Int.J.Curr.Microbiol.App.Sci (2020) Special Issue-10: 521-532

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Special Issue-10 pp. 521-532
Journal homepage: http://www.ijcmas.com

Original Research Article

Impact of Disparate Levels of Humic Substance Enriched with Micronutrients on Productivity and Cultivation Economics of Maize

R. Sagar[1*], G.G. Kadalli[2], M.S. Vivek[3] and M.M. Irfan[4]

[1]Department of Soil Science and Agricultural Chemistry, College of Agriculture, Mandya, University of Agricultural Sciences, Bengaluru, India
[2]Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru
[3]Department of Soil Science and Agricultural Chemistry, [4]Department of Agronomy, University of Agricultural and Horticultural Sciences, Shivamogga, India

***Corresponding author**

A B S T R A C T

The experiment was conducted during *Kharif* 2017 at College of Agriculture, Vishweshwaraiah Canal Farm, Mandya with a major aim to increase the yield and in turn to enhance the net returns by the means of application of disparate levels of humic substance enriched with selected micronutrients. The humic substance required for the experiment was extracted using 0.1 N NaOH from FYM with and without micronutrients and designated as enriched humic substance (EHS) and humic substance (HS), respectively. EHS and HS was tested at two disparate levels i.e., 2.5 and 5 liters ha^{-1} at basal and 30 DAS combinations. The results revealed that among the different treatments, T_{10} treatment (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) recorded significantly higher yield parameters and yield such as cob length, number of grains per row, grain (76.22 q ha^{-1}) and stover yield (103.71 q ha^{-1}) and it was followed by treatment receiving RDF + FYM along with EHS @ 2.5 L ha^{-1} 30 DAS. Whereas lower was recorded for the treatment with RDF alone (T_1). Higher gross returns (Rs. 150941), net returns (Rs. 108432) and cost benefit ratio (3.55) were also recorded in treatment getting RDF + FYM along with EHS @ 5 L ha^{-1} 30 DAS and lower gross returns (Rs. 111038), net returns (Rs. 75151) and cost benefit ratio (3.09) were recorded in treatment getting RDF alone.

Keywords

Humic substance, Micronutrients, Productivity, Cultivation, Economics of maize

Introduction

Humic substance (HS) plays a major part in sustaining soil fertility and productivity. It enhances the soil's physical, chemical and biological properties and impacts plant growth. Utilization of these as a source of nutrients reduces the dependence on chemical fertilizers and also provides substantial quantity of nutrient elements. It maintains soil structure, helps in the exchange of nutrients from the soil to the plant, improves the water holding capacity. Humic substance however isn't a fertilizer, yet considered as complementary to fertilizer (Mackowiak *et al.,* 2001). In recent years, soil scientists, agronomists and farmers understood the significance of keeping up the humus content of soils as an aim to improve the productivity. Use of bulky organic manures as an organic matter source has considered as a burden by the farmers as it requires vast labour for transportation and application to soil. Additionally, use of bulky organic manures brings about spreading of weed seeds in land and control of weeds would likewise be a major issue. In this situation, extraction of humic substances from massive organic manures and their utilization may help in to take care of numerous issues related with utilization of bulky organic manures.

Researchers from all of the states in the country have reported critical response in yields of numerous crops due to micronutrients application. Thus micronutrients have gotten a great importance in crop growth during these years because of their deficiencies in different parts of the country. Keeping this in mind the end goal to upgrade the growth and yield of maize, humic substance can be an alternative and utilized as a supplement to chemical fertilizers. Enrichment of humic substance with micronutrients can improve fertilizer value of humic substance. In this manner including enrichment humic substance as soil application is the principle advantage that the plant will have the capacity to retain and use the nutrients in solution more effectively.

