

Sweet corn response to vermicompost application timing

Nga S. T. T.^{1*}, Ung N. H.¹, Hieu P. C.¹, Dang T. T. T.², Nhu C. T.³, Hang T. T.⁴

(1. School of Agriculture and Aquaculture, Tra Vinh University, Hoa Thuan Ward, Vinh Long, 87000, Viet Nam;

2. Institute of Biotechnology, Tra Vinh University, Hoa Thuan Ward, Vinh Long, 87000, Viet Nam;

3. Mekong Coconut Institute, Tra Vinh University, Hoa Thuan Ward, Vinh Long, 87000, Viet Nam;

4. Student, School of Agriculture and Aquaculture, Tra Vinh University, Hoa Thuan Ward, Vinh Long, 87000, Viet Nam)

Abstract: This field study evaluated the effect of vermicompost application timing on the growth and yield components of Rong Vang F1 sweet corn. Six treatments were compared under field conditions at the Experimental and Research Farm of Tra Vinh University from July to October 2023. A non-fertilized control was compared with five vermicompost-application times receiving the same nominal dose at 5, 10, 20, 30, or 40 days after sowing. Plant height, leaf number, stem diameter, days to tasseling, days to silking, ear length, ear diameter, kernel rows per ear, kernels per row, and thousand-kernel weight were recorded. Among the tested treatments, application at 20 days after sowing produced the best overall response, with the highest plant height (196.82 cm), stem diameter (2.71 cm), leaf number (13.32), ear length (31.25 cm), ear diameter (5.91 cm), kernel rows per ear (15.86), kernels per row (38.33), and thousand-kernel weight (493.36 g), while also reducing days to tasseling and silking. These results indicate that 20 days after sowing was the most favorable application time among the tested treatments under the conditions of this experiment.

Keywords: vermicompost, sweet corn, fertilizer application timing, plant growth.

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1 Introduction

Sweet corn (*Zea mays* L. var. *Rugosa* Bonaf) is one of the high-value vegetable crops widely consumed in the United States, China, Thailand and Japan (Revilla et al., 2021; Ruanjaichon et al., 2021). Sweet corn is an important cereal crop that provides at least 30% of the food calories for more than 4.5 billion people in 94 developing countries (Rebourg et al., 2003). Sweet corn can be consumed fresh during the milk stage without the need for processing. This variety is characterized by its naturally high sugar content, thin and easily digestible pericarp, small cob diameter, uniform kernel arrangement, well-filled ears, and a

fresh, pleasant taste. In Vietnam, sweet corn varieties are increasingly cultivated and have become an important source of economic value. The demand for sweet corn as a food source has been steadily increasing, particularly for waxy and sweet corn varieties, which are commonly consumed fresh, used as ingredients in dishes and soups, and primarily processed through freezing technology for export purposes (Nguyen, et al., 2020).

For decades, chemical fertilizers have been widely used around the world. However, their adverse impacts on soil quality, water resources, and the surrounding environment have been clearly documented. The excessive use of chemical fertilizers, particularly

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***Corresponding author:** Nga, S. T. T. School of Agriculture and Aquaculture, Tra Vinh University, Hoa Thuan Ward, Vinh Long, 87000, Viet Nam. Email: sonthanhnaga@tvu.edu.vn.

nitrogen-based ones, is among the major factors contributing to soil fertility degradation and environmental pollution. Moreover, it negatively affects the quality and safety of agricultural products, posing health risks to humans due to nitrate accumulation, especially in crops like okra, which have a short cultivation cycle and are consumed daily as a staple vegetable (Mahaja et al., 2008). Chemical fertilizers tend to release high concentrations of nutrients into the soil within a short timeframe, often leading to pronounced plant responses, especially in terms of productivity (Hoque et al., 2022).

To improve the quality and ensure the safety of sweet corn products, organic farming methods are receiving much attention. In this context, vermicompost is considered a promising alternative to traditional fertilizers due to its high nutrient content and abundance of biologically active microorganisms (Bejbaruah et al., 2013), as well as humic acid, a plant growth stimulant, and indole-3-acetic acid (IAA), one of the important plant growth regulators that promotes healthy plant growth (Adhikary, 2012). Although the benefits of vermicompost for crops such as watercress and tomatoes (Arancon et al., 2003), mung beans and corn (Zaremanesh et al., 2017) have been documented, the use of vermicompost in sweet corn cultivation in Tra Vinh has not yet been fully studied. Therefore, this study was conducted to determine the most effective time to apply vermicompost to contribute to improving the efficiency of sweet corn cultivation in an environmentally friendly manner.

