International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 829-833

Received: 21-08-2020
Accepted: 06-10-2020

Root and yield paramters of maize as influenced by application of different biostimulants in Alfisols of Karnataka

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DOI: https://doi.org/10.22271/chemi.2020.v8.i6l.10873

Abstract
A field experiment was conducted to evaluate the performance of maize upon applicaton of different biostimulants namely, humic caid extracted from FYM, Spirulina algal extract and microbial consortia in red soils of zone 6 of Karnataka during *Kharif* 2018 on sandy loam soil at college of Agriculture, V.C. Farm, Mandya. The experiment was laid out in RCBD with thirteen treatments including control, 100% RDF, 100% RDF + microbial consortia (MC), 100% RDF + MC + humic acid @ 0.25 and 0.50%, 100% RPP + MC + algal extract @ 10 and 20% and the above treatments were repeated with 75% RPP. Results revealed that application of biostimulants had a significant effect on growth and yield of maize. Application of 100% RPP along with biostimulants had significant effect on yield parameters, root parameters and yield of maize. Higher root length, shoot length, root: shoot, yield parameters like cob length, number of rows per cob, number of kernels per row and test weight was higher in T_7 treatment receiving 100% RPP along with microbial consortia and 20% algal extract. Treatment T_7 recorded significantly higher grain and stover yield of 81.67 and 89.79 q ha^{-1}, respectively.

Keywords: Biostimulant, Humic acid, Algal extract, Microbial consortia.

Introduction

The continuous use of fertilizers in the crop cultivation *i.e.*, showed some deleterious effect on soil quality and environment. Biologically and biochemically mediated processes in soils are of utmost importance to ecosystem function and these functions were under threat in the modern production system. Maintanence of soil health is very important for the biochemical processes including the transformation of organic matter (Miltner *et al.*, 2011) [8], nutrient release (Wichern *et al.*, 2007) [19] and degradation of xenobiotics. The scientists have started recommending firstly the use of organic manure along with chemical fertilizers, secondly completely organic farming techniques and thirdly use of biostimulants to increase the efficiency of nutrient utilization and tolerance to abiotic stress, improve the quality of crops and microbial diversity. Among the above mentioned practices, biostimulant in crop production is recently gaining lot of importance as the most sustainable and viable technology for the producers who are looking for the production of quality produce at the same time without causing undue stress on soil resources.

Biostimulants are either natural or synthetic organic substances containing hormones or precursors of plant hormones, when applied in lower concentration to soil or seed (seed coating) or plant (foliar spray) favour the growth of the plant by improving the vital physiological processes of the crop allowing higher yields and quality produce. Besides, biostimulants enhances the nutrition efficiency, abiotic tolerance and soil biological functions. As a significance of these reported benefits, biostumulants have sparked attention with many crop producers in the recent years. With increasing awareness of benefits of organically produced products, the demand for these are increasing in the market.

The role of biostimulants in improving the yield and quality of the crop produce and soil properties though not clearly demonstrated as these are composed of number of components as ingredient. However, the literature pertaining to the topic indicate that the yield increase and enhanced quality of the crop might be due to improvement in the efficiency of plants' metabolism, increase in plant tolerance and resilience from abiotic stress, improvement in nutrient assimilation/translocation/use, increasing water use efficiency and enhanced soil fertility by fostering the development of complimentary soil microbial community. It means most of biostiumulants improves plant's vigour and do not have any direct actions against pests or diseases and as a source of nutrients, regardless of the presence of nutrients in the products. These biostimulants improve plant nutrition by affecting soil processes and by directly affecting the plant's physiology.

In the present study spirulina algal extract, humic acid extracted from FYM and microbial consortia were used to study the response of maize.

Material and methods

Field experiment was conducted during *Kharif* 2018 on at College of Agriculture, Vishweshwaraiah Canal (V. C.) Farm, Mandya, Karnataka. The experiment consists of 13 treatment combinations as mentioned below

Treatment details

Treatment	Details	Treatment	Details
T_1	Control	T_8	75 % RPP
T_2	100 % RPP	T_9	75 % RPP + MC
T_3	100 % RPP + MC	T_{10}	75 % RPP + MC + HA 0.25 %
T_4	100 % RPP + MC + HA @ 0.25 %	T_{11}	75 % RPP + MC + HA 0.50 %
T_5	100 % RPP + MC + HA @ 0.50 %	T_{12}	75 % RPP + MC + AE @ 10 %
T_6	100 % RPP + MC + AE @ 10 %	T_{13}	75 % RPP + MC + AE @ 20 %
T_7	100 % RPP + MC + AE @ 20 %		

NOTE: MC- Microbial consortia HA- Humic acid AE- Algal extract RPP – Recommended package of practices as per the UAS B package of practices includes application of Recommended dose of NPK for Maize is 150:75:40 kg ha^{-1} + 10 kg ha^{-1} $ZnSO_4$, with farm yard manure (FYM) at the rate of 10 t ha^{-1}.

