Boosting Sweet Corn (*Zea mays* convar. *saccharata* L.): Impact of Humic Acid Foliar Spray and Nutrient Levels on Yield and Quality

Abstract

The increasing demand for sweet corn has driven the need for innovative agricultural practices to enhance yield and quality. One such promising approach is the foliar application of humic acid combined with varied nutrient levels. In this context, the field experiment was conducted to study the effect of foliar application of humic acid on growth and yield of Sweet corn (*Zea mays* convar. *saccharata* L.) at AHRS Kathalagere, University of Agricultural and horticultural Sciences, Shivamogga during the season of 2021. The various treatments included combination of RDF with different concentration of humic acid to improve yield and quality of sweet corn. The significant effect of application of humic acid with varied nutrient levels at recommended dosage on plant height, number of leaves, Leaf area, leaf area index, yield, yield parameters and quality parameters of sweet corn were studied. The highest cob yield of 198.18 q ha^{-1} was in application of 125 per cent RDF + humic acid at 2 per cent foliar spray as compared to recommended dose of fertilizers with an increase of 25.28 per cent and green fodder yield of 263.80 q ha^{-1} was achieved with an increase of 17.88 per cent. The accumulation of crude protein (5.25 %), total sugars (23.21 %), reducing sugars (3.14%) and non-reducing sugars (19.06 %) were observed to be highest in the foliar spray of 2 per cent humic acid combined with 125 per cent RDF. With these additional effects of humic acid, farmers can achieve higher yield and good quality of sweet corn to fulfill the increasing demand.

Key words: Sweet corn, Humic acid, Foliar application, Nutrient levels, Total sugars

Introduction

Sweet corn (*Zea mays* var. *rugosa*), originally from Peru, is a popular maize variety known for its high natural sugar content. Widely grown across America, it is often called sugar corn or pole corn due to its sweetness (Doehlert *et al.*, 1993). This higher sugar content and soft texture makes it ideal for fresh consumption. This hybrid maize has gained popularity in many developed countries, where it is commonly consumed as a frozen vegetable rather than as grain in the USA, Canada, Australia, and increasingly in India and other Asian countries. In India,

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sweet corn is grown by some farmers and private organizations to meet domestic demand. It provides a higher income than traditional maize because it is harvested earlier at the milky stage, with harvests possible in 65 to 90 days, depending on the variety, and offers good export opportunities for farmers. Sweet corn is favorable for fresh consumption because of its delicious taste, soft and sugary texture compared to other corn varieties.

The increasing demand for sweet corn has driven the need for innovative agricultural practices to enhance yield and quality. One such promising approach is the foliar application of humic acid combined with varied nutrient levels. Humic acid, a major component of humic substances, is derived from the decomposition of organic matter. It has been widely recognized for its role in improving soil health, promoting nutrient uptake, and enhancing plant growth (Cenellar *et al*., 2002, Chen *et al*, 2004 and Nardi *et al*., 2004). When applied as a foliar spray, humic acid can directly affect plant physiology by stimulating enzymatic activity, enhancing photosynthesis, and improving nutrient absorption (Kazemi, 2014). This mode of application is particularly advantageous as it allows for the direct uptake of nutrients through the leaves, bypassing potential soil-related limitations.

The nutrient levels in sweet corn cultivation also play a crucial role in determining both yield and quality. Essential nutrients such as nitrogen, phosphorus, potassium, and trace elements are vital for the development of the plant and the accumulation of sugars in the kernels. Balancing these nutrients optimally can lead to improved growth rates, higher yields, and better-quality produce. The combined effect of humic acid and varied nutrient levels on sweet corn is a subject of significant interest. This approach aims to synergize the benefits of both elements, potentially leading to enhanced agricultural outcomes. The foliar application of humic acid, in particular, may offer a more efficient and targeted method of nutrient delivery, thereby maximizing the plant's growth potential and improving the quality of the sweet corn produced.

In this context, this study seeks to investigate the effects of foliar application of humic acid in conjunction with different nutrient levels on the yield and quality of sweet corn. By understanding these interactions, farmers can adopt more effective cultivation practices, ultimately leading to better crop performance and increased profitability.