2 Materials and methods

2.1 Research subjects and period

Research subject: The sweet corn variety Rong Vang F1, originating from Thailand, with an average growth duration of 66 to 72 days.

Survey subject: The effect of Phuoc Hiep vermicompost, a nutrient-rich organic fertilizer, on the growth and development of sweet corn. Vermicompost is an organic waste product created by earthworms digesting food sources such as animal manure (cow, pig), organic waste (vegetables, coffee grounds,

leaves), and earthworm biomass. It contains easily absorbed macro, micro, and trace elements, as well as beneficial microorganisms.

The study was conducted from July to October 2023, at the Experimental and Research Farm of Tra Vinh University. Address: Hamlet 1, Ward 9, Tra Vinh City, Tra Vinh Province, Vietnam. At the time of the study, the maximum temperature ranged from 32°C–34°C and the minimum from 21°C–22°C, rainfall was 1,400–1,600 mm, and humidity was 80%–85%.

The soil at the experimental site was neutral, with a pH-H₂O of 6.8–6.9 and a pH-KCl of 6.0. Soil analysis revealed an organic matter content of 1.1%–1.2% (classified as medium) and a cation exchange capacity (CEC) of 16.7 meq/100 g (classified as high). In terms of nutrient content, the soil contained 0.10%–0.13% total nitrogen, 0.11% total phosphorus, and 1.42%–1.44% total potassium. Available phosphorus was recorded at 57.2–61.4 mg kg⁻¹, considered high according to FAO/UNESCO standards. Continuous calibration was performed to maintain adequate soil moisture throughout the growing season.

2.2 Materials and equipment

Material: sweet corn seeds (Rong Vang F1) and Vermicompost (Phuoc Hiep brand).

The equipment and tools used for the field experiment setup and implementation included a hoe, measuring tape, caliper, electronic scale, and pesticide sprayer.

2.3 Methods

The experiment was arranged in a Randomized Complete Block Design (RCBD) with one factor, consisting of 6 treatments and 5 replications. Each experimental plot contained 5 plants. Data were collected from all five plants in each plot to ensure the highest representation of the experimental unit, resulting in a total of 25 plants monitored per treatment. Vermicompost are applied at a rate of 200 g per plant by scattering them around the base of each plant. Afterward, a light layer of soil is applied to minimize nutrient loss and enhance microbial activity.

Growth parameters were monitored, including plant height, stem diameter, number of leaves, days to

tasseling, and days to silking. Yield components included ear length, ear diameter, number of kernel rows per ear, number of kernels per row, kernel weight, theoretical yield, and actual yield (based on QCVN 01-56:2011/BNNPTNT). Theoretical yield= (number of

fruits/trees x number of trees/m² x number of kernel rows/ear x number of kernels/row x 1000-kernel weight)/ 10 000.

Actual yield (AQ) is the actual yield obtained per planted area.

Table 1 Arrangement of timing and dosage of vermicompost application

Treatment	Fertilizer application time
Control	No fertilization
Trt 1	5 Days After Sowing (DAS) + 200 g
Trt 2	10 DAS + 200 g
Trt 3	20 DAS + 200 g
Trt 4	30 DAS + 200 g
Trt 5	40 DAS + 200 g

2.4 Statistical analysis

The collected data were processed and statistically analyzed using Excel and SPSS version 22.0. Analysis of variance (ANOVA) was performed to assess the differences among treatments, and Duncan's multiple range test was used to compare mean values at the 1% and 5% significance levels.

3 Results and discussion

3.1 Effect of vermicompost application timing on the growth and development of sweet corn Rong Vang F1

Sweet corn leaves are not only the primary organs for photosynthesis but also play roles in other physiological processes such as respiration and nutrient storage, which support plant growth. Therefore, the number of leaves, leaf longevity, and the photosynthetic efficiency of the canopy are key factors influencing both the yield and grain quality of sweet corn (Mai et al., 2022). According to researchers,

approximately 90%–95% of the dry matter accumulated in plants is the result of leaf activity (Tran, 2003).