Among cereals, maize (*Zea mays* L.) is an essential food and feed crop which positions third after wheat and rice on the planet. It is a crop having high return potential and called by the name queen of cereal crop. This product has substantially higher grain protein content than our staple food rice. India is the fifth biggest producer of maize on the planet contributing 3 for each penny of the worldwide generation. The area and production of maize in India is 9.4 million ha and 23 million tones, respectively (Anon., 2015). In Karnataka maize is grown in an area of 1.28 million ha with a production of 4.08 million tonnes (Anon., 2014). The crop is chiefly cultivated for commercial purpose with different uses. Thus, crop is having immense request from diversified part, which makes it to exploit under various agro procedures.

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

Materials and Methods

A field experiment was conducted during *Kharif* 2017 at College of Agriculture, V. C. Farm, Mandya to study the influence of humic substance enriched with micronutrients on micronutrients content and uptake by maize (Fig. 1). 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 (0.38 mg kg^{-1}) while Fe, Mn, Zn and Cu were sufficient (8.32, 5.78, 0.94, 0.81 mg kg^{-1}, respectively).

Calculated amount of FYM was incubated with and without micronutrients separately for two weeks and the humic substance was extracted using 0.1 N NaOH following the method proposed by Schnitzer and Skinner (1968) from FYM with and without micronutrients separately and designated as enriched humic substance (EHS) and humic substance (HS), respectively (Fig. 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

Growth parameters

The data on plant height, number of leaves ($plant^{-1}$) and leaf area (cm^2 $plant^{-1}$) of maize as influenced by application of humic substance enriched with micronutrients at different growth stages are presented in the Tables 2 and 3.

Plant height (cm)

There was a significant difference on plant height due to treatments at different growth stages of maize (Table 2). At 30 DAS, application of EHS @ 5 L ha^{-1} as basal (T_8) recorded significantly higher plant height (74.87 cm) over control followed by EHS @ 2.5 L ha^{-1} (T_7) as basal (73.60 cm). Whereas, treatment with EHS @ 5 L ha^{-1} applied 30 DAS (T_{10}) recorded significantly higher plant height (204.20, 212.67 and 212.80 cm, respectively) over all other treatments followed by treatment with EHS @ 2.5 L ha^{-1} (T_9) applied 30 DAS (197.67, 208.47 and 208.67 cm, respectively) during all growth stages of maize starting from 60 DAS. Lower plant height was recorded for treatment with RDF alone (T_1) during all growth stages of maize (62.66, 181.20, 189.60 and 190.40 cm, respectively).

Number of leaves ($plant^{-1}$)

There was a significant difference on number of leaves ($plant^{-1}$) due to treatments at different growth stages of maize (Table 2). At 30 DAS, application of EHS @ 5 L ha^{-1} as basal (T_8) recorded significantly higher number of leaves (8.00) over control (T_1) and it was on par with treatment getting EHS @ 2.5 L ha^{-1} (T_7) as basal (7.93). Whereas, treatment with EHS @ 5 L ha^{-1} applied 30 DAS (T_{10}) recorded significantly higher number of leaves (12.47, 14.47 and 13.27, respectively) over control (T_1) and it was on par with EHS treatment @ 2.5 L ha^{-1} (T_9) applied 30 DAS (11.93, 13.73 and 12.60, respectively) during all growth stages of maize starting from 60 DAS.

Significantly lower numbers of leaves were recorded for treatment with RDF alone (T_1) during all growth stages of maize (6.33, 9.93, 11.47 and 10.47, respectively).

Leaf area (cm^2 $plant^{-1}$)

There was a significant difference on leaf area due to treatments at different growth stages of maize (Table 3). At 30 DAS, application of EHS @ 5 L ha^{-1} as basal (T_8) recorded significantly higher leaf area (3124.53 cm^2 $plant^{-1}$) over all other treatments followed by EHS @ 2.5 L ha^{-1} (T_7) as basal (3066.90 cm^2 $plant^{-1}$). Whereas, treatment with EHS @ 5 L ha^{-1} applied 30 DAS (T_{10}) recorded significantly higher leaf area (6989.83, 7006.00 and 6173.56 cm^2 $plant^{-1}$, respectively) over all other treatments followed by treatment with EHS @ 2.5 L ha^{-1} (T_9) applied 30 DAS (6893.96, 6895.67 and 5993.05 cm^2 $plant^{-1}$, respectively) during all growth stages of maize starting from 60 DAS. Significantly lower leaf area was recorded for treatment with RDF alone (T_1) during all growth stages of maize (2354.14, 6308.17, 6327.56 and 5417.33 cm^2 $plant^{-1}$, respectively).

