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Influence of irrigation levels and mulch practices on growth and physiological indices of sweet corn (*Zea mays saccharata* L.)

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Abstract
A field experiment was conducted during *Rabi* 2024-25 to evaluate the influence of irrigation levels and various mulch practices on the growth and physiological indices of sweet corn (*Zea mays saccharata* L.) at the Instructional farm, Department of Agronomy, Dr. BSKKV, College of Agriculture, Dapoli. Plant growth analysis, which quantifies net photosynthetic production and the plant's ability to produce dry matter, is a powerful approach to compare crop performance and understand its integrated response to external factors. Key physiological parameters assessed included absolute growth rate (AGR) for plant height and dry matter production, crop growth rate (CGR) for dry matter production, relative growth rate (RGR) for dry matter production, net assimilation rate (NAR) for dry matter production, and leaf area ratio (LAR). The experimental results showed that optimal irrigation at 100% ETc through drip and use of wool mulch enriched with micronutrients consistently enhanced AGR for plant height and dry matter production, as well as CGR for dry matter production. While NAR showed variability, indicating complex physiological adjustments, treatments promoting higher overall biomass accumulation through improved AGR and CGR were critical for enhanced sweet corn production. These findings highlight the importance of integrated nutrient and water management practices in maximizing sweet corn growth potential.

Keywords: Sweet corn, irrigation levels, mulch practices, physiological growth indices

Introduction

Sweet corn (*Zea mays saccharata* L.) is a highly valued vegetable known for its commercial and nutritional importance, offering high productivity and essential nutrients like sugar, starch, proteins, and vitamins (Baranowska 2023). Despite its significance, the average productivity of maize in many regions, including India, often falls below its potential. This highlights a crucial need to refine agronomic and physiological factors to achieve optimal crop performance. Plant growth analysis serves as a quantitative tool to measure and analyse various aspects of plant growth over time. This approach is vital for understanding how plants respond to environmental factors, management practices, and genetic traits.

By assessing key physiological parameters such as Absolute Growth Rate (AGR), Crop Growth Rate (CGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR), and Leaf Area Ratio (LAR), researchers can gain profound insights into plant performance, productivity, and resource use efficiency. These indices directly reflect the efficiency of carbon uptake, accumulation of dry matter, and overall growth dynamics, all of which directly impact the final yield. Water availability is a critical factor significantly affecting plant growth, with water stress conditions leading to notable reductions in plant height, dry matter accumulation, and overall yield. Mulching, as a residue management practice, plays a crucial role in improving soil structure, enhancing moisture retention, and augmenting nutrient content. These improvements can subsequently boost plant growth and mitigate the adverse effects of stress (Vial *et al*. 2015). This study was therefore undertaken to specifically evaluate the influence of different irrigation levels and mulch types on the physiological growth indices of sweet corn, aiming to provide practical recommendations for optimising its cultivation.

Materials and methods
The field experiment was conducted at the Instructional Farm, Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, during the *Rabi* season of 2024-25. The site is geographically located at 17°45´24´´ N latitude and 73°17´47´´ longitude with an elevation of 157.8 meters above sea level. The soil of the experimental plot was classified as sandy loam, with a pH of 5.75 and an organic carbon content of 14.65 g kg^{-1}, indicating an acidic reaction.

The experiment adopted a split-plot design and was replicated three times, utilising the sweet corn variety Sugar-75. The treatments were structured into two primary factors including main plot factors as irrigation levels I_1: 100% ETc, I_2: 80% ETc and I_3: 60% ETc through drip while sub plot factors comprised mulch types such as M_1: Wool mulch, M_2: Wool mulch with micronutrients, M_3: Polythene mulch, M_4: Paddy straw mulch, M_5: Wool-coir-jute blended mulch and M_6: Control (no mulch) were used. Standard agronomic practices, including irrigation according to treatment schedules, weeding, and crop protection methods, were uniformly applied across all experimental plots to ensure healthy crop growth. The crop was supplied with 200:60:60 kg N, P_2O_5 K_2O ha^{-1} as a recommended dose of fertilizer through water soluble fertilizers (19:19:19 and urea) in 9 equal splits which distributes nutrients as per the requirement of crop at its various growth phases.