The results in Table 2 show that the timing of vermicompost application significantly affected the number of leaves at different growth stages. At 13 and 20 DAS, Treatment 1 (Trt 1) recorded the highest number of leaves (5.60 and 7.56 leaves, respectively), with statistically significant differences at the 1% level compared to other treatments. This indicates that early application of vermicompost promotes faster leaf development during the initial growth phase. From 27 to 48 days, treatments with vermicompost application—particularly Trt 1, Trt 3, and Trt 5—consistently produced a significantly higher number of leaves than the control. Among them, Trt 5 and Trt 3 recorded the highest leaf counts at 41 and 48 days (12.42 and 13.32 leaves, respectively). These findings are consistent with the results reported by Mai et al. (2022).

Table 2 Effect of vermicompost application timing on the number of leaves in different treatments

Treatment	Number of leaves					
	13	20	27	34	41	48
Control	5.42 ^b	6.84 ^b	8.16 ^a	9.42 ^c	11.92 ^c	12.58 ^c
Trt 1	5.60 ^a	7.56 ^a	8.60 ^a	10.12 ^b	12.24 ^{ab}	13.24 ^{ab}
Trt 2	5.36 ^b	7.30 ^b	8.72 ^a	10.06 ^b	11.98 ^{bc}	12.88 ^{bc}
Trt 3	5.36 ^b	7.02 ^b	8.76 ^a	10.70 ^a	12.46 ^a	13.32 ^a
Trt 4	5.36 ^b	6.90 ^b	8.46 ^a	10.16 ^b	12.06 ^{bc}	12.84 ^{bc}
Trt 5	5.30 ^b	6.96 ^b	7.30 ^b	10.18 ^b	12.42 ^a	13.32 ^a
F	**	**	*	*	**	**
CV%	2.59	5.92	9.36	5.74	2.38	2.99

Note: Means followed by the same letter are not significantly different according to Duncan's multiple range test; **: significant at 1% level; *: significant at 5% level.

During the seedling stage, leaf growth was relatively slow in all treatments, but accelerated rapidly as the plants entered the reproductive stage. By the tasseling stage (approximately 48 days after sowing), the Rong Vang F1 sweet corn in treatment 3 (Trt 3) reached a maximum of 13.32 leaves/plant. In contrast, the control treatment consistently showed lower leaf numbers throughout the observation periods, highlighting the important role of vermicompost in promoting foliage development. Statistical analysis confirmed that the timing of vermicompost application is a key factor influencing the appearance and maintenance of foliage in sweet corn.

According to the data in Table 3, at 13 and 20 DAS, Trt 1 and Trt 2 exhibited the greatest plant heights, reaching 34.30 cm and 33.42 cm at 13 DAS, and 75.36 cm and 75.54 cm at 20 DAS, respectively. These differences were statistically significant at the 5% level, indicating that early application of vermicompost effectively promotes plant height growth during the early developmental stage. At 27 DAS, although no statistically significant difference was observed (ns),

Trts 2 and 3 still showed a tendency for greater plant height compared to the control. From 34 to 48 DAS, the differences became more pronounced, with Trt 3 recording the highest plant height, particularly at 48 DAS (196.82 cm), which was significantly higher than the control (187.68 cm) at the 1% significance level. Meanwhile, Trts 1, 2, and 5 also exhibited greater plant heights than the control during this period, indicating the cumulative effect of vermicompost on enhancing plant height in later growth stages. Statistical analysis using the F-test revealed significant differences at 13, 20, 34, 41, and 48 DAS, reinforcing the conclusion that the timing of vermicompost application is a key factor influencing plant height. The observed plant heights in this study exceeded those reported for inbred sweet corn lines from generations S4 to S6, which ranged from 94.75 to 134.88 cm and originated from China, the United States, Thailand, the Philippines, and Taiwan (Tran et al., 2013) and were lower than the plant height of the sweet corn variety DL89, which ranged from 200.1 to 214.9 cm (Cao, 2013).