Application of varied levels of humic substance enriched with micronutrients at different intervals significantly increased the plant height, number of leaves and leaf area compared to treatment that received only recommended dose of fertilizer (T_1) and treatment with RDF + FYM @ 10 t ha^{-1} (T_2) during all growth stages of maize. This may be due to better cell division, cell elongation and increased chlorophyll content, physiological processes like photosynthetic activity due to increase in the amount of nitrogen and magnesium supplied which contributed to greater growth (Thakur *et al.*, 2013).

Further, increase in the growth was 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 growth with 30 DAS treatments compared to corresponding basal treatments. This was because of the additional supplement of micronutrients like Fe through enriched HS that might have contributed to formation of chlorophyll thus increased the photosynthetic activity and growth.

In addition, supplement of micronutrients such as Mn, Cu and Zn might have boosted the growth. Similar observations were recorded by Manas *et al.,* (2014) who reported that application of humic acid exhibited an increase in growth due to increase in nitrogen and chlorophyll contents in the leaves. Highest plant height, number of leaves $plant^{-1}$, leaf area and number of branches $plant^{-1}$ were observed in treatment receiving application of HA fortified with Zn and B. Turan *et al.,* (2011) also reported that the soil application of humic substance at 25 kg ha^{-1} was significantly effective on growth of maize.

Yield and yield parameters

The yield parameters of maize such as cob length, cob girth, number of rows per cob, number of grains per row, test weight, grain yield and stover yield as influenced by different treatments are presented in Table 4 and 5.

Cob length

There was a significant difference on cob length due to treatments at harvest of maize (Table 4 and Fig 3). Among the different treatments, T_{10} treatment (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) recorded significantly highest cob length (20.33 cm) over all the treatments followed by T_9 treatment (T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS) (19.10 cm). Significantly lower cob length was recorded for the treatment with RDF alone (14.45 cm) followed by RDF + FYM @ 10 t ha^{-1} (14.90 cm).

Cob girth

No significant differences were observed due to various treatments on cob girth. However, it ranged from 14.85 cm (RDF alone) to 18.37 cm (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS).

Number of rows per cob

No significant differences were observed due to various treatments on number of rows per cob. However, it ranged from 13.27 (RDF alone) to 16.07 (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS).

Number of grains per row

There was a significant difference on number of grains per row due to treatments at harvest of maize (Table 4). Among the different treatments, T_{10} treatment (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) recorded significantly highest number of grains per row (36.87) followed by T_9 treatment (T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS) (36.13). Significantly lower number of grains per row (33.93) were recorded for the treatment with RDF alone (T_1) followed by RDF + FYM @ 10 t ha^{-1} (34.27).

Test weight

No significant differences were observed due to various treatments on test weight. However, it ranged from 32.06 g (RDF alone) to 34.40 g (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS).

Grain and stover yield

There was a significant difference on grain and stover yield due to treatments at harvest of maize (Table 15). Among the different treatments, T_{10} treatment (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) recorded significantly highest grain and stover yield (76.22 and 103.71 q ha^{-1}, respectively), it was on par with T_9 treatment (T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS) (73.83 and 101.54 q ha^{-1}, respectively). Significantly lower grain and stover yield (59.21 and 88.53 q ha^{-1}, respectively) were recorded for the treatment with RDF alone (T_1) followed by RDF + FYM @ 10 t ha^{-1} (61.69 and 90.67 q ha^{-1}, respectively).

Per cent increase in grain yield over Control

The data pertaining to per cent increase in yield over control, T_2 (RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}) is presented in Table 5. Higher per cent increase in yield over T_2 was recorded in the treatment T_{10} treatment (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) (23.55 %) followed by T_9 (T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS) (19.76 %). Among the humic substance treated plots, lowest increase (3.27 %) over control was observed in treatment T_3 with RDF + FYM + HS @ 2.5 L ha^{-1} as basal.