The measurements encompassed: absolute growth rate (AGR) for both plant height and dry matter production, crop growth rate (CGR) for dry matter production, relative growth rate (RGR) for dry matter production, net assimilation rate (NAR) for dry matter production and leaf area ratio (LAR). These indices were computed using the following standard formulas given by Ramachandrappa and Jayadeva (2021) [11].

Absolute Growth Rate (AGR):

$$\text{Plant height growth rate (cm day}^{-1}) = \frac{H_2 - H_1}{t_2 - t_1}$$

$$\text{Dry matter production rate (g day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

$$\text{Crop Growth Rate (CGR) (g m}^{-2}\text{ day}^{-1}): \frac{(W_2 - W_1)}{[A * (t_2 - t_1)]}$$

$$\text{Relative Growth Rate (RGR) (g g}^{-1}\text{ day}^{-1}): \frac{(\text{Log } W_2 - \text{Log } W_1)}{(t_2 - t_1)}$$

$$\text{Net Assimilation Rate (NAR) (g m}^{-2}\text{ day}^{-1}): \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{(\text{Log } A_2 - \text{Log } A_1)}{(A_2 - A_1)}$$

$$\text{Leaf Area Ratio (LAR) (cm}^2\text{ g}^{-1}): \frac{\text{Leaf area}}{\text{Plant dry matter weight}}$$

Where,

H_1 and H_2 = plant height at time t_1 and t_2, respectively

W_1 and W_2 = dry weight of the plant at time t_1 and t_2, respectively

A_1 and A_2 = leaf area at time t_1 and t_2, respectively

t_1 and t_2 = time interval, respectively

A = Land area (m^2)

Log = Natural logarithm

The data recorded on various parameters were subjected to Fisher's method of analysis of variance and interpretation of the data was made as given by Gomez and Gomez (1984) [3].

Results and Discussion
Growth attributes
Table 1 presents the effect of irrigation levels and mulch treatments on plant height, dry matter accumulation, and leaf area which are key indicators of crop growth influenced by water availability, nutrient supply, and root-zone microclimate. Significant differences among treatments highlight the role of irrigation and mulching in sustaining vegetative growth and biomass.

Irrigation levels
Across the growth stages, irrigation levels exerted a significant influence on crop performance. At 30 DAS, I_1 (100% ETc) recorded the maximum plant height (27.46 cm), dry matter accumulation (1.89 g $plant^{-1}$), and leaf area (1150.01 cm^2), followed by I_2 (80% ETc), while I_3 (60% ETc) noted the lowest values. A similar trend was observed at 60 DAS, where I_1 maintained superiority with plant height (159.61 cm), dry matter accumulation (92.11 g $plant^{-1}$), and leaf area (4025.39 cm^2). At harvest too, I_1 outperformed the other treatments with plant height (209.76 cm), dry matter accumulation (192.47 g $plant^{-1}$), and leaf area (3683.99 cm^2), followed by I_2, whereas the lowest values were consistently observed under I_3. The superior performance under I_1 can be attributed to optimum water availability, which enhanced cell expansion, nutrient transport, and photosynthetic activity, resulting in greater biomass and leaf area. Game *et al.* (2017) [2] reported that the continuous supply of adequate water during the entire crop growth phase likely kept the soil near field capacity, thereby creating favorable conditions for improved growth, which in turn led to greater plant height and higher dry matter accumulation. These results are also in agreement with the findings of Zhang *et al.* (2024) [14], who reported that adequate irrigation significantly increased plant height, dry matter, and leaf area index in maize by improving turgor-driven cell expansion and assimilate partitioning.