Table 3 Effect of vermicompost application timing on plant height

Treatment	Plant Height (cm)					
	13	20	27	34	41	48
Control	28.76 ^c	65.90 ^b	100.62	119.36 ^b	180.28 ^c	187.68 ^c
Trt 1	34.30 ^a	75.36 ^a	105.64	134.22 ^a	185.16 ^{bc}	193.88 ^{ab}
Trt 2	33.42 ^{ab}	75.54 ^a	106.96	127.36 ^{ab}	188.48 ^{ab}	190.02 ^{bc}
Trt 3	30.96 ^{abc}	74.82 ^a	107.68	134.24 ^a	191.62 ^a	196.82 ^a
Trt 4	30.76 ^{bc}	69.38 ^{ab}	102.88	130.04 ^{ab}	185.08 ^{bc}	189.62 ^{bc}
Trt 5	30.94 ^{bc}	70.14 ^{ab}	100.76	118.76 ^b	184.96 ^{bc}	193.88 ^{ab}
F	*	*	ns	*	*	**
CV%	9.07	8.37	5.42	7.97	2.89	2.45

Note: Means followed by the same letter are not significantly different according to Duncan's multiple range test; **: significant at 1% level; *: significant at 5% level.

The data in Table 4 indicate that the timing of vermicompost application had a significant effect on stem diameter during various growth stages. At 13 and 20 DAS, treatments with vermicompost particularly Trts 1, 2, and 3 exhibited greater stem diameters compared to the control. Among them, Trts 1 and 3 recorded the highest values (1.21 cm), with statistically

significant differences at the 5% level, suggesting that early application of vermicompost promotes stem development during the early growth stage. At the later stages (27–48 DAS), treatments with vermicompost continued to maintain higher stem diameters compared to the control. Notably, Trts 3 and 5 recorded the highest values at 48 DAS (2.71 cm and 2.49 cm,

respectively), with statistically significant differences at the 1% level compared to the control (2.16 cm). At most observation points, the control consistently exhibited markedly lower stem diameter values, highlighting the positive impact of vermicompost on stem development. F-values indicated statistically significant differences at all time points, reinforcing the conclusion that the timing of vermicompost application is a key factor influencing stem diameter growth. Among the treatments, Trt3 demonstrated the most pronounced effect in promoting stem diameter expansion.

According to Atiyeh et al. (2002), vermicompost contains a balanced nutrient profile along with beneficial microorganisms that enhance soil structure and improve nutrient uptake. These factors contribute to the stimulation of cambial activity, thereby increasing stem diameter. Additionally, vermicompost provides natural plant growth regulators such as auxins and cytokinins, which promote cell division and the thickening of basal tissues. Therefore, applying vermicompost at an appropriate time, as demonstrated in Trt3 can serve as an effective biological strategy to enhance stem diameter, ultimately improving plant vigor and yield potential.

Table 4 Effect of Vermicompost Application Timing on Stem Diameter

Treatment	Stem diameter (cm)					
	13	20	27	34	41	48
Control	0.68 ^b	1.12 ^{abc}	1.47 ^b	1.73 ^c	2.02 ^c	2.16 ^c
Trt 1	0.87 ^a	1.21 ^a	1.54 ^b	2.02 ^{ab}	2.13 ^{bc}	2.27 ^{bc}
Trt 2	0.86 ^a	1.18 ^{ab}	1.62 ^{ab}	1.88 ^{bc}	2.03 ^c	2.19 ^c
Trt 3	0.85 ^a	1.21 ^a	1.76 ^a	2.10 ^a	2.55 ^a	2.71 ^a
Trt 4	0.83 ^a	1.08 ^{bc}	1.49 ^b	1.87 ^{bc}	2.08 ^c	2.20 ^c
Trt 5	0.84 ^a	1.03 ^c	1.47 ^b	1.94 ^{ab}	2.37 ^{ab}	2.49 ^{ab}
F	*	*	*	**	**	*
CV%	10.97	8.77	10.89	8.33	12.27	10.68

Note: Means followed by the same letter are not significantly different according to Duncan's multiple range test; **: significant at 1% level; *: significant at 5% level.