Application of humic substance enriched with micronutrients to soil at different levels significantly increased the cob length, number of grains per row, grain and stover yield and non-significant differences were observed for cob girth, number of rows per cob and test weight. Further, increase in the yield was 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 the yield with 30 DAS treatments when compared to corresponding basal treatments. Significantly higher yield and yield parameters were recorded in treatment T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS followed by T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS compared to RDF (T_1) alone and RDF + FYM 10 t ha^{-1}. This may be due to formation of stable soluble complexes of humic substances with nutrient metal ions which are made available to the plants over a period lead to higher growth and growth parameters which was mainly associated with the proportionate increase in the yield and yield parameters. Sharif *et al.,* (2002) observed that, about 20 to 23 per cent in shoot and 32 to 39 per cent in root dry weight of maize plants was increased with the addition of HA when compared to control. Govindaswamy and Ravikumar (2002) revealed that the soil application of humic acid along with $FeSO_4$ and $ZnSO_4$ recorded the highest yield of cane (131 t ha^{-1}) and sugar (19.62 t ha^{-1}) thereby enhancing the yield of cane and sugar by 18.6 and 26.2 per cent, respectively over control. Similar findings were also reported by Ehab *et al.,* (2015) in dry bean and Tuba Arjumend *et al.,* (2015) in wheat.

Economics of maize crop production

The data regarding cost economics of maize production is presented in Table 6. The benefit cost ratio was calculated to evaluate the economics of maize crop under different treatments imposed. Higher gross returns (Rs. 150941) was recorded in T_{10} (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS followed by T_9 (T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS) (Rs. 146649). The least (Rs. 111038) gross returns was recorded in T_1 receiving only RDF. The higher net returns were recorded (Rs. 108432) in T_{10} followed by T_9 treatment (Rs. 104144). The least net returns were recorded (Rs. 75151) in T_1 receiving RDF alone. The higher B: C ratio of 3.55 was recorded in T_{10} treatment followed by T_9 (3.45). Whereas the least B: C ratio (2.99) was observed in T_2 receiving RDF + FYM.

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

Table.2 Effect of humic substance enriched with micronutrients on plant height and number of leaves of maize at different stages

Treatments		Plant height (cm)				Number of leaves ($plant^{-1}$)			
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	RDF (150:75:40 kg NPK ha^{-1})	62.66	181.20	189.60	190.40	6.33	9.93	11.47	10.47
T_2	RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}	64.93	182.67	192.60	193.00	7.47	10.07	11.60	10.40
T_3	T_2 + HS @ 2.5 L ha^{-1} as basal	70.80	183.53	194.47	194.75	7.53	10.33	11.80	10.93
T_4	T_2 + HS @ 5 L ha^{-1} as basal	73.53	184.87	197.33	197.40	7.60	10.93	12.13	11.27
T_5	T_2 + HS @ 2.5 L ha^{-1} 30 DAS	64.33	194.07	204.47	204.80	7.53	11.20	12.33	11.40
T_6	T_2 + HS @ 5 L ha^{-1} 30 DAS	64.13	196.40	207.87	208.00	7.47	11.27	12.60	11.80
T_7	T_2 + Enriched HS @ 2.5 L ha^{-1} as basal	73.60	186.13	196.27	196.53	7.93	11.53	13.00	12.00
T_8	T_2 + Enriched HS @ 5 L ha^{-1} as basal	74.87	194.40	206.47	206.60	8.00	11.87	13.13	12.27
T_9	T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS	64.20	197.67	208.47	208.67	7.47	11.93	13.73	12.60
T_{10}	T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS	64.13	204.20	212.67	212.80	7.60	12.47	14.47	13.27
	S. Em±	**0.84**	**1.42**	**1.23**	**1.24**	**0.11**	**0.36**	**0.26**	**0.29**
	CD at 5%	**2.58**	**4.24**	**3.73**	**3.73**	**0.32**	**1.08**	**0.78**	**0.87**

Table.3 Effect of humic substance enriched with micronutrients on leaf area of maize at different growth stages

