significantly influenced by organic manures in combination with inorganic fertilizers and recorded the highest values of urease activity in treatment T_3 *i.e* RDN (50% N) + 50% N applied through poultry manure in normal soil at 30 DAS, 60 DAS and at harvest. In saline sodic soil, the conjoint use of organic manures and mineral fertilizers might have favored significantly to increase the highest urease activity in soil (26.00 at 30 DAS, 34.67 at 60 DAS and 46.76 mg NH4+-N 100 g^{-1} soil at harvest respectively) in treatment T_3 *i.e* RDN (50% N) + 50% N application through poultry manure.

The enzyme activities were significantly influenced by combined application of organic and inorganic sources to wheat crop and recorded the highest value of dehydrogenase activity in treatment T_2 *i.e* RDN (50% N) + 50% N applied through vermicompost, in normal soil at 30 DAS, 60 DAS and at harvest (28.90, 37.27, 45.20 µg TPF g^{-1} soil hr^{-1}, respectively followed by the treatment T_7. The saline sodic soil recorded highest dehydrogenase activity at 30 DAS, 60 DAS and at harvest (26.53, 34.93, 41.60 µg TPF g^{-1} soil hr^{-1}, respectively) was recorded in T_2 followed by T_7.

The highest values of ß-glucosidase activity was recorded in treatment T_4 with the application of RDN (50% N) + 50% N through press mud compost and in normal soil at 30 DAS, 60 DAS and at harvest (15.93, 16.07, 16.00 mg PNP g^{-1} soil hr^{-1}, respectively). In saline sodic soil, the highest values of ß-glucosidase activity at 30 DAS, 60 DAS and at harvest (16.23, 18.90, 17.30 mg PNP g^{-1} soil hr^{-1}, respectively).

The acid phosphatase activity significantly increased in normal soil in comparison to saline sodic soil with the combined application of organic and inorganic sources. Normal soil recorded the significantly the highest (14.67, 16.00 and 14.76 µg PNP g $soil^{-1}$ hr^{-1}) values of acid phosphatase activity in treatment T_7 *i.e* GRDF (120:60:40 $N:P_2O_5:K_2O$ kg ha^{-1})+ 10 t FYM ha^{-1}. The highest acid phosphatase activity (14.00, 15.80 and 14.67 µg PNP g^{-1} soil hr^{-1}) in saline sodic soil was recorded in treatment T_7.

The application of treatment T_3 *i.e* RDN (50% N) + 50% N through poultry manure, in normal soil as well as in saline sodic soil, observed the significantly the highest alkaline phosphatase activity at 30 DAS, 60 DAS and at harvest (27.43, 34.49, 40.63 (µg PNP g^{-1} soil hr^{-1}), (28.18 35.97, 46.00 (µg PNP g^{-1} soil hr^{-1}) respectively.

The yield of wheat was significantly influenced by organic and inorganic sources and recorded the significantly the highest grain yield (27.87. q ha^{-1}) and straw yield (41.00 q ha^{-1}) in the treatment T_7 for normal soil. In saline sodic soil, the significantly the highest grain yield (34.43 q ha^{-1}) and straw yield (44.02 q ha^{-1}) was recorded in treatment (T_7) with the application of GRDF (120:60:40 $N:P_2O_5:K_2O$ kg ha^{-1}) + 10 t FYM ha^{-1}. The lowest grain yield was recorded in control T_8 for all the growth stages in both the soil types The yield obtained from saline sodic plot was higher than that obtained from normal soil plot. Application of NPK, in combination with organic manures, significantly increased the total NPK uptake of wheat over control. The significantly the highest uptake of total N (88.00 kg ha^{-1}), total P (16.00 kg ha^{-1}) and total K (100.00 kg ha^{-1}) was obtained in treatment T_7 which received the dose of (GRDF (120:60:40 $N:P_2O_5:K_2O$ kg ha^{-1}) + 10 t FYM ha^{-1}) in normal soil and in saline sodic soil the significantly the highest uptake of total N (93.36 kg ha^{-1}) total P (17.20 kg $ha^{-1)}$ and total K (103.00 kg ha^{-1}) was recorded in T_7. The yield and uptake of saline sodic soil was higher as compared to normal soil.