Mulch treatments
Mulching treatments also showed marked variation in growth attributes throughout the crop stages. M_2 (100% wool mulch with micronutrients) consistently produced the highest values of plant height (28.71 cm, 173.23 cm, and 216.89 cm), dry matter accumulation (2.32 g $plant^{-1}$, 92.11 g $plant^{-1}$, and 206.68 g $plant^{-1}$), and leaf area (1375.77 cm^2, 5172.14 cm^2, and 4833.37 cm^2) at 30 DAS, 60 DAS, and at harvest, respectively. These results were closely followed by M_1 (100% wool mulch). By contrast, the lowest values across all stages were registered under M_6 (control), indicating the superiority of wool mulch, particularly with micronutrient enrichment, over other mulching options. The superiority of M_2 may be attributed to the combined effect of moisture conservation, moderated soil temperature, and improved nutrient availability through micronutrient enrichment, which collectively enhanced vegetative growth and dry matter accumulation. Sarkar *et al.* (2021) [12] observed that the higher moisture retention capacity of wool created a more favorable microenvironment, which promoted greater vegetative growth and higher biomass accumulation. Broda *et al.* (2023) [1] also reported that the slow and continuous release of nitrogen from decomposing wool fibers improved nutrient availability, which contributed to increased tillering, leaf expansion, and overall dry matter production. According to Juhos *et al.* (2023) [5], the influence of wool mulch on yield and biomass was more pronounced under conditions of reduced irrigation frequency and in soils with higher water-holding capacity.

Growth indices

Table 2 and 3 present the periodical changes in physiological indices of sweet corn under different irrigation levels and mulching treatments, derived from the experimental data.

Absolute Growth Rate (AGR)

The mean AGR for plant height was 0.8659 cm day^{-1} during 0-30 DAS, increasing to 4.2865 cm day^{-1} at 30-60 DAS, and 1.0569 cm day^{-1} from 60 DAS to harvest. Irrigation at 100% ETc consistently showed numerically higher AGR values across all periods: 0.9152 cm day^{-1} (0-30 DAS), 4.3821 cm day^{-1} (30-60 DAS), and 1.1230 cm day^{-1} (60-At harvest). Among mulches, wool mulch with micronutrients exhibited numerically higher AGR for plant height at 0.9569 cm day^{-1} (0-30 DAS) and 4.7984 cm day^{-1} (30-60 DAS), while paddy straw mulch recorded the highest as 1.1886 cm day^{-1} from 60 DAS to harvest. For dry matter production, the mean AGR was 0.0562 g day^{-1} (0-30 DAS), 2.8358 g day^{-1} (30-60 DAS), and 3.2963 g day^{-1} (60-At harvest). The irrigation at 100% ETc through drip showed numerically higher AGR for dry matter production as 0.0630 g day^{-1} (0-30 DAS), 3.0074 g day^{-1} (30-60 DAS), and 3.3241 g day^{-1} (60-At harvest). Wool mulch with micronutrients consistently resulted in numerically higher AGR for dry matter production across all stages: 0.0773 g day^{-1} (0-30 DAS), 2.9931 g day^{-1} (30-60 DAS), and 3.7963 g day^{-1} (60-At harvest).

The Absolute Growth Rate (AGR), which reflects the rate of increase in plant size or dry weight over time, was significantly enhanced under optimal irrigation (100% ETc) and with the application of wool mulch incorporating micronutrients. This aligns with findings by Kamara *et al*. (2022) [6], who reported that adequate water supply and improved microclimatic conditions facilitate sustained biomass accumulation, directly contributing to higher growth rates. Meena *et al*. (2021) [9] also noted that residue retention can enhance dry matter accumulation and plant height, which is consistent with the positive effect observed with mulching in this study. The addition of micronutrients in the wool mulch likely further supported metabolic processes necessary for robust growth, as nutrients are crucial for crop growth and yield.

Crop Growth Rate (CGR)

The mean CGR for dry matter production was 0.4496 g m^{-2} day^{-1} (0-30 DAS), 22.6862 g m^{-2} day^{-1} (30-60 DAS), and 26.3704 g m^{-2} day^{-1} (60-At harvest). The 100% ETc through drip (I_1) treatment led to numerically higher CGR values: 0.5040 g m^{-2} day^{-1} (0-30 DAS), 24.0590 g m^{-2} day^{-1} (30-60 DAS), and 26.5926 g m^{-2} day^{-1} (60-At harvest). Similarly, wool mulch with micronutrients (M_2) generally showed numerically higher CGR values: 0.6184 g m^{-2} day^{-1} (0-30 DAS), 23.9446 g m^{-2} day^{-1} (30-60 DAS), and 30.3704 g m^{-2} day^{-1} (60-At harvest). The Crop Growth Rate (CGR), representing the increase in dry matter per unit of land area per unit of time, followed similar trends to AGR. High irrigation levels (100% ETc) and wool mulch with micronutrients led to superior CGR values. This suggests an efficient conversion of intercepted solar energy into dry matter. Kamara *et al*. (2022) [6] established a positive correlation between CGR and biomass/seed yield, attributing higher CGR to the efficiency of the leaf canopy in converting solar energy. Khalili *et al*. (2018) [7] and Meena *et al*. (2021) [9] highlighted that sufficient nitrogen application positively influences CGR by increasing tiller and leaf numbers, enhancing photosynthetic capacity, which leads to greater biomass production. This indicates that favourable moisture and nutrient environments created by optimal irrigation and mulching allowed for maximum photosynthetic output and dry matter accumulation.