Treatments		Leaf area (cm^2 $plant^{-1}$)			
		30 DAS	**60 DAS**	**90 DAS**	**At harvest**
T_1	RDF (150:75:40 kg NPK ha^{-1})	2354.14	6308.17	6327.56	5417.33
T_2	RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}	2561.87	6433.96	6466.46	5572.15
T_3	T_2 + HS @ 2.5 L ha^{-1} as basal	2747.30	6515.32	6525.99	5613.81
T_4	T_2 + HS @ 5 L ha^{-1} as basal	3053.73	6677.99	6673.52	5760.26
T_5	T_2 + HS @ 2.5 L ha^{-1} 30 DAS	2562.83	6739.19	6736.31	5895.75
T_6	T_2 + HS @ 5 L ha^{-1} 30 DAS	2564.03	6854.67	6869.12	5978.01
T_7	T_2 + Enriched HS @ 2.5 L ha^{-1} as basal	3066.90	6693.73	6696.90	5773.37
T_8	T_2 + Enriched HS @ 5 L ha^{-1} as basal	3124.53	6761.58	6789.89	5907.74
T_9	T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS	2565.30	6893.96	6895.67	5993.05
T_{10}	T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS	2555.13	6989.83	7006.00	6173.56
	S. Em±	**16.58**	**18.54**	**9.85**	**11.39**
	C. D. at 5%	**49.54**	**55.62**	**29.27**	**33.83**

Table.4 Effect of humic substance enriched with micronutrients on yield parameters of maize at harvest

Treatments		Cob length (cm)	Cob girth (cm)	No of rows per cob	No of grains per row	Test weight (g)
T_1	RDF (150:75:40 kg NPK ha^{-1})	14.45	14.85	13.27	33.93	32.06
T_2	RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}	14.90	15.40	13.67	34.27	32.68
T_3	T_2 + HS @ 2.5 L ha^{-1} as basal	15.43	16.36	13.87	34.43	32.91
T_4	T_2 + HS @ 5 L ha^{-1} as basal	17.10	16.87	14.47	34.77	33.21
T_5	T_2 + HS @ 2.5 L ha^{-1} 30 DAS	18.47	17.39	14.73	35.27	33.31
T_6	T_2 + HS @ 5 L ha^{-1} 30 DAS	18.94	17.85	15.67	35.53	33.60
T_7	T_2 + Enriched HS @ 2.5 L ha^{-1} as basal	17.26	16.92	14.53	34.87	33.17
T_8	T_2 + Enriched HS @ 5 L ha^{-1} as basal	17.90	17.36	14.73	35.47	33.36
T_9	T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS	19.10	17.56	15.73	36.13	33.71
T_{10}	T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS	20.33	18.37	16.07	36.87	34.40
S. Em±		**0.24**	**0.74**	**0.68**	**0.54**	**0.42**
CD at 5%		**0.71**	**NS**	**NS**	**1.60**	**NS**

Table.5 Effect of humic substance enriched with micronutrients on grain and stover yield of maize at harvest

Treatments		Yield (q ha^{-1})		Per cent increase in grain yield over T_2
		Grain	**Stover**	
T_1	RDF (150:75:40 kg NPK ha^{-1})	59.21	88.53	-4.02
T_2	RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}	61.69	90.67	--
T_3	T_2 + HS @ 2.5 L ha^{-1} as basal	63.71	92.48	+ 3.27
T_4	T_2 + HS @ 5 L ha^{-1} as basal	65.75	96.58	+ 6.58
T_5	T_2 + HS @ 2.5 L ha^{-1} 30 DAS	67.24	98.69	+ 8.99
T_6	T_2 + HS @ 5 L ha^{-1} 30 DAS	71.13	101.30	+ 15.30
T_7	T_2 + Enriched HS @ 2.5 L ha^{-1} as basal	64.96	96.81	+ 5.30
T_8	T_2 + Enriched HS @ 5 L ha^{-1} as basal	67.59	99.60	+ 9.56
T_9	T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS	73.83	101.54	+ 19.76
T_{10}	T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS	76.22	103.71	+ 23.55
S. Em±		**1.40**	**1.92**	**--**
CD at 5%		**4.28**	**5.75**	**--**

