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Soil Biological Properties as Influenced by Organic and Inorganic Source of Nutrients in Wheat (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was conducted during *Rabi* season of 2020-21 and 2021-22 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur (Rajasthan) to study the impacts of organic and inorganic source of nutrients on soil biological properties in Typic Haplustepts soil of Sub-humid Southern Plain and Aravalli Hills Region in Rajasthan. The experiment was laid out according to factorial Randomized Block Design with three replications. The treatments consisting of four levels of organic source of nutrients (control, 2 t EC/ha + two foliar spray of seaweed extract @ 5%, 4 t EC/ha + two foliar spray of seaweed extract @ 10 % and 6 t EC/ ha+ two foliar spray of seaweed extract @ 15%) and four levels of inorganic source of nutrients (control, 50% RDF + two foliar spray of Nano Zn 0.5%, 75% RDF + two foliar spray of Nano Zn 0.5% and 100% RDF + two foliar spray of Nano Zn 0.5%) were applied to the wheat var. Raj-3077 as soil application with uniform application of nitrogen, phosphorus and potassium as per the recommended doses.

Key words : *Organic, Inorganic, Soil characteristics, Inorganic fertilizers, Organic fertilizers*

Introduction

Wheat (*Triticum aestivum*) is one of the most important staple food crops of the world, occupying 17 per cent (one sixth) of crop acreage worldwide, feeding about 40 per cent (nearly half) of the world population and provide 20 per cent (one fifth) of the total food calories and protein in human nutrition. In India, it is grown in an area of 31.35 million hectare with the total production of 107.86 million tonnes and productivity of 3440 kg ha^{-1} (Anonymous, 2020). In Rajasthan, it is grown in an area of 31.18 lac ha with the production of 109.16 lac tonnes and productivity 3501 kg ha^{-1}, respectively (Anonymous, 2020).

The conversion of agricultural residues into value-added compost and its incorporation in soil with cheap nutrient sources *viz*., rock phosphate improves the crops productivity as well as soil quality (Gaind *et al.*, 2006). Organic nutrient is considered a valuable organic fertilizer, supplying nutrients for the crop and hence saving substantial amount if mineral fertilizes (Erhart *et al*., 2005). Organic nutrient besides supplying plant nutrients, add a sufficient amount of organic matter to the soil, which helps in improving the biological properties of the soil.

Seaweed extracts isolated from seaweeds, which contain a wide range of macronutrient and microelement nutrients and organic components such as growth hormones, amino acids, vitamins, betaines, cytokinins, and sterols (Khan *et al*., 2009) have played an important role in the development of the environment-friendly crops planting system (Calvo *et al*., 2014). In general, seaweed extracts can induce changes in the physiological/biochemical process in agriculture associated with nutrient uptake and growth of plants.

Materials and Methods

Experimental site and soil: The experiment was laid out at Institutional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur during *Rabi* season of 2020-21 and 2021-22. The Rajasthan College of Agriculture, Udaipur, Udaipur is situated at an altitude of 579.5 metres above mean sea level and at $24^0 34'$ North latitude and $73^0 42'$ East longitude. This region falls under agro-climatic zone-IVa (Sub- humid Southern Plain and Aravalli Hills) of Rajasthan. Soil of the experimental site was clay loam in texture, alkaline in pH (8.25±0.16), electrical conductivity is normal (0.63±0.01dS/m), medium in organic carbon (0.62±0.01%), low in available N (272.13±5.45 kg/ha), available P_2O_5 (17.55±0.32 kg/ha), and high in available K_2O (353.23±7.12 kg/ha).

Experimental design and treatments: The experiment was laid out in factorial randomized block design and replicated thrice in the plot size of 1.8 m×3.0m ($5.4m^2$). The treatments comprised of four levels of organic nutrients, viz. control, 2 t enriched compost ha^{-1} + two foliar spray of seaweed extract @ 5 %, 4 t enriched compost ha^{-1} + two foliar spray of seaweed extract @ 10% and 6 t enriched compost ha^{-1} + two foliar spray of seaweed extract @ 15% and four levels of inorganic nutrients (kg/ha), viz. control, 50% RDF + two foliar spray of Nano Zn 0.5%, 75% RDF+ two foliar spray of Nano Zn 0.5% and 100% RDF + two foliar spray of Nano Zn 0.5%.