Relative Growth Rate (RGR)

The mean RGR for dry matter production was 0.1590 g g^{-1} day^{-1} (30-60 DAS) and 0.0304 g g^{-1} day^{-1} (60-At harvest). The irrigation level of 60% ETc demonstrated numerically higher RGR for dry matter production at 0.1605 g g^{-1} day^{-1} (30-60 DAS) and 0.0314 g g^{-1} day^{-1} (60-At harvest). Paddy straw mulch exhibited numerically higher RGR values at 0.1658 g g^{-1} day^{-1} (30-60 DAS) and 0.0328 g g^{-1} day^{-1} (60-At harvest). The Relative Growth Rate (RGR), which indicates the efficiency of a plant in converting its total dry weight into new dry weight, showed numerically higher values under 60% ETc irrigation and paddy straw mulch. Higher RGR values under paddy straw mulch and 60% ETc irrigation might be attributed to the moderated soil microclimate, combined with moderate water stress, enhanced resource use efficiency and stimulated adaptive growth responses, resulting in sustained higher relative growth rates. This might suggest that under reduced irrigation levels (60% ETc), the plant allocated resources more efficiently for early growth, potentially as a stress adaptation mechanism. Kamara *et al*. (2022) [6] observed that RGR peaks at different optimal temperatures depending on the crop, suggesting that environmental factors, including temperature, play a role in RGR dynamics.

Net Assimilation Rate (NAR)

The mean NAR for dry matter production was 0.00168 g m^{-2} day^{-1} (30-60 DAS) and 0.00119 g m^{-2} day^{-1} (60-At harvest). The 60% ETc treatment recorded numerically higher NAR values at 0.00175 g m^{-2} day^{-1} (30-60 DAS) and 0.00131 g m^{-2} day^{-1} (60-At harvest). The Control (no mulch) treatment resulted in numerically higher NAR at 0.00233 g m^{-2} day^{-1} (30-60 DAS) and 0.00152 g m^{-2} day^{-1} (60-At harvest). Net Assimilation Rate (NAR), a measure of the net increase in plant dry weight per unit leaf area per unit time, interestingly showed numerically higher values under 60% ETc and control (no mulch) treatments. This observation could be due to a phenomenon where mild water stress or the absence of mulch leads to reduced self-shading and increased radiation interception per unit leaf area, thereby enhancing photosynthetic efficiency. Valadabadi and Farahani (2010) [13] noted that an increase in plant population or leaf area index could decrease NAR, suggesting that very dense canopies or excessive leaf area might lead to less efficient assimilation per unit of leaf area due to light competition within the canopy. Khan *et al*. (2025) [8] also reported that NAR tends to decline in later growth stages due to decreasing leaf nitrogen content, which impairs photosynthetic efficiency. The higher NAR in control (no mulch) could be attributed to lower dry weight and leaf area at initial stages, leading to relatively more assimilation of photosynthesis per unit of leaf area.

