E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(7): 564-567
Received: 18-05-2024
Accepted: 22-06-2024

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Effect of humic acid on growth, yield and quality of sugarcane

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i7Sh.1142

Abstract
The effect of humic acid on growth yield and quality of sugarcane crop were investigated at Vasantdada Sugar Institute, Manjari bk. Pune (MH). The soil was clay in texture with low in available nitrogen, high in available phosphorus and moderately high in available potassium. Humic acid was applied in soil, foliar and combination of soil and foliar application. A absolute control plot did not receive any fertilizer. NPK fertilizers were applied uniformly to all the plots. The results concluded that application of humic acid @ 10 kg ha^{-1} at planting or ratooning increased cane yield by 24.3 t ha^{-1} and sugar yield by 4.9 t ha^{-1} of sugarcane (var. Co. 86032) and found economically beneficial (B:C ratio 3.94). The increased cane yield was contributed by increased nutrient availability in soil, no. of milliable canes and cane height in humic acid applied treatment. Humic acid application in soil improved phosphate and potash availability. Therefore this study recommended that application of humic acid @ 10 kg ha^{-1} at planting or ratooning increased cane and sugar yield.

Keywords: Humic acid, growth yield, quality, sugarcane crop

Introduction
Sugarcane is an important cash crop grown in India under irrigated conditions. Although India has the second largest area under sugarcane, average cane productivity is much lower compared to other countries. The use of high analysis fertilizers and restricted recycling of organics have resulted in low yields. Sugarcane is an exhaustive crop and depletes the soil properties like changes in soil organic matter, bulk density and increases soil compaction.

Humus is highly colloidal and amorphous in nature. Moreover, its surface area and adsorptive capacity are much higher than that of clay collides. The cation exchange capacity (CEC) humus ranges from 150 to 300 Cmol (P^+) kg-^{1}. Humus has higher water adsorptive capacity than that of clay. Humic acid are weakly dissociated and determine the buffering capacity of soil. The humic acid molecules are not compact but have a loose structure with a large number of internal spaces which is more important in soil processes.

Humus is defined as a complex and rather resistant mixture of brown or dark brown amorphous and colloidal substances modified from the original tissues or synthesized by the various soil organisms. Humic acid is a commercial product contains many elements which improve the soil fertility and increasing the availability of nutrient elements and consequently affected plant growth and yield. Humic acid particularly is used to remove or decrease the negative effects of chemical fertilizers and some chemicals from the soil. Humic acid reduces other fertilizer requirements, increases yield in crops, improved drainage, increase aeration of the soil, increase the protein and mineral contents of most crops and establish a desirable environment for microorganism development. (Ekin *et al.*, 2019) [2].

The humic substances applied in soil as well as foliar feed to crops improved the quality and yield of crops. Fuentes *et al.*, (2018) [4] showed that the application of humic acid caused a significant increase of sucrose, root yield and sugar yield compared to the control. However, EL-Hassanin *et al.*, (2016) [3] reported that foliar application of humic acid statistically improved sucrose and yield of sugar beet. Selim *et al.*, 2011 [8] showed 100% yield increases from fertilizers containing NPK and humic acids in potatoes and cabbage.

However, there is very meager work on application of humic acid in soil as well as foliar spray in relation to quality and yield of sugarcane crop therefore, the present investigation was undertaken to study the effect of humic acid with chemical fertilizer on nutrient availability, yield and quality of sugarcane during 2017- 2020.