The results in Table 5 show that, regarding days to tasseling, the control treatment exhibited the latest tasseling time (49.39 days), which was significantly different at the 1% level compared to the other treatments. All treatments with vermicompost application shortened the tasseling period, with Trt3 showing the earliest tasseling time (45.26 days). This indicates that vermicompost application, particularly when applied at an appropriate time, can accelerate the tasseling process in sweet corn. Similarly, the silking time of treatments with vermicompost application was significantly earlier than that of the control (51.80 days), with Trt3 recording the earliest silking time (48.53 days), showing a statistically significant difference at the 5% level. The findings suggest that vermicompost not only accelerates plant development but also contributes to the shortening of key growth stages. The coefficients of variation (CV%) for both

indicators were low (below 5%), indicating high data stability and reliability. Overall, vermicompost application, particularly in Trts 3 and 5, significantly enhanced plant growth and reduced the duration to tasseling. Physiologically, this enhancement can be attributed to the fact that vermicompost supplies readily available organic nutrients (such as nitrate, phosphate, and potassium), along with beneficial microorganisms and natural plant growth hormones (such as auxins and gibberellins) (Nguyen et al., 2024). These factors not only stimulate root system development but also enhance enzymatic activity and metabolic processes, thereby promoting reproductive differentiation. According to studies by Atiyeh et al. (2002) and Sinha et al. (2010) vermicompost has the potential to accelerate the physiological maturity of plants, leading to earlier flowering and fruiting compared to the use of conventional chemical

fertilizers.

Table 5 Effect of Vermicompost Application Timing on Days to Tasseling and Silking

Treatment	Days to Tasseling	Days to Silking
Control	49.39 ^a	51.80 ^a
Trt 1	46.19 ^{bc}	49.13 ^{bc}
Trt 2	48.66 ^{ab}	51.06 ^{ab}
Trt 3	45.26 ^c	48.53 ^c
Trt 4	46.86 ^{bc}	50.53 ^{abc}
Trt 5	46.33 ^{bc}	49.66 ^{bc}
F	**	*
CV%	4.64	3.53

Note: Means followed by the same letter are not significantly different according to Duncan's multiple range test; **: significant at 1% level; *: significant at 5% level.

3.2 Effect of vermicompost application timing on sweet corn yield

Determining the optimal harvest time for sweet corn is far more important than for regular corn, as the fresh eating quality of sweet corn changes very quickly within just a few days. Typically, sweet corn is ready for harvest about 18 to 22 days after the plant begins to tassel.

The results presented in Table 6 demonstrate that vermicompost application significantly influenced the characteristics of sweet corn, as reflected in ear length and diameter. In terms of ear length, all treatments with vermicompost showed greater values compared to the control (26.73 cm), with Trt3 recording the highest length (31.25 cm), a statistically significant difference at the 5% level. This suggests that the timing of vermicompost application in Trt3 was optimal for promoting ear elongation. As for ear diameter, the differences among treatments were even more pronounced, with statistical significance at the 1% level. Trt3 again achieved the highest value (5.91 cm), followed by Trt1 (5.70 cm), whereas the control had

the smallest diameter (5.16 cm). These findings confirm that vermicompost application can significantly enhance both the length and girth of sweet corn ears.

These findings are consistent with the results of Nguyen et al. (2024), which demonstrated that vermicompost application significantly enhances plant height, leaf number, and yield compared to the unfertilized control. Additionally, other studies have highlighted that vermicompost is a nutrient-rich organic fertilizer containing natural plant growth regulators such as auxins, gibberellins, and cytokinins. According to Sinha et al. (2010), these hormones play essential roles in promoting plant growth and yield, particularly in fruit-bearing vegetables. Furthermore, vermicompost improves soil structure and stimulates beneficial microbial activity in the rhizosphere, thereby contributing to enhanced crop quality and productivity. Collectively, these findings support the potential of vermicompost as a sustainable alternative to chemical fertilizers in modern agriculture.

Table 6 Effect of vermicompost application timing on ear length and diameter

Treatment	Ear length (cm)	Ear diameter (cm)
Control	26.73 ^b	5.16 ^d
Trt 1	29.19 ^{ab}	5.70 ^{ab}
Trt 2	28.86 ^{ab}	5.37 ^{cd}
Trt 3	31.25 ^a	5.91 ^a
Trt 4	28.39 ^b	5.53 ^{bc}
Trt 5	28.99 ^{ab}	5.57 ^{bc}
F	*	**
CV%	7.19	5.23

Note: Means followed by the same letter are not significantly different according to Duncan's multiple range test; **: significant at 1% level; *: significant at 5% level.