The microbial consortia was applied to soil along with FYM i.e. at 15 days before sowing of maize. While, humic acid and algal extract was foliar sprayed at 30 and 45 days after sowing.

Extraction of humic substances

Humic acid was extracted from well decomposed FYM by alkaline extraction method and further acidification as described by Stevenson (1981) [16]. Five kg of air dried FYM was weighed and transferred to plastic container to which 25 liters of 0.5 N NaOH was added and the contents were shaken for 24 hours (Schnitzer and Skinner, 1968) [12]. The dark coloured supernatant solution was separated by filtration and collected. Then the supernatant was acidified and centrifuged to obtain humic acid. Precipitation and centrifugation was repeated to attain partial purification of humic acid fraction. Then it was placed in oven and dried at 60 ˚C to a constant weight. The humic acid obtained was ground and diluted to get the required concentration.

Microbial consortia

Microbial consortia consisting of N- fixer (*Azotobacter chrococcum*) + P- solubilizer (*Bacillus megaterium*) + K- solubilizer (*Frateuria aurantia*) + *Pseudomonas fluorescens* + *Trichoderma viridae* was obtained from Biofertilizer Unit, University of Agricultural Sciences, Bangalore and applied to soil along with FYM (15 days before sowing) at the rate of 2 kg per acre.

Production of the algal extract

The mother culture of *Spirulina platensis* was obtained from Center for Conservation and Utilization of Blue green Algae, IARI, New Delhi. Two ml of mother culture was inoculated into media broth to get sub-cultures for future use. Fifty ml culture was mixed initially with 500 ml zorrouck's medium (pH 10). The culture was kept in an orbital shaker with natural illumination (3000 lux) and temperature of 30 °C for 7 days. Using the subcultures, the mass production has been carried out to obtain spirulina algal mass. The extract obtained was smashed in pestle and mortar and the solution was considered as 100 per cent. The solution was further diluted to get required concentration.

Table 1: Initial Physico-chemical properties of soil at the experimental site

Sl. No	Parameter	Method	Value
Physical Properties			
1	Sand (%)	International pipette method	80.51
2	Silt (%)		9.14
3	Clay (%)		9.23
4	Textural class		Sandy loam
5	Bulk density (Mg m^{-3})		1.51
Chemical properties			
1	pH(1:2.5)	Potentiometry	7.21
2	$EC_{2.5}$ (dS m^{-1})	Conductometry	0.17
3	Organic carbon (g kg^{-1})	Wet digestion	5.70
4	Available N (kg ha^{-1})	Alkaline potassium permanganate distillation method	276.87
5	Available P_2O_5 (kg ha^{-1})	Olsens extractant method, Colorimetry	35.33
6	Available K_2O (kg ha^{-1})	Ammonium acetate extractant method, Flame photometry	260.80
7	Available Ca (cmol (p$^+$) kg^{-1})	Ammonium acetate extractant method, Versenate titration method	4.71
8	Available Mg (cmol (p$^+$) kg^{-1})		3.13
9	Available S (mg kg^{-1})	$CaCl_2$ extraction, Turbidimetry	14.72
10	DTPA Fe (mg kg^{-1})	Atomic absorption spectrophotometry	12.76
11	DTPA Zn (mg kg^{-1})		0.79
12	DTPA Mn (mg kg^{-1})		7.94
13	DTPA Cu (mg kg^{-1})		0.61
14	Hot water soluble Boron (mg kg^{-1})	Hot water extraction method and colorimetry using Azomethine-H	0.51

The soil at the experimental site was sandy loam in texture with 80.51, 9.14, and 9.23 per cent sand, silt and clay, respectively and bulk density of soil was 1.51 Mg m^{-3}. The soil was neutral in reaction (pH 7.21) and low in soluble salts (0.17 dS m^{-1}). The soil was medium in organic carbon (5.70 g kg^{-1}), low in available nitrogen (276.87 kg ha^{-1}), medium in available P_2O_5 (35.33 kg ha^{-1}), medium in available K_2O (260.80 kg ha^{-1}) and sufficient in sulphur (14.72 mg kg^{-1}). The exchangeable calcium and magnesium content of soil was 4.71 and 3.13 c mol kg^{-1}, respectively. The content of DTPA extractable iron, zinc, manganese, copper and hot water soluble boron was 12.76, 0.79, 7.94, 0.61 and 0.51 mg kg^{-1}, respectively.