Table 1: Effect of inorganic fertilizers and organic manures on yield and growth parameters of wheat in normal and saline sodic Inceptisol

Tr. No.	Treatments	Normal Soil					Saline Sodic Soil				
		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Test weight (gm)	Plant height (cm)	Spike length (cm)	Grain weight (kg ha^{-1})	Straw weight (kig ha^{-1})	Test weight (gm)	Plant height (cm)	Spike length (cm)
T_1	RDN (50% N) + 50% N through FYM	24.34	27.61	39.44	78	6.67	25.61	39.04	37.82	80	6.8
T_2	RDN (50% N) + 50% N through vermicompost	24.33	32.05	40.67	85	7.17	31.69	40.67	38.97	87	7.19
T_3	RDN (50% N) + 50% N through Poultry manure	26.33	40.23	41.88	85	7.33	34.17	42.12	40.61	86	9.40
T_4	RDN (50% N) + 50% N through Press mud compost	24.34	28.62	42.34	86	7.50	30.00	38.67	40.96	88	7.50
T_5	RDN (50% N) + 50% N through Goat manure	23.00	29.65	40.97	84	6.75	29.78	40.02	39.57	86	6.75
T_6	RDN (50% N) + 50% N through Urban compost	27.81	40.00	42.56	89	9.17	30.99	42.53	40.94	89	8.17
T_7	GRDF (120:60:40 $N:P_2O_5:K_2O$ kg ha^{-1})+ 10 t FYM ha^{-1}	27.87	41.00	43.72	92	9.92	34.43	44.02	42.40	91	9.82
T_8	Absolute control	11.00	18.07	31.50	65	4.33	16.63	28.81	32.62	68	5.31
	S.Em. ±	0.66	1.81	0.64	2.14	0.18	1.22	1.23	0.47	0.15	0.19
	CD at 5%	2.03	5.45	1.93	6.4	0.55	3.63	3.68	1.47	0.45	0.57

Table 2: Effect of inorganic fertilizers and organic manures on N, P and K uptake by wheat grown in normal and saline Sodic Inceptisol

Tr. No.	Treatments	Normal Soil			Saline Sodic Soil		
		Uptake (kg ha^{-1})					
		N	P	K	N	P	K
T_1	RDN (50% N) + 50% N through FYM	74.44	9.24	80.81	95.88	10.90	86.00
T_2	RDN (50% N) + 50% N through vermicompost	63.85	10.46	84.06	77.13	15.68	88.00
T_3	RDN (50% N) + 50% N through Poultry manure	86.48	14.00	90.10	97.59	15.39	96.00
T_4	RDN (50% N) + 50% N through Press mud compost	68.01	11.70	91.61	74.31	14.92	93.00
T_5	RDN (50% N) + 50% N through Goat manure	55.68	10.66	79.51	59.56	10.04	87.00
T_6	RDN (50% N) + 50% N through Urban compost	85.92	10.40	94.70	73.20	13.41	100.00
T_7	GRDF (120:60:40 $N:P_2O_5:K_2O$ kg ha^{-1})+ 10 t FYM ha^{-1}	88.00	16.00	100.00	99.36	17.20	103.00
T_8	Absolute control	33.06	4.45	41.25	38.50	5.88	69.31
	S.Em. ±	0.94	0.66	2.21	1.1	1.14	3.05
	CD at 5%	2.82	2.03	6.63	3.3	3.52	9.16

Conclusion

3. Among all the organic manures, better results were observed in the treatment T_7 *i.e* GRDF (120:60:40 $N:P_2O_5:K_2O$ kg ha^{-1}) + 10 t FYM ha^{-1} with respect to microbial population, yield and uptake of NPK by wheat in normal and saline sodic soil. The yield of saline sodic soil obtained was higher compared to normal soil.

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