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Materials and Methods

A field experiment was conducted at AHRS Kathalagere, KSNUAHS, Shivamogga, during summer 2021, to study the impact of humic acid foliar spray and nutrient levels on yield and quality of sweet corn. The experiment was in Randomized Complete Block Design with eight treatments replicated thrice. The treatments include *viz.,* absolute control (T_1), 75% RDF (T_2), 100% RDF (T_3), 125% RDF (T_4), humic acid at 0.2% foliar spray (T_5), 75% RDF + humic acid at 0.2% foliar spray (T_6), 100% RDF + humic acid at 0.2% foliar spray (T_7) and 125% RDF + humic acid at 0.2% foliar spray (T_8). Before sowing, the soil was analyzed for pH, organic carbon, and the availability of nitrogen, phosphorus, and potassium. The soil at the experimental site was slightly acidic, with a pH of 6.3 and a low salt load, indicated by an electrical conductivity (EC) of 0.18 dS m^{-1}. The soil had a medium level of organic carbon at 0.63%, with nitrogen and potassium at medium levels (284.85 kg ha^{-1} and 281.65 kg ha^{-1}, respectively) but the phosphorus content was high, at 65.64 kg ha^{-1}. Data on growth parameters were recorded at 30 DAS, 60 DAS and at harvest. Both biological and economical yield were recorded from individual plots at harvest and converted to kg/ha.

Statistical analysis: Data obtained on growth, yield and quality parameters was subjected to statistical analysis adopting Fisher's method of analysis of variance as out lined by Gomez and Gomez (1984). In case of significant results, critical difference (CD) at 5% level of probability was calculated for testing the difference between the two treatment means.

Results and Discussion

Growth Parameters

Plant height gradually increased with each stage of crop development. Data analysis revealed that plant height increased with crop age, but notable increases were only seen between 30 and 60 days after sowing (DAS) and peaked at harvest. The application of 125 per cent RDF with foliar spray of 0.2 per cent humic acid significantly influenced the plant height (49.93, 198.46 and 223.40 cm at 30, 60 DAS and harvest, respectively) as compared to the application of 100 per cent RDF (47.40, 178.30 and 202.40 cm at 30, 60 DAS and harvest, respectively). Similarly, number of leaves also significantly increased with the application of 125 per cent RDF with foliar spray of 0.2 per cent humic acid (8.54, 19.54 and 14.88 at 30, 60 DAS and harvest, respectively) which also on par with the application of 100 per cent RDF (**Table 1**). The increase in plant height and number of leaves is attributed to overall improvements in plant growth, vigor,

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and photosynthesis. This enhancement is due to better nutrient availability from both soil and foliar applications. Foliar application of humic acid boosts cell division and elongation, resulting in taller plants. Specifically, treatments with 125% of the Recommended Dose of Fertilizer (RDF) and 0.2% humic acid foliar spray demonstrated notable growth and increased plant height. Suruthi *et al*. (2019) observed similar results in barnyard millet, where the application of additional inorganic nutrients and humic acid enhanced photosynthesis and activated various enzymes, facilitating the transport of assimilates to growing regions. The observed increase in plant height can be attributed to the roles of nitrogen, phosphorus, potassium, and humic acid in key physiological processes such as enzyme activation, stomatal regulation, and chlorophyll formation (Jan *et al*., 2015 and Vidhyashree, 2019).

The growth and development of crops depend on the assimilatory surface, such as the number of leaves and leaf area. At all growth stages, the application of 125% Recommended Dose of Fertilizer (RDF) combined with 0.2% humic acid foliar spray led to significantly higher number leaves (8.54, 19.54, and 14.88 at 30, 60 DAS and harvest, respectively), leaf area (1262.41,9720.57, and 5986.54 cm^2 $plant^{-1}$ at 30, 60 DAS, and harvest, respectively) and leaf area index (0.94, 7.20, and 4.43 at 30, 60 DAS, and harvest, respectively) compared to 100% RDF, number of leaves (7.70, 15.87 and 11.87 at 30, 60 DAS and harvest, respectively), leaf area (828.96, 8795.59 and 4809.72 cm^2 $plant^{-1}$ at 30, 60 DAS and harvest, respectively), leaf area index (0.61, 6.52 and 3.56 at 30, 60 DAS and harvest, respectively). alone, which showed lower values in these parameters (**Table 1**).

This improvement can be attributed to the enhanced nutrient availability from both inorganic and organic sources, which supports greater metabolic activity and photosynthesis. The increased number of nodes in taller plants leads to more leaves, and the higher leaf area and leafarea index result from improved leaf expansion, cell division, and cell enlargement. The effective photosynthetic structure, facilitated by the combined application of RDF and humic acid, supports greater synthesis, accumulation, partitioning, and translocation of photosynthates,

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Table 1: Plant heigh, number of leaves, leaf area and Leaf area index of sweet corn at different growth stages as influenced by foliar application of humic acid with varied nutrient levels