Table.6 Economics of maize cultivation due to effect of humic substance enriched with micronutrients

Treatments		Cost of cultivation (Rs. per ha)	Gross returns (Rs. per ha)	Net returns (Rs. per ha)	B:C ratio
T_1	RDF (150:75:40 kg NPK ha^{-1})	35,887	111038	75151	3.09
T_2	RDF (150:75:40 kg NPK ha^{-1}) + FYM @ 10 t ha^{-1}	42,037	125532	83495	2.99
T_3	T_2 + HS @ 2.5 L ha^{-1} as basal	42,508	129063	86555	3.04
T_4	T_2 + HS @ 5 L ha^{-1} as basal	42,510	133765	91256	3.15
T_5	T_2 + HS @ 2.5 L ha^{-1} 30 DAS	42,508	136757	94249	3.22
T_6	T_2 + HS @ 5 L ha^{-1} 30 DAS	42,510	143219	100710	3.37
T_7	T_2 + Enriched HS @ 2.5 L ha^{-1} as basal	42,505	132853	90348	3.13
T_8	T_2 + Enriched HS @ 5 L ha^{-1} as basal	42,509	137667	95158	3.24
T_9	T_2 + Enriched HS @ 2.5 L ha^{-1} 30 DAS	42,505	146649	104144	3.45
T_{10}	T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS	42,509	150941	108432	3.55

Fig.1 General view of experimental plot

Fig.2 HS extracted from FYM enriched without (a) and with micronutrients (b)

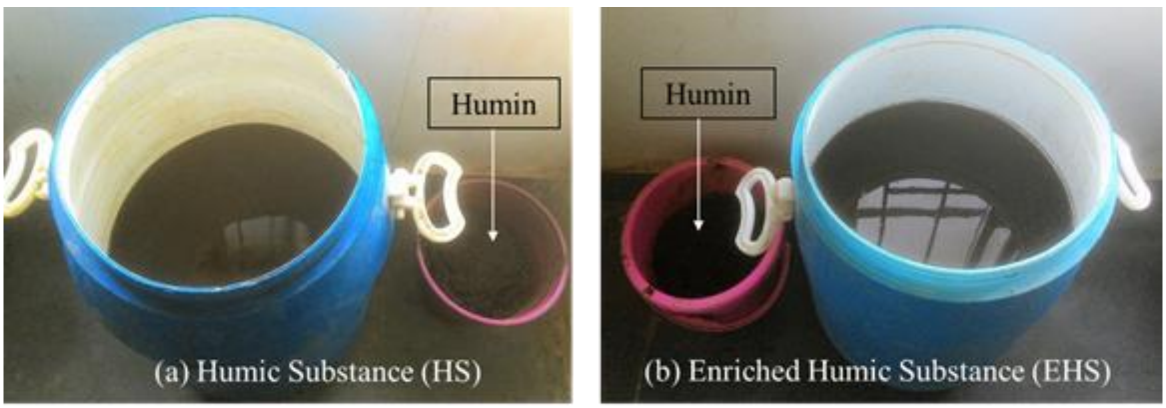
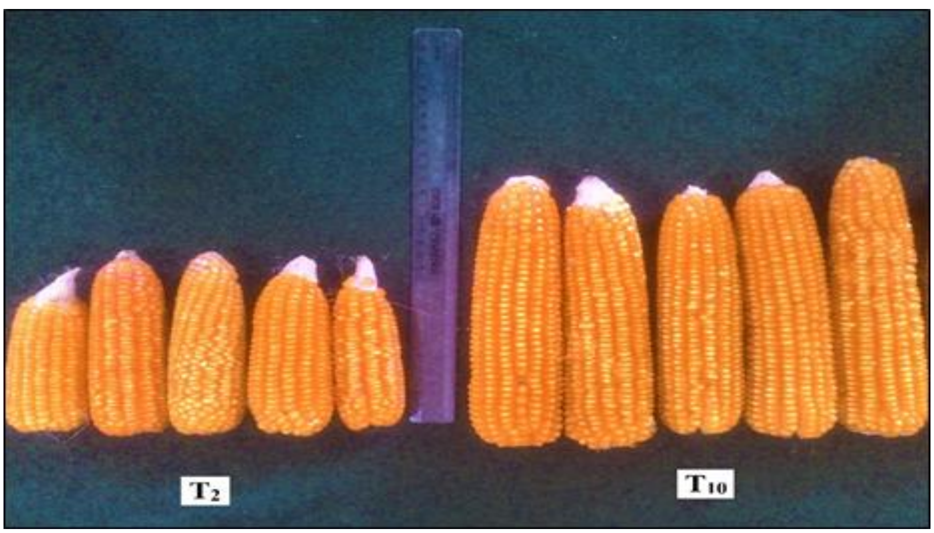