Statistical analysis: The data recorded for different parameters were analyzed with the help of analysis of variance (ANOVA) technique for a factorial randomized block design. The results are presented at 5% level of significance (P=0.05).

Results and Discussion

Alkaline phosphatase activity and dehydrogenase activity

Effect of organic source of nutrients: The application of increasing levels of organic nutrients significantly increased the alkaline phosphatase activity and dehydrogenase activity in soil over control (Table 1). The maximum value of alkaline phosphatase activityanddehydrogenase activity (178.00 µg PNP g^{-1} soil h^{-1} and 14.05 µg TPF g^{-1} soil h^{-1}) in soil after harvest of the wheat crop was obtained under ON_3 (6 t enriched compost ha^{-1} + two foliar spray of seaweed extract @ 15%) which was significantly superior over the ON_2 (4 t enriched compost ha^{-1}+ two foliar spray of seaweed extract @ 10%) and ON_1 (2 t enriched compost ha^{-1} + two foliar spray of seaweed extract @ 5%) treatments as well as control (ON_0) in pooled analysis, respectively. The per cent increase the alkaline phosphatase activity in soil were in order of 35.62, 29.95 and 16.61 and dehydrogenase activity in soil were in order of 41.73, 34.44 and 16.95 in pooled analysis due to application of 6, 4 and 2 t enriched compost ha^{-1} + two foliar spray of seaweed extract as compared to control (ON_0), respectively. Thedehydrogenase enzyme activity is commonly used as an indicator of biological activity in soils. It is might be due to increased microbial activity as a result of increased availability of organic carbon by phospho-enriched compost (Meena and Biswas 2015). The soil microbial respiration is strongly linked to soil enzyme activity, indicating the intensity of soil metabolic processes and providing important information about nutrients cycling in the soil (Dsouza *et al.*, 2018).

Effect of inorganic source of nutrients: The application of inorganic nutrients with foliar spray of Nano Zn significantly increased the alkaline phosphatase activity and dehydrogenase activity in soil over control (Table 1). The maximum value of alkaline phosphatase activity and dehydrogenase activity (177.49 µg PNP g^{-1} soil h^{-1} and 14.03 µg TPF g^{-1} soil h^{-1}) in soil were recorded under ION_3 (100% RDF + two foliar spray of Nano Zn 0.5%) which was significantly superior over ION_2 (75% RDF + two foliar spray of Nano Zn 0.5%) and ION_1 (50% RDF + two foliar spray of Nano Zn 0.5%) treatments as well as control (ION_0) in pooled basis, respectively. The per cent increase the alkaline phosphatase activityin soil were in order of 35.22, 30.32 and 16.56 and dehydrogenase activity in soil were in order of 41.05, 34.64 and 15.78 in pooled analysis due to application of100% RDF + two foliar spray of Nano Zn 0.5% (ION_3), 75% RDF + two foliar spray of Nano Zn 0.5%(ION_2) and 50% RDF + two foliar spray of Nano Zn 0.5% (ION_1) as compared to control (ION_0), respectively. Parewa *et al.* (2014) reported that the dehydrogenase and phosphatase enzyme activity of soil after the harvest of wheat were improved significantly due to the integration of inorganic fertilizers with FYM and bio-inoculation.

Soil microbial biomass carbon

Effect of organic source of nutrients: The application of increasing levels of organic nutrients significantly increased the soil microbial biomass carbon in soil (Table 1). The maximum value of soil microbial biomass carbon (195.35 mg/kg) in soil was obtained under ON_3 (6 t enriched compost ha^{-1} + two foliar spray of seaweed extract @ 15%) followed by ON_2 (4 t enriched compost ha^{-1}+ two foliar spray of seaweed extract @ 10%) and ON_1 (2 t enriched compost ha^{-1} + two foliar spray of seaweed extract @ 5%) treatments as well as control (ON_0) in pooled analysis, respectively. The per cent increase in soil microbial biomass carbon in soil were in the order of 16.15, 9.91 and 3.00 in pooled analysis due to application of 6, 4 and 2 t enriched compost ha^{-1} + two foliar spray of seaweed extract as compared to control (ON_0), respectively. The amount of soil microbial biomass carbon increased significantly due to incorporation of organic source of nutrients in to soil. In general, there was an increase in microbial growth and activities of enzymes with the addition of carbon substrate and declined as the available carbon exhausted (Manna and Ganguly, 2000) as microbial carbon were positively correlated with soil organic matter. The increase insoil microbial biomass carbon might also is due to reduction in pH, electrical conductivity and exchangeable sodium percentage of soil on account of addition of organic material (Meena and Biswas, 2015). The computation of biomass turnover can predict the flux of plant nutrients and the size at plant nutrient pool supplied by microbial biomass turnover in the soil (Dsouza *et al.,* 2018).