Results and discussion

Table 2: Root parameters at 60 DAS as influenced by application of different biostimulant

Treatments	Root dry weight (g)	Shoot dry weight (g)	Root: Shoot
T_1	16.85	75.46	0.22
T_2	19.05	96.10	0.20
T_3	19.92	96.74	0.21
T_4	21.87	97.16	0.23
T_5	22.01	97.92	0.22
T_6	23.47	98.16	0.24
T_7	24.18	98.82	0.24
T_8	18.68	90.12	0.21
T_9	18.71	91.07	0.21
T_{10}	19.08	92.12	0.21
T_{11}	19.86	92.73	0.21
T_{12}	20.11	94.48	0.21
T_{13}	20.82	95.32	0.22
S.Em±	0.92	4.21	0.01
CD @ 5%	2.67	NS	0.03

Table 3: Yield attributes of maize as affected by application of different biostimulants

Treatments	Cob length (cm)	No. of rows per cob	Kernels per row	Test weight
T_1	12.10	11.50	21.90	25.57
T_2	17.80	15.65	27.13	30.03
T_3	18.00	15.70	27.97	30.19
T_4	18.40	15.95	28.17	30.51
T_5	18.40	16.15	28.30	30.79
T_6	18.80	16.53	31.00	31.07
T_7	19.10	16.67	31.30	31.20
T_8	16.90	14.53	24.80	28.43
T_9	17.00	14.67	25.85	28.60
T_{10}	17.20	14.87	26.01	28.97
T_{11}	17.30	15.10	26.23	29.16
T_{12}	17.93	15.47	26.65	29.73
T_{13}	18.27	15.63	27.07	29.95
S.Em±	0.78	0.68	1.22	1.32
CD @ 5%	2.28	1.99	3.56	NS

Table 4: Kernel and stover yield (q ha^{-1}) as affected by application of different biostimulants in maize

Treatments	Kernel yield (q ha^{-1})	Stover yield (q ha^{-1})
T_1	41.12	45.39
T_2	71.59	80.41
T_3	73.28	81.36
T_4	77.16	86.19
T_5	78.24	87.01
T_6	80.86	88.57
T_7	81.67	89.79
T_8	62.89	71.87
T_9	63.97	72.09
T_{10}	66.03	74.91
T_{11}	67.30	76.04
T_{12}	70.14	78.91
T_{13}	71.03	80.73
S.Em±	3.06	3.48
CD @ 5%	8.94	10.16

Root dry weight

The root dry weight at 60 DAS as influenced by application of biostimulants is indicated in Table 2. Higher root dry weight of 24.18 g was recorded in T_7 (100% RPP + MC + 20% AE) which was on par with T_4 (21.87 g), T_5 (22.01 g) and T_6 (23.19 g) and significant with all other treatments. Lower root dry weight of 16.85 g was recorded in control.

Shoot dry weight

At 60 DAS, the data of shoot dry weight varied significantly due to treatments. The shoot dry weight in control was 75.46 g which increased significantly to 98.82 g in treatment T_7 (100% RPP + MC + 20% AE) which was on par with all the treatments except control.

Root: shoot

The root: shoot varied significantly due to treatments and indicated in Table 2.

Root to shoot ratio indicated that, significantly higher root to shoot ratio was recorded in T6 and T_7 (0.24) which received 100% RPP + MC + AE and was on par with all other treatments except T2 (0.20).

Higher root dry weight and root to shoot ratio was observed in biostimulants applied treatments than that of treatments having fertilizer alone. Biostimulants are known to have a crucial role in altering the root physiology which might be attributed to activity of hormones, which triggers root proliferation with higher root length, root branching and root hair density and thereby higher nutrient absorption capacity of the plant.

These results are in conformity with those reported by Chen and Aviad (1990) [3], who have reported that application of HA derived from vermicompost increased lateral-root proliferation and elongation in maize. They attributed this effect to the auxin-like activity of HS, which stimulates plasma membrane H^+-ATPase, thereby stimulating cellular growth. Similar improvement in root density of maize with application of humic acid was reported by Chen and Aviad (1990) [3] and algal extract by Canellas *et al.* (2002) [2] and Sharif *et al.* (2006) [14]. An increase in root proliferation, lateral-root and root-hair development increases the surface area of the root, which would explain the increased nutrient uptake induced by biostimulants application.

