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Nutrient status of soil as influenced by micronutrients fortified humic substance

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Abstract
A Field experiment was conducted during *Kharif* 2017 at College of Agriculture, Vishweshwaraiah Canal Farm, Mandya. The experiment was laid out following RCBD with 10 treatments replicated thrice. The humic substance was extracted from FYM incubated with and without micronutrients and designated as enriched humic substance (EHS) and humic substance (HS), respectively. EHS and HS was tested at two levels i.e., 2.5 and 5 litres ha^{-1} using maize as test crop. The results revealed that no significant differences were observed on pH, electrical conductivity and organic carbon content of soil after the harvest of maize. But, T_{10} treatment (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) recorded significantly higher available N, P_2O_5 K_2O and micronutrients (Fe, Mn, Zn and Cu) content (279.19, 116.57, 187.80 kg ha^{-1}, 9.30, 5.81, 1.20 and 0.94 mg kg^{-1}, respectively) and also higher exchangeable Ca and Mg (7.87 and 3.87 (c mol (p+) kg^{-1}, respectively). Significantly higher available sulphur (35.53 mg kg^{-1}) content was recorded for T_{10} treatment over control. Whereas all the nutrients were observed to be lower for the treatment with RDF alone (T_1).

Keywords: Nutrient, micronutrients, humic substance

Introduction

Presently, soils are over-cropped, abused, mishandled and exhausted of organic matter and some essential elements. Soil health is an urgent factor for acknowledging higher production of crops. Excessive and sub optimum application of chemical fertilizers without organic manures may affect soil health and manageable efficiency. So addition of organic manures, which can supplement necessity of yields to some degree, discharge nutrients in a slow and controlled way and enhance production of some crops without much impact on the environment. Organic matter is considered as the “Life of soil” because of its importance in maintaining soil fertility, the depletion of the same will turn into a noteworthy risk to sustenance security in the years to come. Thus, there is a need to improve the soil fertility in a sustainable manner by utilizing the locally available organic wastes as these wastes contains substantial amount of nutrients which are necessary for the plant growth in addition to maintaining of soil health. Utilization of these organic wastes as a source of nutrients reduces the dependence on chemical fertilizers and these organic wastes provides substantial quantity of nutrient elements as well as humus which helps in improving the physical, chemical and biological properties of soil.

Humus is the final product of the microbial disintegration of organic matter and it shapes a noteworthy part of organic matter. It is generally much steady and genuinely impervious to facilitate fast breakdown. Segments of humus are oxidized or mineralized and afterward used by plants. Humic substances have both direct and indirect consequences for plant development (Sangeetha *et al*., 2006) [1]. It enhances the physical, chemical and biological properties of the soil and impacts plant development. It maintains soil structure, helping with exchanging the supplements from the soil to the plant, upgrades the water maintenance, improves seed germination, enhances water holding capacity, root penetration and increases microorganisms population in the soils.

Micronutrients have received a lot of significance in crop generation during these years due to their inadequacies in various parts of the nation. Keeping in mind the end goal to upgrade soil nutrient status, enrichment of humic substance with micronutrients can be an alternative and can improve fertilizer value of humic substance. In this manner including enrichment humic substance as soil application is the principle advantage that the soil will have the capacity to retain and supply the nutrients more effectively.

Hence, considering the above facts, an attempt has been made to test the effect of micronutrients enriched humic substance on soil properties using maize as test crop and the present work was carried out.

Material and Methods

A field experiment was conducted during Kharif 2017 at B block, College of Agriculture, V. C. Farm, Mandya to study the effect of humic substance enriched with micronutrients on soil properties. Soil of the experimental site (Table 1) was sandy loam in texture and neutral in reaction with pH 7.28. Electrical conductivity was 0.41 dS m^{-1} and organic carbon status was found to be high (9.80 g kg^{-1}). The available nitrogen status was low (242.06 kg ha^{-1}), phosphorus was high (107.72 kg $P_2O_5 ha^{-1}$) and potassium was medium (213.54 kg K_2O ha^{-1}). The exchangeable Ca and Mg status was adequate and the available sulphur status was high. Among the micro nutrients boron status was in deficient range while Fe, Mn, Zn and Cu were sufficient.