Effect of inorganic source of nutrients: The soil microbial biomass carbon in soil after harvest of the wheat crop was significantly affected by application of inorganic nutrients with foliar spray of Nano Zn (Table 1). The maximum value of soil microbial biomass carbon (195.17 mg/kg) in soil was recorded under ION_3 (100% RDF + two foliar spray of Nano Zn 0.5%) followed by ION_2 (75% RDF + two foliar spray of Nano Zn 0.5%) and ION_1 (50% RDF + two foliar spray of Nano Zn 0.5%) treatments as well as control (ION_0) in pooled basis, respectively. The per cent increase in soil microbial biomass carbon in soil were in order of 15.99, 9.91 and 2.97 in pooled analysis due to application of 100% RDF + two foliar spray of Nano Zn 0.5% (ION_3), 75% RDF + two foliar spray of Nano Zn 0.5%(ION_2) and 50% RDF + two foliar spray of Nano Zn 0.5% (ION_1) as com-

Table 1. Effect of organic and inorganic source of nutrients on alkaline phosphatase activity, dehydrogenase activity and soil microbial biomass carbon of soil after harvest of wheat

Treatments	Alkaline phosphatase activity (µg PNP g^{-1} soil h^{-1})			Dehydrogenase activity (µg TPF g^{-1} soil h^{-1})			Soil microbial biomass carbon (mg kg^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Organic nutrients (t ha^{-1})									
Control (ON_0)	129.82	132.66	131.24	9.74	10.09	9.92	166.40	169.97	168.19
2 (ON_1)	151.40	154.68	153.04	11.41	11.79	11.60	171.40	175.08	173.24
4 (ON_2)	168.73	172.36	170.54	13.12	13.54	13.33	182.89	186.80	184.85
6 (ON_3)	176.11	179.88	178.00	13.84	14.27	14.05	193.30	197.41	195.35
SEm ±	2.172	2.216	1.105	0.173	0.176	0.088	1.056	1.077	0.537
CD (P=0.05)	6.274	6.400	3.126	0.500	0.510	0.249	3.049	3.110	1.519
Inorganic nutrients (kg ha^{-1})									
Control (ION_0)	129.84	132.69	131.26	9.78	10.12	9.95	166.47	170.05	168.26
50% RDF+ foliar spray of Nano Zn 0.5% (ION_1)	151.36	154.64	153.00	11.28	11.76	11.52	171.41	175.09	173.25
75% RDF+ foliar spray of Nano Zn 0.5% (ION_2)	169.24	172.88	171.06	13.24	13.55	13.40	182.98	186.89	184.93
100% RDF + foliar spray of Nano Zn 0.5% (ION_3)	175.61	179.37	177.49	13.82	14.25	14.03	193.12	197.23	195.17
SEm ±	2.172	2.216	1.105	0.173	0.176	0.088	1.056	1.077	0.537
CD (P=0.05)	6.274	6.400	3.126	0.500	0.510	0.249	3.049	3.110	1.519

pared to control (ION_0), respectively. The microbial biomass carbon increased with increase in dose of inorganic fertilizers, may be due firstly to increase in microbial population (Parewa *et al.*, 2014). The higher value of microbial biomass C (MBC), microbial biomass N (MBN) and was found with the application NPK+ FYM (Meena *et al.*, 2012).