Fig.3 Effect of treatments on cob length of maize



Conclusion and practical utility is as follows:

Humic substance enriched with micronutrients can be used as a rich nutrient source in enhancing productivity thereby it increases the net returns. From the results obtained, it can be concluded that the use enriched humic substance @ 5 L ha^{-1} 30 DAS along with RDF and FYM increased the grain and stover yield by 23.55 and 12.57 per cent, respectively over the package of practice. It also increased the net returns by 24,937 Rs. ha^{-1}. Therefore, the treatment T_{10} (T_2 + Enriched HS @ 5 L ha^{-1} 30 DAS) was found better.

References

Anonymous, 2014, Area, production and productivity of maize in India. Directorate of Maize Reasearch.

Anonymous, 2015, Area, production and productivity of maize in India. Directorate of Maize Reasearch.

Ehab, A., Ibrahima, Whaba, A. and Ramadan, 2015, Effect of zinc foliar spray alone and combined with humic acid or/and chitosan on growth, nutrient elements content and yield of dry bean (*Phaseolus vulgaris* L.) plants sown at different dates. *Scientia Horti.,* 14: 101–105.

Govindaswamy, M. and Ravikumar, C. M., 2002, Maximizing sugarcane yield through the addition of humic acid and micronutrients. *National seminar on Recent trends on the use of humic substances for sustainable agriculture,* pp. 5-6.

Mackowiak, C., Grossl, P. and Bugbee, B., 2001, Beneficial effects of humic acid on micronutrient availability to wheat. *Soil. Sci. Soc. Am. J.,* 65(6): 1744-1750.

Manas, D., Bandopadhyay, P. K., Chakravarthy, A., Pal, S. and Bhattacharya, A., 2014, Effect of foliar application of humic acid, zinc and boron on biochemical changes related to pungent pepper (*Capsicum annum* L.). *African J. Plant Sci.,* 8(6): 320-335.

Schnitzer, M. and Skinner, S. I. M., 1968, Alkali versus acid extraction of soil organic matter. *Soil Sci.*, 105: 392-396.

Sharif, M., Khattak, R, A. and Sarir, M. S., 2002. Effect of different levels of lignitic coal derived humic acid on growth of maize plants. *Commun. Soil Sci. Pl. Anal*., 33: 3567-3580.

Thakur, H., Rekha, K. B., Babu, S. S. N. and Padmaja, G., 2013, Effect of humic substances on growth and yield of sunflower (*Helianthus annuus* L.). *J. Res. ANGRAU*., 41(4): 106-108.

Tuba Arjumend, Kaleem Abbasi, M. and Ejaz Rafique, 2015, Effects of lignite-derived humic acid on some selected soil properties, growth and nutrient uptake of wheat (*Triticum aestivum* L.) grown under greenhouse conditions. *Pak. J. Bot.*, 47(6): 2231-2238.

Turan, M. A., Asik, B. B., Katkat, A. V and Celik, H., 2011, The effects of soil – applied humic substances to the dry weight and mineral nutrient uptake of maize plants under soil-salinity conditions. *Ntulae botanicae horti agrobotanici cluj-napoca,* 39(1): 171-177.