Table 1: Initial soil properties of the experimental plot

Parameters		Values
Particle size distribution	Sand (%)	69.24
	Silt (%)	23.88
	Clay (%)	6.88
	Texture	Sandy loam
pH (1:2.5)		7.28
EC (dS m^{-1}) (1:2.5)		0.41
OC (g kg^{-1})		9.80
Available Nitrogen (kg ha^{-1})		242.06
Available Phosphorus (kg ha^{-1})		107.72
Available Potassium (kg ha^{-1})		213.54
Exchangeable Calcium (c mol (p+) kg^{-1})		7.50
Exchangeable Magnesium (c mol (p+) kg^{-1})		3.80
Available Sulphur (mg kg^{-1})		26.50
DTPA-Iron (mg kg^{-1})		8.32
DTPA-Manganese (mg kg^{-1})		5.78
DTPA-Copper (mg kg^{-1})		0.81
DTPA-Zinc (mg kg^{-1})		0.94
Boron (mg kg^{-1})		0.38

Calculated amount of FYM was incubated with and without micronutrients separately for two weeks and the humic substance was extracted from the FYM with and without micronutrients separately following the method proposed by Schnitzer and Skinner (1968) [2]. The per cent humic substance present in the HS and EHS extracts was determined by gravimetric method and it was found to be 1.70% and 1.80%, respectively. The content of humic substance in both the materials was concentrated to 10% by evaporating the moisture and used for the experiment.

Treatment details

T_1: RDF (150:75:40 kg ha^{-1} NPK)
T_2: RDF + FYM @ 10 t ha^{-1}
T_3: T_2 + HS @ 2.5 L ha^{-1} as basal
T_4: T_2 + HS @ 5 L ha^{-1} as basal
T_5: T_2 + HS @ 2.5 L ha^{-1}30 DAS
T_6: T_2 + HS @ 5 L ha^{-1}30 DAS
T_7: T_2 + EHS @ 2.5 L ha^{-1} as basal
T_8: T_2 + EHS @ 5 L ha^{-1} as basal
T_9: T_2 + EHS @ 2.5 L ha^{-1} 30 DAS
T_{10}: T_2 + EHS @ 5 L ha^{-1}30 DAS

- RDF: Recommended Dose of Fertilizers-50% N + 100% P and K as basal dose and 25% N each, one at 20 DAS and another at 30 DAS
- $ZnSO_4$@ 10 kg $ha^{-1}$is common for all the treatments except T_1
- HS: Humic Substance without micronutrients enrichment
- EHS: Humic Substance with micronutrients enrichment

Results and Discussion

Soil properties after harvest of maize

The soil properties *viz*., pH, EC, OC and available nutrient status of soil at harvest were assessed and the results are given in Table 2 to 5.

Changes in pH, EC and organic carbon status of soil

No significant differences were observed due to various treatments on pH, electrical conductivity and organic carbon content of soil after the harvest of maize. However, higher and lower soil pH values (7.31 and 7.17, respectively) were recorded in treatment T_6 (T_2 + HS @ 5 L ha^{-1}30 DAS and T_1 (RDF alone). Higher and same EC (0.46 dS m^{-1}) and organic carbon values (1.03%) were recorded in treatments T_{10} (T_2 + Enriched HS @ 5 L ha^{-1}30 DAS) and T9 (T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS). Whereas lower EC (0.37 dS m^{-1}) and organic carbon values (0.96%) were recorded in treatment T_1 (RDF alone).

Available N, P_2O_5 and K_2O status of soil

The effect of various treatments on available N, P_2O_5 and K_2O status of soil after the harvest of maize are presented in Table 3. Among the different treatments, T_{10} treatment (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) recorded significantly higher available N, P_2O_5 and K_2O content (279.19, 116.57 and 187.80 kg ha^{-1}, respectively) followed by treatment T_9 (T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS) (277.01, 115.56 and 185.76 kg ha^{-1}, respectively). Whereas lower available N, P_2O_5 and K_2O content (249.06, 96.00 and 168.13 kg ha^{-1}, respectively) were recorded for the treatment with RDF alone (T_1).

Exchangeable Ca, Mg and available sulphur status of soil

The effect of various treatments on exchangeable Ca, Mg and available sulphur status of soil after the harvest of maize are presented in Table 4. Among the different treatments, T_{10} treatment (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) recorded significantly higher exchangeable Ca and Mg (7.87 and 3.87 (c mol (p+) kg^{-1}), respectively) followed by treatment T_6 (T_2 + HS @ 5 L ha^{-1} 30 DAS) (7.67 and 3.77 (c mol (p+) kg^{-1}), respectively). Whereas lower exchangeable Ca and Mg (7.13 and 3.23 (c mol (p+) kg^{-1}, respectively) was recorded for the treatment with RDF alone (T_1).