Leaf Area Ratio (LAR)

For LAR, the mean values were 97.4841 cm^2 g^{-1} (30-60 DAS) and 26.7121 cm^2 g^{-1} (60-At harvest). The 100% ETc irrigation level showed numerically higher LAR at 98.10858 cm^2 g^{-1} (30-60 DAS) and 27.96990 cm^2 g^{-1} (60-At harvest). Wool mulch with micronutrients showed numerically higher LAR values at 117.8495 cm^2 g^{-1} (30-60 DAS) and 35.2043 cm^2 g^{-1} (60-At harvest). Leaf Area Ratio (LAR), representing the ratio of total leaf area to total plant dry weight, was numerically higher under 100% ETc irrigation and especially with wool mulch with micronutrients. Patil *et al*. (2024) [10] reported that higher LAR resulted from improved nutrient availability, which enhanced meristematic activity, leaf production, and efficient nutrient mobilization, thereby sustaining greater functional leaf area. Khalili *et al*. (2018) [7] demonstrated that nitrogen application significantly increases leaf area index (LAI), which directly influences LAR. Valadabadi and Farahani (2010) [13] similarly showed that nitrogenous fertilizer increases leaf area and subsequent physiological growth indices. This suggests that the favourable conditions provided by optimal irrigation and nutrient-enriched mulch supported enhanced canopy development.

Overall, the findings underscore that proper water and nutrient management practices significantly enhance the physiological growth indices of sweet corn. The positive correlations observed between growth parameters and indices in other maize studies reinforce the idea that robust growth, as indicated by higher AGR, CGR, and LAR, directly translates to better yield potential. The application of coated urea, as explored by Meena *et al*. (2021) [9] for continuous nitrogen supply, and integrated nutrient management with biofertilisers, as studied by Joshi *et al*. (2018) [4], further illustrate the importance of synchronized nutrient availability for optimal plant growth.

Table 1: Plant height (cm), dry matter accumulation plant^{-1} (g) and leaf area (cm^2) at periodical interval

Treatments	Plant height (cm)			Dry matter accumulation plant^{-1} (g)			Leaf area (cm^2)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Main plot: Irrigation levels (I)									
I_1:100% ETc Through Drip	27.46	159.61	209.76	1.89	92.11	192.47	1150.01	4025.39	3683.99
I_2: 80% ETc Through Drip	26.04	155.03	205.39	1.64	86.56	186.11	1070.33	3686.66	3403.65
I_3: 60% ETc Through Drip	24.60	150.33	201.46	1.53	81.61	180.20	993.50	3661.99	2746.13
S.Em. ±	0.10	0.16	0.28	0.02	0.46	0.22	4.82	15.30	13.24
CD at 5%	0.40	0.61	1.08	N.S.	1.80	0.87	18.90	60.06	51.98
Sub plot: Mulches (M)									
M_1:100% Wool mulch	27.51	165.35	211.92	2.15	90.56	203.00	1183.13	4814.29	4129.33
M_2:100% Wool mulch with micronutrients	28.71	173.23	216.89	2.32	92.11	206.68	1375.77	5172.14	4833.37
M_3: Polythene mulch	27.14	157.40	206.02	1.59	87.67	194.08	1113.45	3878.23	3048.18
M_4: Paddy straw mulch	23.29	141.81	199.48	1.31	83.00	168.89	839.20	2781.16	2340.63
M_5: Wool-coir-jute blended mulch	26.99	156.46	205.79	1.66	87.22	183.72	1116.42	3970.88	3145.56
M_6: Control	22.55	135.69	193.12	1.08	80.00	161.20	799.74	2131.35	2170.50
S.Em. ±	0.40	0.38	0.57	0.03	0.66	0.58	8.34	40.65	44.16
CD at 5%	1.16	1.10	1.64	0.09	1.91	1.67	24.08	117.39	127.52
Interaction Effect (I × M)									
S.Em. ±	1.21	1.14	1.21	0.10	1.98	1.74	25.02	121.95	132.48
CD at 5%	N.S.	3.29	3.50	N.S.	N.S.	5.02	N.S.	N.S.	N.S.