Treatment	Plant height (cm)			Number of leaves			Leaf area (cm^2 $plant^{-1}$)			Leaf area index		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1: Absolute control	34.12	151.37	165.28	6.15	11.09	9.00	562.83	5286.85	3418.43	0.42	3.92	2.53
T_2: 75 % RDF	43.93	164.54	187.37	7.23	13.36	11.61	706.92	7991.15	4293.90	0.52	5.92	3.18
T_3: 100 % RDF	47.40	178.30	202.40	7.70	15.87	11.87	828.96	8795.59	4809.72	0.61	6.52	3.56
T_4: 125 % RDF	49.17	189.93	213.58	8.21	18.78	14.35	1192.45	9443.63	5548.87	0.88	7.00	4.11
T_5: Humic acid at 0.2 % foliar spray	39.37	158.43	181.65	7.16	13.15	11.60	689.08	6167.39	3917.53	0.51	4.57	2.90
T_6: 75 % RDF + Humic acid at 0.2 % foliar spray	45.50	175.39	194.50	7.42	14.43	11.72	756.88	8536.89	4573.21	0.56	6.32	3.39
T_7: 100 % RDF + Humic acid at 0.2 % foliar spray	48.59	186.65	207.53	7.97	17.71	14.16	847.25	9054.91	5385.67	0.63	6.71	3.99
T_8: 125 % RDF + Humic acid at 0.2 % foliar spray	49.93	198.46	223.40	8.54	19.54	14.88	1262.41	9720.57	5986.54	0.94	7.20	4.43
SE.m ±	**0.37**	**2.75**	**3.05**	**0.26**	**0.88**	**0.67**	**23.71**	**207.57**	**201.45**	**0.02**	**0.15**	**0.15**
CD @ 5%	**1.13**	**8.21**	**9.08**	**0.79**	**2.60**	**1.98**	**71.92**	**629.61**	**611.03**	**0.05**	**0.47**	**0.45**

Note: RDF - 150: 75: 45 kg (N: P_2O_5: K_2O / ha)**,** RDF- Recommended dose of fertilizer**,** DAS- Days after sowing

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contributing to the overall growth and development of the crop (Veysel *et al.,* 2011). Additionally, humic acid appears to enhance respiration and photosynthesis by modifying mitochondrial and chloroplast functions, which helps alleviate the negative effects of abiotic stresses on plants, as supported by Sangeetha *et al*. (2006).

Table 2. Yield and yield attributes of sweet corn at harvest as influenced by foliar application of humic acid with varied nutrient levels

Treatment	No. of cobs plant^{-1}	Cob length (cm)	Cob girth (cm)	Fresh cob yield with husk (q ha^{-1})	Green fodder yield (q ha^{-1})
T_1: Absolute control	1.00	13.92	9.72	87.72	125.70
T_2: 75 % RDF	1.10	16.42	10.70	142.91	205.65
T_3: 100 % RDF	1.13	18.60	13.63	158.19	223.78
T_4: 125 % RDF	1.27	19.82	15.11	181.17	254.87
T_5: Humic acid at 0.2 % foliar spray	1.00	14.97	10.17	120.62	173.65
T_6: 75 % RDF + Humic acid at 0.2 % foliar spray	1.20	17.13	11.85	153.84	212.45
T_7: 100 % RDF + Humic acid at 0.2 % foliar spray	1.27	19.63	14.43	171.45	240.15
T_8: 125 % RDF + Humic acid at 0.2 % foliar spray	1.40	21.42	15.77	198.18	263.80
SE.m ±	**0.09**	**0.34**	**0.32**	**7.21**	**11.78**
CD @ 5%	**NS**	**1.01**	**0.97**	**21.49**	**29.28**

Note: RDF - 150: 75: 45 kg (N: P_2O_5: K_2O / ha)**,** RDF- Recommended dose of fertilizer**,** DAS- Days after sowing, NS - Non significant

Yield attributes

The yield attributes like number of cobs per plant, cob length, cob girth were significantly increased with the application of humic acid with RDF. Among the various treatments, applying 125% RDF with a 0.2% humic acid foliar spray resulted in significantly more cobs per plant (1.40) longer cobs (21.42 cm) and thicker cobs (15.77 cm). This was followed by 125% RDF alone (1.27 in number, 19.82 cm length and 15.11 cm girth), and 100% RDF (1.13, 18.60 cm length and 13.63 cm girth). The improved NPK levels during the reproductive stage, due to

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increased nutrient availability, enhanced the source-sink relationship in sweet corn. This increase in NPK fertilization led to better growth, photosynthesis, and overall plant development and yield. These results are consistent with findings by Sulok Kevin *et al*. (2007).