Significantly higher available sulphur (35.53 mg kg^{-1}) content was recorded for T_{10} treatment over control and it was followed by treatment T_8 (T_2 + Enriched HS @ 5 L ha^{-1} as basal) (34.77 mg kg^{-1}). Whereas lower available sulphur (25.20 mg kg^{-1}) was recorded for the treatment with RDF alone (T_1).

Available micronutrients (Fe, Mn, Zn and Cu) status of soil

The effects of various treatments on available micronutrients (Fe, Mn, Zn and Cu) content of soil after the harvest of maize are presented in Table 5. Among the different treatments, T_{10} treatment (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) recorded significantly higher available micronutrients (Fe, Mn, Zn and Cu) content (9.30, 5.81, 1.20 and 0.94 mg kg^{-1}, respectively) followed by treatment T_8 (T_2 + EHS @ 5 L ha^{-1} as basal) (9.11, 5.70, 1.13and 0.91 mg kg^{-1}, respectively). Whereas lower available micronutrients (Fe, Mn, Zn and Cu) content

(7.96, 5.14, 0.79and 0.67 mg kg^{-1}, respectively) was recorded for the treatment with RDF alone (T_1).
The soil pH, electrical conductivity and organic carbon content varied non-significantly due to the effect of humic substance enriched with micronutrients. Similar trends were obtained by Haroon *et al.* (2010). Whereas application of various treatments significantly increased all the nutrients content of soil at harvest of maize. Further, increase in the available nutrients content were recorded in the enriched treatments (T_7 to T_{10}) when compared to corresponding non enriched treatments (T_3 to T_6) and there was also increase in available nutrients content with 30 DAS treatments compared to corresponding basal treatments.
Humic acid are mainly produced from nitrogenous compounds containing decomposed amino acids and aromatic complexes and these organic complexes can improve nutrient availability (Lee and Bartlette, 1976) [3].

Table 2: Effect of humic substance enriched with micronutrients on pH, EC and organic carbon status of soil at harvest.

Treatments		pH (1:2.5)	EC (dS m^{-1})	OC (%)
T_1	RDF (150:75:40 kg NPK ha^{-1})	7.17	0.37	0.96
T_2	RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}	7.18	0.39	0.98
T_3	T_2 + HS @ 2.5 L ha^{-1} as basal	7.27	0.42	1.00
T_4	T_2 + HS @ 5 L ha^{-1} as basal	7.29	0.45	1.01
T_5	T_2 + HS @ 2.5 L ha^{-1}30 DAS	7.29	0.43	1.01
T_6	T_2 + HS @ 5 L ha^{-1}30 DAS	7.31	0.45	1.02
T_7	T_2 + Enriched HS @ 2.5 L ha^{-1} as basal	7.25	0.43	1.00
T_8	T_2 + Enriched HS @ 5 L ha^{-1} as basal	7.26	0.45	1.02
T_9	T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS	7.28	0.46	1.02
T_{10}	T_2 + Enriched HS @ 5 L ha^{-1}30 DAS	7.29	0.46	1.02
	S. Em±	0.188	0.021	0.014
	CD at 5%	NS	NS	NS

Table 3: Effect of humic substance enriched with micronutrients on available N, P_2O_5 andK_2O status of soil at harvest.

Treatments		Av-N (kg ha^{-1})	Av-P_2O_5 (kg ha^{-1})	Av-K_2O (kg ha^{-1})
T_1	RDF (150:75:40 kg NPK ha^{-1})	249.06	96.00	168.13
T_2	RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}	254.41	100.15	171.20
T_3	T_2 + HS @ 2.5 L ha^{-1} as basal	251.18	102.03	173.18
T_4	T_2 + HS @ 5 L ha^{-1} as basal	267.25	105.91	175.07
T_5	T_2 + HS @ 2.5 L ha^{-1}30 DAS	272.21	109.22	176.77
T_6	T_2 + HS @ 5 L ha^{-1}30 DAS	276.19	108.12	176.76
T_7	T_2 + Enriched HS @ 2.5 L ha^{-1} as basal	262.91	112.72	177.65
T_8	T_2 + Enriched HS @ 5 L ha^{-1} as basal	274.32	113.68	182.29
T_9	T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS	277.01	115.56	185.76
T_{10}	T_2 + Enriched HS @ 5 L ha^{-1}30 DAS	279.19	116.57	187.80
	S. Em±	1.666	2.268	4.003
	CD at 5%	4.950	6.740	11.894

Table 4: Effect of humic substance enriched with micronutrients on exchangeable Ca, Mg and available sulphur status of soil at harvest.