Materials and Methods

A field experiment was carried out during Suru season at Vasantdada Sugar Institute research farm during 2017-20. Initial soil analysis data of experimental plot and Humic analysis is reported in Table 1a and 1b. The soil under experimental plot was clayey in texture, moderate in available Nitrogen, high in available phosphorus and moderately high in available potassium and organic carbon. Experiment was designed in Randomized block design (RBD) with three replication and ten treatments. Treatment T_1 is Absolute control where no fertilizers were applied. Treatment T_2 is control where only recommended dose of NPK fertilizer was applied. In treatment T_3 and T_4 applied humic acid 5 kg ha^{-1} and 10 kg ha^{-1} at the time of planting and in treatment T_5 and T_6 where foliar application of humic acid @ 0.01% and 0.02% at 60 days after planting. Treatment T_7 and T_8 where applied Humic acid 5 kg ha^{-1} and 10 kg ha^{-1} at the time of planting and foliar application of 0.01% at 60 days after planting. In treatment T_9 and T_{10} applied humic acid 5 kg ha^{-1} and 10 kg ha^{-1} at the time of planting and foliar application of 0.02% at 60 days after planting. The recommended dose of fertilizers (250:115:115 N, P_2O_5 and K_2O kg ha^{-1}) and other package of practices for sugarcane were imposed uniformly for all the treatments including control. The field observations of biometric, growth and yield parameters were taken at different stages of the crop and at harvest. The soil chemical analysis was done by methods of AOAC (1975) [1], Jackson, (1973) [6]. The data collected was statistically analyzed as per the procedures given.

Results and Discussion

The data regarding cane yield, sugar yield & growth parameters are reported in Table 2 & 3.

Cane yield

The pooled data of two plantcane and one ratoon crop presented in Table 2 indicated that all the treatments are on par with each other except treatment T_5 and T_6 where foliar application of humic acid @ 0.01% and @ 0.02%. The treatments T_3 (134.2 t ha^{-1}) and T_4 (140.0 t ha^{-1}) where humic acid was applied 5 kg ha^{-1} and 10 kg ha^{-1} in soil were found on par with each other and significantly superior over RDF (115.7 t ha^{-1}). The treatment T_7 and T_8 where humic acid was applied 5 and 10 kg ha^{-1} in soil and humic acid was sprayed @ 0.01% also increased the cane yield 134.2 t ha^{-1} and 135.5 t ha^{-1} respectively. The soil application of humic acid 5 and 10 kg ha^{-1} along with foliar application of 0.02% significantly increased cane yield up to 135.0 t ha^{-1} and 139.1 t ha^{-1} respectively. It revealed that the soil application of humic acid @ 10 kg ha^{-1} at planting or ratooning was beneficial and economical for increasing cane yield. Govindasmy and Chandrasekaran (1992) [5] also reported that humic acid addition increased the cane yield and sugar yield.

Commercial Cane Sugar Yield

The data regarding commercial cane sugar yield is reported in Table 2. The data showed there was significant increase in CCS yield due to application of humic acid in soil as well as combination of soil and foliar application over RDF. The maximum CCS yield (24.3 t ha^{-1}) in treatment T_4 where humic acid was applied @ 10 kg ha^{-1} at the time of planting followed by (24.0 t ha^{-1}) in treatment T_{10} where humic acid was applied @ 10 kg ha^{-1} at the time of planting and spray of humic acid @ 0.02%.which was significantly superior over RDF (19.4 t ha^{-1}).

Yield contributing parameters

The data regarding yield contributing parameters is reported in Table 3. The highest plant population (100.3 thousand ha^{-1}) was recorded in treatment T_8 where application of humic acid @ 10 kg ha^{-1} in soil and foliar application of 0.01% followed by 98.6 thousand ha^{-1} in treatment T_4 where soil application of humic acid @ 10 kg ha^{-1} at planting or was found significantly superior over RDF (87.6 thousand ha^{-1}). All the treatment of application of humic acid in soil and combination of soil and foliar was significantly superior over RDF.

The maximum milliable cane height (237.9 cm) was recorded in treatment T_{10} where 10 kg ha^{-1} humic acid was applied at the time of planting and foliar application of 0.02% humic acid followed by (236.4 cm) was recorded in treatment T_4 where 10 kg ha^{-1} humic acid was applied at the time of planting. All the treatments of humic acid application @10 kg ha^{-1} in soil as well as soil and foliar combination were significantly superior over RDF.