Cob and green fodder yield

The combined application of both organic and inorganic sources which facilitated greater availability of nutrients for the development of vegetative structures, cell division, number of grains, husk weight, more dry matter accumulation, nutrient uptake, improved translocation of photosynthates from source to sink and partitioning which resulted in higher fresh cob yield and green fodder yield as observed at foliar spray of 125 per cent RDF + Humic acid at 0.2 per cent foliar spray (198.18 and 263.80 q ha^{-1}, respectively) which was on par with the application of 125 per cent of RDF alone (181.17 and 254.87 q ha^{-1}, respectively) (**Table 2**). The increase in growth and yield due to the application of fertilizers combined with humic acid can be attributed to the essential role of these nutrients in nucleotides, proteins, chlorophyll, and enzymes, which are involved in various metabolic processes affecting both the vegetative and reproductive phases of plants (Mengel and Kirkby, 1996). The combined application of organic and inorganic sources enhances nutrient availability, supporting vegetative structure development, increased photosynthetic activity, accelerated respiration, hormonal growth responses, and better nutrient uptake. This leads to improved cell division, grain number, husked weight, dry matter accumulation, and translocation of photosynthates from source to sink, resulting in higher fresh cob and green fodder yields. Similar observations have been reported by Rao *et al*. (1987), Reddy *et al*. (2018), and Shahzad *et al*. (2017).

Quality parameters

Quality parameters like crude protein, total sugars, reducing and non-reducing sugars were analyzed and the results showed the non-significant improvement among the treatments. Quality aspects involve complex physiological processes that are challenging to control through management practices in just one season. However, data on quality parameters revealed that applying 125% RDF with a 0.2% humic acid foliar spray resulted in higher crude protein (5.25%), total sugar (23.21%), reducing sugar (3.14%), and non-reducing sugar (19.06%) (**Table 3**). This improvement is mainly due to the hormonal effects of humic acid, which enhance

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respiratory catalytic activity, cell permeability, and nutrient uptake (Thenmozhi *et al.*, 2004). Similar findings were reported by Bakry *et al.* (2013).

Table 3. Quality parameters of sweet corn as influenced by foliar application of humic acid with varied nutrient levels

Treatment	Crude protein (%)	Total sugars (%)	Reducing sugars (%)	Non reducing sugars (%)
T_1: Absolute control	3.94	18.70	1.91	15.95
T_2: 75 % RDF	4.88	20.61	2.29	17.40
T_3: 100 % RDF	5.04	21.90	2.62	18.32
T_4: 125 % RDF	5.13	22.81	2.95	18.87
T_5: Humic acid at 0.2 % foliar spray	4.31	19.34	2.02	16.45
T_6: 75 % RDF + Humic acid at 0.2 % foliar spray	5.01	21.23	2.45	17.84
T_7: 100 % RDF + Humic acid at 0.2 % foliar spray	5.06	22.28	2.79	18.52
T_8: 125 % RDF + Humic acid at 0.2 % foliar spray	5.25	23.21	3.14	19.06
SE.m ±	**0.29**	**1.06**	**0.21**	**1.01**
CD @ 5%	**NS**	**NS**	**NS**	**NS**

Note: RDF - 150: 75: 45 kg (N: P_2O_5: K_2O / ha)**,** RDF- Recommended dose of fertilizer**,** DAS- Days after sowing, NS - Non significant

Economics

Higher gross return (Rs. 284,009 ha^{-1}), net return (Rs. 197,328 ha^{-1}) and B: C ratio (3.28) was recorded in the treatment 125% RDF + Humic acid at 0.2% foliar spray which received 125 per cent RDF + humic acid at 0.2 per cent foliar spray. However, which was on par with the application of 125% RDF (Rs. 261,008 ha^{-1}, Rs. 176127 ha^{-1}) (**Table 4**). The higher gross return and net return were mainly attributed to higher fresh cob yield and green fodder yield of sweet corn. Similar findings were also observed by Patel (2011) in wheat.

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Table 4. Economics of sweet corn cultivation as influenced by foliar application of humic acid with varied nutrient levels

Treatment	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C
T_1: Absolute control	61,000	109,086	48086	1.79
T_2: 75 % RDF	81,563	206,344	124781	2.53
T_3: 100 % RDF	83,459	228,025	144566	2.73
T_4: 125 % RDF	84,881	261,008	176127	3.07
T_5: Humic acid at 0.2 % foliar spray	78,850	174,167	95317	2.21
T_6: 75 % RDF + Humic acid at 0.2 % foliar spray	83,363	221,237	137874	2.65
T_7: 100 % RDF + Humic acid at 0.2 % foliar spray	85,259	246,904	161645	2.90
T_8: 125 % RDF + Humic acid at 0.2 % foliar spray	86,681	284,009	197328	3.28
SE.m ±		**12125**	**12125**	**0.14**
CD @ 5%		**36778**	**36778**	**0.44**

Conclusion

Results of the study concluded that application of 125 per cent RDF + humic acid at 0.2 per cent as foliar spray able to produce 25.27 per cent higher fresh cob yield with husk and 17.88 per cent higher green fodder yield compared to application of 100 per cent RDF. On the basis of these results, it can be concluded that humic acid in combination with RDF gives additional effect on growth and yield parameters of sweet corn with higher B:C ratio which might help farmers to produce good quality sweet corn with increased yield.

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