Treatments		Exch. Ca (c mol (p+) kg^{-1})	Exch. Mg (c mol (p+) kg^{-1})	Available-S (mg kg^{-1})
T_1	RDF (150:75:40 kg NPK ha^{-1})	7.13	3.23	25.20
T_2	RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}	7.43	3.47	27.12
T_3	T_2 + HS @ 2.5 L ha^{-1} as basal	7.47	3.50	30.31
T_4	T_2 + HS @ 5 L ha^{-1} as basal	7.57	3.60	31.20
T_5	T_2 + HS @ 2.5 L ha^{-1}30 DAS	7.60	3.67	30.90
T_6	T_2 + HS @ 5 L ha^{-1}30 DAS	7.67	3.77	31.83
T_7	T_2 + Enriched HS @ 2.5 L ha^{-1} as basal	7.53	3.57	33.76
T_8	T_2 + Enriched HS @ 5 L ha^{-1} as basal	7.57	3.67	34.77
T_9	T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS	7.63	3.70	34.00
T_{10}	T_2 + Enriched HS @ 5 L ha^{-1}30 DAS	7.87	3.87	35.53
	S. Em±	0.101	0.102	0.761
	CD at 5%	0.301	0.304	2.262

Table 5: Effect of humic substance enriched with micronutrients on available micronutrients (mg kg^{-1}) status of soil at harvest.

Treatments		Fe	Mn	Zn	Cu
T_1	RDF (150:75:40 kg NPK ha^{-1})	7.96	5.14	0.79	0.67
T_2	RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}	8.22	5.25	0.83	0.70
T_3	T_2 + HS @ 2.5 L ha^{-1} as basal	8.46	5.30	0.87	0.73
T_4	T_2 + HS @ 5 L ha^{-1} as basal	8.71	5.36	0.90	0.79
T_5	T_2 + HS @ 2.5 L ha^{-1}30 DAS	8.54	5.33	0.88	0.76
T_6	T_2 + HS @ 5 L ha^{-1}30 DAS	8.80	5.39	0.93	0.80

T_7	T_2 + Enriched HS @ 2.5 L ha^{-1} as basal	9.00	5.62	0.97	0.85
T_8	T_2 + Enriched HS @ 5 L ha^{-1} as basal	9.11	5.70	1.13	0.91
T_9	T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS	9.05	5.67	1.05	0.87
T_{10}	T_2 + Enriched HS @ 5 L ha^{-1}30 DAS	9.30	5.81	1.20	0.94
	S. Em±	0.262	0.116	0.049	0.038
	CD at 5%	0.778	0.345	0.147	0.114

Increase in humic substances application rates decreases nutrients leaching which was reflected in increasing macro and micronutrients concentration in soil after the harvest of tubers was reported by Selim *et al.* (2009) [4]. Susilawati *et al*. (2009) [5] doubted that the application of both humic and fulvic acids may be effective in promoting NH_4^+ retention and will have greater ability in controlling NH_3 loss, thereby retaining NH_4^+ which further increased its availability to plants. Inadvertent accretion of micronutrients through HS might have increased the microbial activity in the soil and thus increased the nutrient availability. Increase in nutrient availability from less soluble hydroxides, particularly iron, zinc and manganese due to increase in degree of polymerization and P fixation capacity reduced by formation of organomineral complex with HA due to removal of charges balancing aluminium hydroxyl species (Chen *et al*., 2004) [6].

Conclusion and practical utility

Humic substance extracted from farm yard manure incubated with micronutrients can be used as a rich nutrient source in improving soil nutrient sources. From the results obtained, it can be concluded that the use enriched humic substance along with RDF and FYM increased all the nutrient status especially micronutrients. The treatment T_{10} (T_2 + Enriched HS @ 5 L ha^{-1}30 DAS) was found better in terms of improving nutrient status of soil.

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