Economical evaluation

The treatment wise gross monetary return, net monetary return and benefit cost ratio are reported in Table 4. The highest benefit cost ratio was found maximum (3.94) in treatment T_4 where applied 10 kg ha^{-1} humic acid at the time of planting.

Soil analysis at harvest

Soil analysis data at harvest is reported in Table 5 available nitrogen is higher in T_8 where application of humic acid @ 10 kg ha^{-1} along with foliar application of humic acid 0.01%. Rate of response of sugarcane yield to humic acid application @ 10 kg ha^{-1} at the time of planting is similar to the phosphate and potash availability. Phosphorus and potassium content is higher in treatments T_4 where applied humic acid @ 10 kg ha^{-1}. Humic acid application in soil improves phosphorus and potash availability.

Table 1a: Initial soil analysis of experimental site

Analytical Parameters	Analytical Values
pH	8.30
Electrical Conductivity (dSm^{-1})	0.245
Organic carbon (%)	0.68
Available N (kg ha^{-1})	259.2
Available P (kg ha^{-1})	49.1
Available K (kg ha^{-1})	438.9
Fe (mg kg^{-1})	5.12
Mn (mg kg^{-1})	6.15
Zn (mg kg^{-1})	1.47
Cu (mg kg^{-1})	3.78

Table 1b: Humic analysis

	N (%)	P (%)	K (%)	Humic acid (%)
Potassium humate (Granules)	4.90	0.60	4.89	15
Potassium humate (Liquid)	4.95	0.69	4.90	15

Table 2: Effect of humic acid on Cane yield and CCS yield (pooled)

Treatments	Cane yield (t ha^{-1})	CCS yield (t ha^{-1})
T_1 - Absolute control	99.2	15.1
T_2 - RDF	115.7	19.4
T_3- Soil application of HA @ 5 kg ha^{-1} at planting	134.2	22.2
T_4- Soil application of HA @10 kg ha^{-1} at planting	140.0	24.3
T_5 - Foliar application of HA @ 0.01% - 60 DAP	126.1	19.4
T_6 - Foliar application of HA @ 0.02% - 60 DAP	128.0	20.5
T_7 - Soil application of HA @ 5 kg ha^{-1}+ Foliar application of HA @ 0.01%	134.2	23.0
T_8 - Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.01%	135.5	23.4
T_9 - Soil application of HA @ 5 kg ha^{-1} + Foliar application of HA @ 0.02%	135.0	23.6
T_{10}-Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.02%	139.1	24.0
S.E.±	3.71	0.73
CD at 5%	7.80	1.54

Table 3: Effect of humic acid on milliable cane and milliable cane height (pooled)

Treatments	Milliable canes ('000'ha^{-1})	Milliable Cane Height (cm)
T_1 - Absolute control	85.9	213.6
T_2 - RDF	87.6	217.7
T_3- Soil application of HA @ 5 kg ha^{-1} at planting	95.8	230.7
T_4- Soil application of HA @10 kg ha^{-1} at planting	98.6	236.4
T_5 - Foliar application of HA @ 0.01% - 60 DAP	94.5	224.6
T_6 - Foliar application of HA @ 0.02% - 60 DAP	93.9	223.8
T_7 - Soil application of HA @ 5 kg ha^{-1}+ Foliar application of HA @ 0.01%	95.3	231.6
T_8 - Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.01%	100.3	235.4
T_9 - Soil application of HA @ 5 kg ha^{-1} + Foliar application of HA @ 0.02%	95.4	232.5
T_{10}-Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.02%	97.9	237.9
S.E.±	2.57	0.73
CD at 5%	6.39	1.54

Table 4: Effect of humic acid on economic evaluation (pooled)