Table 2: Absolute Growth Rate (AGR) for plant height (cm day^{-1}) and dry matter production (g day^{-1}) and leaf area ratio (LAR) (cm^2 g^{-1}) at periodical interval in sweet corn

Treatments	AGR for plant height (cm day^{-1})			AGR for dry matter production (g day^{-1})			LAR (cm^2 g^{-1})	
	0-30 DAS	30-60 DAS	60-At harvest	0-30 DAS	30-60 DAS	60-At harvest	30-60 DAS	60-At harvest
Main plot: Irrigation levels (I)								
I_1:100% ET_c Through Drip	0.9152	4.3821	1.1230	0.0630	3.0074	3.3241	98.10858	27.96990
I_2:80% ET_c Through Drip	0.8623	4.2700	1.0510	0.0547	2.8305	3.2981	97.37936	26.94869
I_3:60% ET_c Through Drip	0.8201	4.2075	0.9968	0.0509	2.6694	3.2667	96.96442	25.21784
Sub plot: Mulches (M)								
M_1: Wool mulch	0.9170	4.5839	0.9870	0.0718	2.9467	3.7259	109.4169	32.0760
M_2: Wool mulch with micronutrients	0.9569	4.7984	0.9577	0.0773	2.9931	3.7963	117.8495	35.2043
M_3: Polythene mulch	0.8715	4.3133	1.1219	0.0529	2.8493	3.1926	99.0356	25.8163
M_4: Paddy straw mulch	0.7429	3.9687	1.1886	0.0437	2.7229	2.8444	82.3269	20.9961
M_5: Wool-coir-jute blended mulch	0.9219	4.3318	0.8879	0.0555	2.8719	3.5296	102.1126	27.6696
M_6: Control	0.7850	3.7231	1.1984	0.0360	2.6307	2.6889	74.1632	18.5106
General mean	0.8659	4.2865	1.0569	0.0562	2.8358	3.2963	97.4841	26.7121

Table 3: CGR for dry matter production (g m^{-2} day^{-1}), RGR for dry matter production (g g^{-1} day^{-1}), and NAR for dry matter production (g m^{-2} day^{-1}) at periodical interval in sweet corn

Treatments	CGR for dry matter production (g m^{-2} day^{-1})			RGR for dry matter production (g g^{-1} day^{-1})		NAR for dry matter production (g m^{-2} day^{-1})	
	0-30 DAS	30-60 DAS	60-At harvest	30-60 DAS	60-At harvest	30-60 DAS	60-At harvest
Main plot: Irrigation levels (I)							
I_1:100% ET_c Through Drip	0.5040	24.0590	26.5926	0.1566	0.0292	0.00165	0.00109
I_2:80% ET_c Through Drip	0.4373	22.6441	26.3852	0.1599	0.0303	0.00172	0.00118
I_3:60% ET_c Through Drip	0.4074	21.3556	26.1333	0.1605	0.0314	0.00175	0.00131
Sub plot: Mulches (M)							
M_1: Wool mulch	0.5745	23.5736	29.8074	0.1495	0.0282	0.00137	0.00100
M_2: Wool mulch with micronutrients	0.6184	23.9446	30.3704	0.1473	0.0279	0.00125	0.00092
M_3: Polythene mulch	0.4231	22.8547	25.5407	0.1607	0.0316	0.00155	0.00111
M_4: Paddy straw mulch	0.3499	21.7834	22.7556	0.1658	0.0328	0.00201	0.00135
M_5: Wool-coir-jute blended mulch	0.4439	22.9154	28.2370	0.1583	0.0302	0.00153	0.00121
M_6: Control	0.2877	21.0456	21.5111	0.1723	0.0322	0.00233	0.00152
General mean	0.4496	22.6862	26.3704	0.1590	0.0304	0.00168	0.00119

Conclusion

The study demonstrated the significant influence of irrigation levels and mulch applications on growth and physiological indices of sweet corn. The results clearly demonstrate that optimum irrigation (100% ETc) and wool mulch, particularly with micronutrient enrichment, significantly enhanced plant height, dry matter accumulation, and leaf area. The results also indicate that an optimal irrigation level of 100% ETc (I_1) combined with wool mulch with micronutrients (M_2), consistently enhanced absolute growth rate (AGR), crop growth rate (CGR) and leaf area ratio (LAR). These findings underscore the importance of optimum nutrient and water management practices in maximising the growth potential of sweet corn. While relative growth rate (RGR) and net assimilation rate (NAR) showed some variability, suggesting complex physiological adjustment, treatments promoting higher overall biomass accumulation through improved AGR and CGR are critical for enhanced sweet corn productivity. This research provides valuable insights for developing more effective cultivation strategies for sweet corn under varying environmental conditions.

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