Corn yield is determined by three factors: number of fruits/trees, number of trees/m², number of kernel rows/ear, and number of kernels/row x 1000-kernel weight. Therefore, kernel weight is one of the direct components of the final yield. The weight of 1000 kernels is a genetic trait characteristic of the variety, but it also directly reflects environmental conditions. Heavier kernels indicate better accumulation of dry matter in the kernels (the heading stage), resulting in plump, non-empty kernels. The results in Table 7 show that the timing of vermicompost application had a significant effect on sweet corn yield components, including the number of kernel rows/ear, the number

of kernels/row, and the 1000 kernel weight. The control treatment (without vermicompost) recorded the lowest values for all three parameters, whereas treatments with vermicompost, especially Trt3 performed significantly better. Specifically, Trt3 produced the highest number of kernel rows (15.86), the greatest number of kernels per row (38.33), and the heaviest 1000-kernel weight (493.36 g), with statistically significant differences at the 1% level. These findings indicate that appropriately timed vermicompost application markedly improves kernel development and biomass accumulation in sweet corn.

Table 7 Effect of vermicompost application timing on sweet corn yield components

Treatment	Number of kernel rows/ear	Number of kernels/row	1000-kernel weight (g)
Control	14.26 ^b	32.66 ^b	448.70 ^c
Trt 1	15.59 ^a	37.26 ^a	477.40 ^b
Trt 2	14.79 ^{ab}	35.39 ^{ab}	471.42 ^b
Trt 3	15.86 ^a	38.33 ^a	493.36 ^a
Trt 4	14.99 ^{ab}	35.66 ^{ab}	465.24 ^b
Trt 5	15.06 ^{ab}	37.13 ^a	474.68 ^b
F	**	**	**
CV%	5.89	8.31	3.70

Note: Means followed by the same letter are not significantly different according to Duncan's multiple range test; **: significant at 1% level; *: significant at 5% level.

Table 8 The effect of vermicompost application timing on sweet corn yield (tons ha⁻¹)

Treatment	Theoretical yield	Actual yield
CT	10.5 ^e	9.3 ^f
Trt 1	14.0 ^b	11.7 ^b
Trt 2	12.3 ^d	10.3 ^c
Trt 3	15.0 ^a	12.6 ^a
Trt 4	12.4 ^d	10.5 ^d
Trt 5	13.3 ^c	11.4 ^c
F	**	**
CV%	11.5	9.8

Note: Means followed by the same letter are not significantly different according to Duncan's multiple range test; **: significant at 1% level; *: significant at 5% level.

3.3 The effect of vermicompost application timing on sweet corn yield

Data on theoretical and actual yields presented in Table 8 show clear differences between the times of vermicompost application. Statistical analysis results show that the timing of vermicompost application had a very significant effect ($p < 0.01$) on both the theoretical and actual yields of sweet corn. Treatment 3 achieved the highest yield, with an actual yield of

12.6 tons ha⁻¹, 35.5% higher than the control. This result is consistent with observations on yield components such as 1000-grain weight (493.36 g) and number of grains per row (38.33 grains), which also reached the highest values at Treatment 3. The increase in yield at Treatment 3 may be due to the application of vermicompost at the time of 20 DAS coinciding with the stage when the corn plant begins to grow strongly in biomass and prepares for reproductive

organ differentiation. At this point, plant growth regulators such as auxin and cytokinin in vermicompost stimulated cell division and optimized the photosynthetic capacity of the leaves. All treatments supplemented with vermicompost showed superior actual yields (from 10.3 to 12.6 tons ha⁻¹) compared to the control group (9.3 tons ha⁻¹). This demonstrates that the use of vermicompost not only improves growth characteristics but is also a key factor in ensuring yield in sweet corn cultivation.

4 Conclusion

Research results show that the timing of vermicompost application significantly affects the growth and yield components of the Rong Vang F1 sweet corn variety. In the treatments, applying 200 g of vermicompost 20 days after sowing in Treatment 3 yielded the most positive results in terms of plant height, stem diameter, and number of leaves; it also shortened the tasseling and silking time and improved indicators such as ear size, kernel weight, theoretical yield, and actual yield compared to the control. These results confirm that applying vermicompost at the right time, especially 20 days after sowing, plays a crucial role in promoting growth and increasing sweet corn yield under field cultivation conditions.

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