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Growth indices of sweet corn as influenced by different nutrient levels in sweet corn-green gram cropping sequence

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Abstract
A field experiment was conducted during 2021-22 and 2022-23 at PGI, Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (India) to evaluate the growth indices of *rabi* sweet corn as influenced by different nutrient levels in sweet corn-green gram cropping sequence. The results of experiment indicated that, the higher growth indices *viz*., AGR, CGR, RGR, Leaf area index, Leaf area duration and net assimilation rate was observed with treatment (T_7) 100 % of RDF + *Acetobacter* (120:60:40 N, P_2O_5, K_2O kg ha^{-1}) than others treatments during both experimental years.

Keywords: Sweet corn, growth indices, nutrient levels, cropping sequence, relative growth rate (RGR), crop growth rate (CGR)

Introduction

Maize (*Zea mays* L.), a member of the Poaceae family, is one of the world's most widely cultivated cereal crops, grown in more than 150 countries. In India, it is cultivated on 9,958 hectares, yielding 33,730 tons of grain with a productivity of 3,387 kg ha^{-1} (Anonymous, 2022-23) [1]. In Maharashtra, maize is grown on 1,251 hectares, producing 3,584.78 tons annually with an average productivity of 2,882 kg ha^{-1} during 2021-22. Maize cultivation in the state is divided into *kharif* and *rabi* seasons. *Kharif* maize covers 811.47 hectares, yielding 2,186.10 tons with a productivity of 2,694 kg ha^{-1}, while *rabi* maize occupies 439.56 hectares, producing 1,398.68 tons with a productivity of 3,182 kg ha^{-1}. Sweet corn cultivation in Maharashtra is primarily concentrated in the districts of Kolhapur, Satara, and Pune. In Kolhapur district during 2022-23, *kharif* sweet corn was cultivated on 13.9 hectares, yielding 43.2 metric tons with a productivity of 3,108.3 kg ha^{-1} (Anonymous, 2022-23) [1].

Among various production practices, fertilizer management through inorganic fertilizers is a crucial agronomic practice for enhancing crop yield and maintaining soil fertility. Different essential nutrients can be readily applied to plants through inorganic fertilizers. However, the prevailing nutrient management strategies for these crops primarily rely on inorganic, chemical-based fertilizers, which pose significant risks to human health and the environment. The steeply rising costs of chemical fertilizers are severely limiting marginal farmers' ability to apply recommended doses. Consequently, the utilization of beneficial microorganisms as biofertilizers has become increasingly crucial in modern agriculture, given their potential to enhance food safety and promote sustainable crop production. Hence, introducing biofertilizers like Acetobacter to sweet corn is essential for improving soil fertility, boosting productivity, and reducing reliance on chemical fertilizers. *Acetobacter* applications not only increase nutrient availability to crops but also allow for a 50 % reduction in chemical nitrogen fertilizer use in sweet corn (Bidarkar and Murumkar, 2020) [2]. Therefore, it is necessary to investigate optimal levels of NPK to achieve higher yields and quality in sweet corn-green gram cropping sequences under various climatic conditions in Maharashtra.

The present investigation aimed to evaluate the growth indices of sweet corn as influenced by different nutrient levels in a sweet corn-green gram cropping sequence.

Material and Methods

A field experiment was conducted during 2021-22 and 2022-23 at PGI, Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar Maharashtra (India) to evaluate the growth indices of *rabi* sweet corn as influenced by different nutrient levels in sweet corn-green gram cropping sequence. The experiment employed a randomized block design in the *rabi* season and a split-plot design in the summer season. Each treatment was replicated three times in both years. Sweet corn treatments comprised seven nutrient levels: T_1 (Control), T_2 (50% of RDF), T_3 (50% of RDF + *Acetobacter*), T_4 (75% of RDF), T_5 (75% of RDF + *Acetobacter*), T_6 (100% of RDF) and T_7 (100% of RDF + *Acetobacter*), arranged in a randomized block design with three replications. Throughout the two-year study period, 'Sugar-75' sweet corn was cultivated. The soil of experiment was low in available nitrogen, medium in available phosphorus and high in available potassium content.

Results and Discussion

Absolute growth rate for plant height

Growth analysis revealed that absolute growth rates for plant height varied across different nutrient management treatments and growth stages, as shown in Table 1. The absolute growth rate for sweet corn plant height was increased rapidly between 45-60 DAS, then growth rate declined slowly up to harvest. The, data furnished in Table 1 pointed that treatment T_7 (100% of RDF + *Acetobacter*) produced the highest crop growth rate for plant height at 30-45 and 45-60 DAS was 3.325 and 5.869 cm day^{-1} $plant^{-1}$ during first year and 3.399 and 5.913 cm day^{-1} $plant^{-1}$ during second year, respectively as compared to rest of the treatments. Lower crop growth rate for plant height was recorded in treatment T_1 (control) at all the growth stages of crop during both years of experimentation. This increased growth may be attributed to greater nutrient availability and uptake, leading to enhanced photosynthesis and subsequent increases in plant height. These findings align with those reported by Wagh (2002) [8].