Yield Parameters

The data with respect to cob length, number of rows per cob, kernels per row and test weight are indicated in Table 3.

Cob length (cm)

The experimental data indicated that, significantly higher cob length of 19.10 cm was recorded in T_7 compared to control (12.10 cm). T7 treatment was on par with all other treatments except control.

Number of rows per cob

The data on number of rows per cob as influenced by the application of biostimulants are presented in Table 3.

Number of rows per cob varied significantly due to imposition of treatments. Least number of rows per cob was recorded in control (11.50) which increased significantly to 16.67 in T_7 due to application of 100 per cent RPP + microbial consortia + 20 per cent algal extract. But the number of rows per cob recorded in T_7 was statistically at par with all the treatments except T_1, T_8 and T_9.

Kernels per row

Significantly higher number of kernels per row was recorded in T_7 (31.30) (100% RPP + MC + 20% AE) which was on par with treatments receiving 100% RPP with either of the biostimulants and significant with rest of the treatments. Lowest number of kernels per row was recorded in control (21.90).

Test weight (g)

As indicated in Table 3, test weight did not vary significantly. The data indicated that, higher test weight of 31.20 g was recorded in T_7 and lowest test weight was recorded in control (25.57 g).

The observed increase in yield parameters with the application of biostimulants (HA, AE and MC) along with NPK fertilizer might be attributed to improvement in growth parameters. Application of biostimulants have a major role in improving the plant vigour and higher nutrient absorption which results in improved source to sink relationship. Thus increase in yield parameters may be attributed to efficient translocation of photosynthates and availability of adequate amount of nutrients (Harshad *et al.*, 2013) [7], enhanced photosynthetic rate, better nutrient uptake from the soil and increased accumulation and translocation of metabolites or nutrients (Shahmaleki *et al.* (2014) [13]. Zodape *et al.* (2009) [19] reported that the increase in growth and yield attributes in crops with the application of biostimulants might be due to presence of some growth promoting substances such as IAA and IBA, gibberellins, cytokinin, micronutrients, vitamins and amino acids in the biostimulants. Similar response in yield parameters upon application of biostimulants were recorded by Ebrahimpour *et al.* (2011) [4], Fatma *et al.* (2014) [5] and Tejada *et al.* (2018) [16] in maize.

4.3.5 Kernel and stover yield (q ha^{-1})

The data on kernel and stover yield of maize as influenced by application of graded levels of HA and SAE are presented in Tables 4.

The kernel and stover yield of maize varied significantly with the application of HA and SAE along with chemical fertilizers. The data indicated that, kernel yield of 81.67 q ha^{-1} recorded in T_7 treatment (100% RPP + MC + 20% AE) was significantly higher than that recorded in control (41.12 q ha^{-1}) and T_2 (71.59 q ha^{-1})and it was on par with all other treatments.

In case of stover yield, treatment T_7 (100% RPP + MC + 20% AE) recorded higher stover yield of 89.79 q ha^{-1} which was on par with treatments receiving 100% RPP and T_{13} (80.73 q ha^{-1}).

The yield of crop is a manifestation of growth and yield parameters of crop and environmental conditions. Thus the higher yield recorded in the present investigation with T_7 treatment (82.20 q ha^{-1}) was due to higher growth parameters, yield parameters and nutrients uptake recorded in the treatment. The yield obtained with foliar application of humic acid (0.25 and 0.50%) + MC + fertilizers (100 and 75%) was giving on par results with that of treatments receiving foliar application of algal extract. Biostimulants might have facilitated the acquisition of nutrients by supporting metabolic processes in plants such as cell division, expansion of cell wall, meristematic activity, enzymatic activity, photosynthetic efficiency which contributed for the observed higher kernel and stover yield of maize. The improved metabolic process in the plants was due to the presence of amino acids and hormones present in the biostimulants.

The positive response of maize to humic acid application with respect to grain and stover yield was evidenced by Reza and Moghadam *et al.* (2014) [10], Sharif *et al.* (2006) [14], Verlinden *et al.* (2011) [17] and to algal extract application by Gaurav Kumar [6] and Dinabandhu Sahoo, 2011 [6], Fatma *et al.* (2014) [5], Andrade *et al.* (2018) [1], Safinaz and Ragaa (2013) [11] and Nofal *et al.* (2016) [9].

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