Treatments	Net Profit	B:C ratio
T_1 - Absolute control	139100.6	3.50
T_2 - RDF	164977.2	3.33
T_3- Soil application of HA @ 5 kg ha^{-1} at planting	190300.7	3.81
T_4- Soil application of HA @10 kg ha^{-1} at planting	200086.5	3.94
T_5 - Foliar application of HA @ 0.01% - 60 DAP	174343.2	3.49
T_6 - Foliar application of HA @ 0.02% - 60 DAP	176125.4	3.52
T_7 - Soil application of HA @ 5 kg ha^{-1}+ Foliar application of HA @ 0.01%	190914.4	3.76
T_8 - Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.01%	195569.5	3.82
T_9 - Soil application of HA @ 5 kg ha^{-1} + Foliar application of HA @ 0.02%	191765.7	3.75
T_{10}-Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.02%	201213.2	3.89

Table 5: Effect of humic acid on soil properties at harvest (pooled)

Treatments	pH	EC (dSm^{-1})	Organic Carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1 - Absolute control	8.38	0.22	0.59	245.6	18.2	345.9
T_2 - RDF	8.32	0.22	0.60	265.6	25.5	362.7
T_3- Soil application of HA @ 5 kg ha^{-1} at planting	8.46	0.23	0.71	278.5	41.5	498.6
T_4- Soil application of HA @10 kg ha^{-1} at planting	8.41	0.28	0.84	285.4	43.3	503.4
T_5 - Foliar application of HA @ 0.01% - 60 DAP	8.39	0.27	0.68	258.5	27.6	419.6
T_6 - Foliar application of HA @ 0.02% - 60 DAP	8.38	0.28	0.65	255.6	25.1	408.4
T_7 - Soil application of HA @ 5 kg ha^{-1} + Foliar application of HA @ 0.01%	8.36	0.28	0.70	286.2	38.1	469.2
T_8 - Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.01%	8.41	0.24	0.81	290.6	42.5	472.4
T_9 - Soil application of HA @ 5 kg ha^{-1} + Foliar application of HA @ 0.02%	8.38	0.36	0.71	289.2	40.2	498.9
T_{10}-Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.02%	8.30	0.32	0.78	291.5	42.2	486.1

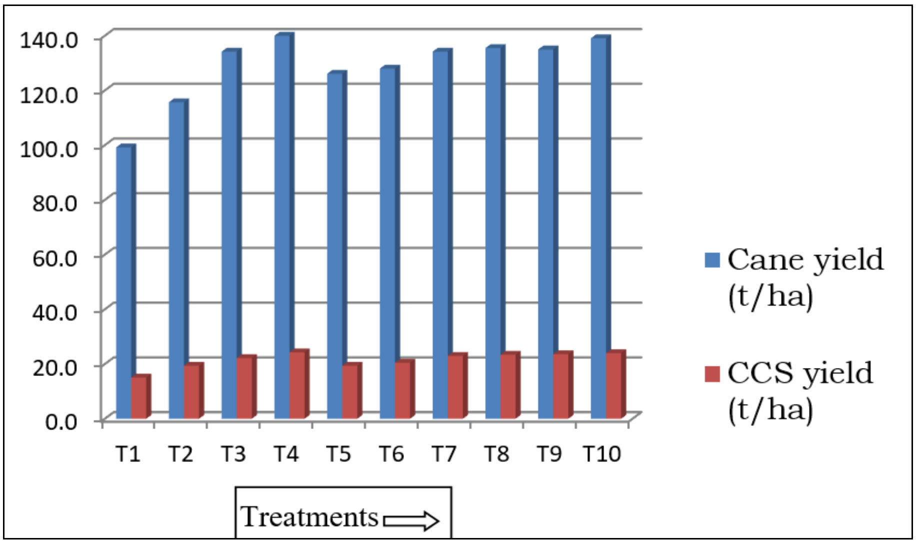

Fig 1: Effect of humic acid on Cane yield and CCS yield (pooled)

Conclusion

The results concluded that application of humic acid @ 10 kg ha^{-1} at planting or ratooning increased cane yield by 24.3 t ha^{-1} and sugar yield by 4.9 t ha^{-1} of sugarcane (var. Co 86032) and found economically beneficial (B:C ratio 3.94). The increased cane yield is significantly contributed by increased nutrient availability in soil.

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