Absolute growth rate for dry matter (g day^{-1} plant^{-1})

Data pertaining to absolute growth rates for dry matter under different nutrient management treatments at various growth stages are presented in Table 1. Absolute growth rate exhibited an increasing trend with the advancement of crop age, reaching a peak at the growth interval of 45 to 60 days after sowing. The data presented in Table 1 revealed that highest absolute growth rate for dry matter was recorded in treatment T_7 (100% of RDF + *Acetobacter*) at 30-45 and 45-60 DAS was 5.555 and 5.923 g day^{-1} plant^{-1} during first year and 5.551 and 6.161 g day^{-1} plant^{-1} during second year, respectively as compared to rest of the treatments. Lower crop growth rate for dry matter was recorded under treatment T_1 (control) at all the growth stages of crop during both years of experimentation. Sweet corn plants, being highly responsive to nutrient application, exhibited increased metabolic activity when supplied with higher doses of nutrients. This enhanced metabolic activity led to increased photosynthesis, resulting in higher rates of dry matter production and subsequent enhanced vegetative growth. These findings are line with Wagh (2002) [8].

Table 1: Mean absolute growth rate for plant height and dry matter of sweet corn as influenced periodically by different nutrient management treatments

Treatment	AGR (cm day^{-1} plant^{-1})				AGR (g day^{-1} plant^{-1})			
	2021		2022		2021		2022	
	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS
T_1: Control	2.673	4.945	2.713	4.893	3.745	4.644	3.822	4.669
T_2: 50% of RDF	2.737	5.179	2.755	5.169	4.211	4.911	4.325	4.983
T_3: 50% of RDF + *Acetobacter*	2.997	5.482	3.025	5.537	5.139	5.492	5.056	5.784
T_4: 75% of RDF	2.863	5.474	2.984	5.431	4.675	5.207	4.713	5.313
T_5: 75% of RDF + *Acetobacter*	3.237	5.779	3.240	5.881	5.533	5.894	5.528	6.155
T_6: 100% of RDF	3.043	5.562	3.063	5.591	5.172	5.614	5.143	5.828
T_7: 100% of RDF + *Acetobacter*	3.325	5.869	3.399	5.913	5.555	5.923	5.551	6.161
General mean	2.982	5.470	3.026	5.488	4.862	5.384	4.877	5.556

Crop growth rate (g m^{-2} day^{-1})

Data furnished to crop growth rates under different nutrient management treatments at various growth stages are presented in Table 2. The data showed that crop growth rate increased with crop age, peaking between 45 and 60 days after sowing. The data displayed in Table 2 revealed that the maximum crop growth rate was observed in treatment T_7 (100% of RDF + *Acetobacter*) at 30-45 and 45-60 DAS was 0.463 and 0.494 g m^{-2} day^{-1} plant^{-1} during first year and 0.463 and 0.513 g m^{-2} day^{-1} plant^{-1} during second year, respectively. The minimum crop growth rate was recorded in treatment T_1 (control) at all the growth stages of crop during both years of experimentation. Crop growth rate, a key factor in agricultural production, is determined by the rate of dry matter accumulation. Adequate nutrient availability significantly boosts CGR by accelerating cell division, elongation, and differentiation, leading to increased biomass and overall plant growth. These findings corroborate the observations reported by Kumar and Bohra (2014) [5].

Table 2: Mean crop growth rate and relative growth rate of sweet corn as influenced periodically by different nutrient management treatments

Treatment	CGR (g m^{-2} day^{-1} plant^{-1})				RGR (g g^{-1} day^{-1} plant^{-1})			
	2021		2022		2021		2022	
	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS
T_1: Control	0.312	0.387	0.319	0.389	0.095	0.039	0.091	0.040
T_2: 50% of RDF	0.351	0.409	0.360	0.415	0.096	0.040	0.093	0.040
T_3: 50% of RDF + *Acetobacter*	0.428	0.458	0.421	0.482	0.102	0.041	0.096	0.042
T_4: 75% of RDF	0.390	0.434	0.393	0.443	0.100	0.040	0.096	0.041
T_5: 75% of RDF + *Acetobacter*	0.461	0.491	0.461	0.513	0.107	0.044	0.105	0.043
T_6: 100% of RDF	0.431	0.468	0.429	0.486	0.106	0.042	0.101	0.042
T_7: 100% of RDF + *Acetobacter*	0.463	0.494	0.463	0.513	0.107	0.046	0.107	0.045
General mean	0.405	0.449	0.406	0.463	0.102	0.042	0.098	0.042

Relative growth rate (g g^{-1} day^{-1})

The relative growth rates of sweet corn crop under different nutrient management treatments at various growth stages are presented in Table 2. The highest mean value of relative growth rate was observed during 30-45 DAS then growth rate declined slowly up to harvest. According to Table 2, the treatment T_7 (100% of RDF + *Acetobacter*) showed the most significant increase in relative growth rate at 30-45 and 45-60 DAS was 0.107 and 0.046 g g^{-1} day^{-1} during first year and 0.107 and 0.045 during second year, respectively than rest of the treatments. The treatment T_1 (control) exhibited the minimum relative growth rate at all growth stages of the crop in both years of experiment. Relative growth rate depends on how much dry matter accumulates compared to the plant's existing size. Variations in dry matter production cause differences in relative growth rate. By providing a balanced and consistent nutrient supply, this approach likely optimizes plant function, leading to increased dry matter production and overall crop growth. This conclusion is supported by previous research findings of Manjunath *et al*. (2021) [6].