Soil microbial population

Effect of organic source of nutrients: The application of organic nutrients significantly increased microbial population in soil over control (Table 2). The maximum value of bacteria, fungi and actinomycetes population (76.63, 26.37 and 42.00cfu/g) in soil was obtained under ON_3 (6 t enriched compost ha^{-1} + two foliar spray of seaweed extract @ 15%) followed by ON_2 (4 t enriched compost ha^{-1}+ two foliar spray of seaweed extract @ 10%) and ON_1 (2 t enriched compost ha^{-1} + two foliar spray of seaweed extract @ 5%) treatments as well as control (ON_0) in pooled analysis, respectively. The increased microorganism population might be due to addition of organic carbon in the form of phospho-enriched compost turn provides adequate biomass as nourish for the microbes and helps in increasing microbial population in soil (Mali *et al.*, 2017).

Effect of inorganic source of nutrients: The increasing levels of inorganic nutrients with foliar spray of Nano Zn significantly increased microbial population in soil over control (Table 2). The highest value of bacteria, fungi and actinomycetes population (76.03, 25.96 and 40.76cfu/g) in soil were recorded under ION_3 (100% RDF + two foliar spray of Nano Zn 0.5%) followed by ION_2 (75% RDF + two foliar spray of Nano Zn 0.5%) and ION_1 (50% RDF + two foliar spray of Nano Zn 0.5%) treatments as well as control (ION_0) in pooled basis, respectively. However, the increase was significant up to ION_2 during both the years as well as in pooled analysis which was found statistically at par with ION_3. Parewa *et al.* (2014) reported that application of increasing levels of fertilizer increased the bacteria and fungi population in rhizosphere soil significantly up to 100 % NPK (Meena *et al.*, 2021) reported that application of 100% RDF+ 1st spray of Nano Zn at 14 DAS + 2nd spray of Nano Zn at 28 DAS resulted in highest bacterial (78.54 CFU x 10^6) and fungi (34.25 CFU x 10^4) population in soil after harvest of wheat crop.

Conclusion

On the basis of experimental finding, it can be concluded that the application ofenriched compost @ 6 t ha^{-1} + two foliar spray of seaweed extract @ 15% and 100% RDF + two foliar spray of Nano Zn 0.5% along with their commended doses of fertilizer re-

Table 2. Effect of organic and inorganic source of nutrients on soil microbial population of soil after harvest of wheat

Treatments	Soil microbial population (cfu g^{-1})								
	Bacteria			Fungi			Actinomycetes		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Organic nutrients (t ha^{-1})									
Control (ON_0)	62.30	63.80	63.05	21.88	22.57	22.22	33.50	34.42	33.96
2 (ON_1)	67.77	69.37	68.57	23.11	23.83	23.47	36.88	37.87	37.37
4 (ON_2)	72.75	74.46	73.60	24.79	25.54	25.17	38.87	39.90	39.39
6 (ON_3)	75.75	77.51	76.63	25.98	26.75	26.37	41.46	42.54	42.00
SEm ±	0.939	0.958	0.477	0.320	0.326	0.163	0.494	0.504	0.251
CD (P=0.05)	2.711	2.766	1.351	0.923	0.942	0.460	1.426	1.455	0.710
Inorganic nutrients (kg ha^{-1})									
Control (ION_0)	62.32	63.81	63.06	21.85	22.53	22.19	33.62	34.54	34.08
50%RDF+ foliar spray of Nano Zn 0.5% (ION_1)	66.64	68.22	67.43	23.02	23.73	23.38	36.94	37.93	37.44
75%RDF+ foliar spray of Nano Zn 0.5% (ION_2)	74.46	76.20	75.33	25.32	26.07	25.69	39.91	40.96	40.44
100%RDF+ foliar spray of Nano Zn 0.5% (ION_3)	75.15	76.91	76.03	25.58	26.34	25.96	40.23	41.29	40.76
SEm ±	0.939	0.958	0.477	0.320	0.326	0.163	0.494	0.504	0.251
CD (P=0.05)	2.711	2.766	1.351	0.923	0.942	0.460	1.426	1.455	0.710

sults insignificantly, higher biological properties, i.e. alkaline phosphatase activity, dehydrogenase activity, soil microbial biomass carbon, bacteria, fungi and actinomycetes population in soil after harvest of wheat cropin Typic Haplustepts soil of Sub-humid Southern Plain and Aravalli Hills Region in Rajasthan.

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