Leaf area index (LAI)

The mean leaf area index plant^{-1} of sweet corn was significantly influenced by different nutrient management treatments administered at various growth stages, as presented in Table 3. The data presented in Table 3 demonstrate that treatment T_7 (100% of RDF + *Acetobacter*) resulted the highest leaf area index plant^{-1} at 45 and 60 DAS was 5.15 and 6.91 during first year and 5.24 and 6.99 during second year, respectively than rest of the treatments. The maximum leaf area index was observed in treatment T_1 (control) at all the growth stages of crop, across both experimental years. Leaf Area Index (LAI) reflects a plant's photosynthetic capacity. Higher LAI means better light capture and biomass production. In this study, nutrient stress significantly reduced sweet corn LAI. This likely occurred because limited nutrients hindered the production of pigments and enzymes essential for photosynthesis. These findings align with previous research conducted by Wagh (2002) [8].

Table 3: Mean leaf area index plant^{-1} and leaf area duration of sweet corn as influenced periodically by different nutrient management treatments

Treatment	Leaf area index				Leaf area duration			
	2021		2022		2021		2022	
	45 DAS	60 DAS	45 DAS	60 DAS	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS
T_1: Control	3.81	5.23	3.85	5.26	45.84	67.78	46.48	68.38
T_2: 50% of RDF	4.13	5.63	4.19	5.69	49.73	73.19	50.79	74.07
T_3: 50% of RDF + *Acetobacter*	4.75	6.41	4.83	6.50	58.14	83.69	59.46	85.02
T_4: 75% of RDF	4.44	6.02	4.51	6.09	54.11	78.46	55.12	79.51
T_5: 75% of RDF + *Acetobacter*	5.08	6.85	5.20	6.93	62.54	89.50	64.16	91.01
T_6: 100% of RDF	4.78	6.44	4.88	6.53	58.54	84.20	60.12	85.62
T_7: 100% of RDF + *Acetobacter*	5.15	6.91	5.24	6.99	63.48	90.47	64.80	91.77
General mean	4.59	6.21	4.67	6.29	56.05	81.04	57.28	82.20

Leaf area duration

Growth analysis studies revealed that leaf area duration was significantly influenced by various nutrient management treatments applied at different growth stages, as detailed in Table 3. The leaf area duration was recorded the maximum in treatment T_7 (100% of RDF + *Acetobacter*) at 30-45 and 45-60 DAS was 63.48 and 90.47 during first year and 64.80 and 91.77 during second year, respectively. The minimum leaf area duration was observed in T_1 (control) at all the growth stages of crop during both experimental years. Leaf area duration, a key factor in photosynthesis, increases with higher fertilizer application. This is likely due to increased leaf number and size, delayed leaf senescence, and improved photosynthesis efficiency. These findings are in agreement with previous research conducted by Joshi and Chandrashekar (2017) [4].

Net assimilation rate (g m^{-2} day^{-1} plant^{-1})

The net assimilation rate of sweet corn, as presented in Table 4, was assessed over two experimental years. Net assimilation rate is a key physiological parameter that reflects the photosynthetic efficiency of plants. The data presented in Table 4 reveal that treatment T_7 (100% of RDF + *Acetobacter*) resulted in the highest net assimilation rate plant^{-1} between 30-45 and 45-60 DAS was 11.24 and 8.64 g m^{-2} day^{-1} during first year and 10.94 and 8.60 g m^{-2} day^{-1} during second year, respectively. The minimum net assimilation rate was observed in treatment T_1 (control) at all the growth stages of crop during both years of experimentation. Leaf size significantly impacts net assimilation rate. Larger leaves intercept more light, increasing photosynthesis and biomass production. This interaction between leaf area and photosynthesis contributes to variations in plant growth. The present results were in accordance with the findings of Choudhary *et al*. (2021).

Table 4: Mean net assimilation rate plant^{-1} of sweet corn as influenced periodically by different nutrient management treatments

Treatment	NAR (g m^{-2} day^{-1} plant^{-1})			
	2021		2022	
	30-45 DAS	45-60 DAS	30-45 DAS	45-60DAS
T_1: Control	10.43	8.24	10.49	8.41
T_2: 50% of RDF	10.81	8.26	10.80	8.45
T_3: 50% of RDF + *Acetobacter*	11.12	8.36	10.87	8.51
T_4: 75% of RDF	11.00	8.29	10.85	8.48
T_5: 75% of RDF + *Acetobacter*	11.24	8.46	10.88	8.57
T_6: 100% of RDF	11.24	8.40	10.88	8.57
T_7: 100% of RDF + *Acetobacter*	11.24	8.64	10.94	8.60
General mean	11.01	8.38	10.82	8.51

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