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Economic Factors and Different Growth Phases of Sweet Corn (*Zea mays* L. Var. Saccharata) in the South Gujarat Area, India as Affected by Intra-Row Spacing and Potassium Levels

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To determine how intra-row spacing and potassium levels affected sweet corn (*Zea mays* L. var. *Saccharata*), a field experiment was conducted in Junagadh (Gujarat) during the Rabi season of 2016–17. Four levels of intra-row spacing (5, 10, 15 and 20 cm) and four potassium levels (0, 20, 40, and 60 kg K_2O/ha) were combined into sixteen different treatment combinations. Three replications of a factorial randomized block design were used to set up the experiment. Based on the data of growth attributes significant and maximum recorded dry matter accumulation (102.46

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and 144.54 g plant^{-1}) at 60 DAS and harvest, absolute growth rate (3.07 and 1.41 g day^{-1}) at 45-60 DAS and 60 DAS-harvest, crop growth rate (0.00275 and 0.00126 g m^{-2}day^{-1}) at 45-60 DAS and 60 DAS-harvest under the treatment intra-row spacing (20 cm), respectively.

According to data on growth attributes, the treatment (K_4) 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha resulted in significant and maximum dry matter accumulation (96.93 and 142.00 g plant^{-1}) at 60 DAS and harvest, absolute growth rate (3.03 and 1.39 g day^{-1}) at 45-60 DAS and 60 DAS-harvest, and crop growth rate (0.00272 and 0.00124 g m^{-2}day^{-1}) respectively. Economic analysis showed that higher net returns and B: C ratio from sweet corn (Sweet-16) can be secured by sowing the crop at 20 cm intra-row spacing + application of 60 kg K_2O/ha.

Keywords: Economics; spacing; Gujarat; growth; potassium.

1. INTRODUCTION

Due to its classification as a C_4 type crop, maize (*Zea mays* L.) is often grown effectively throughout the year. Among the numerous forms of maize, sweet corn is particularly famous for the use of its green cobs all throughout the world. Popular vegetable sweet corn is in second in farm value and fourth in terms of commercial crops. The sweet corn is possible to boost agricultural revenue because of the rise in demand. The major consideration is to maintain stand density in order to increase cob yields. The form and size of plant leaf area are determined by its spatial layout, which in turn affects how well it can absorb solar energy and how quickly its roots can develop and function. Only when plant population permits each plant to reach its full natural potential and maximum production can be anticipated. In order to get the best population density, inter- and intra-row spacing must be modified in connection to other agronomic parameters [1].

For maize, potassium (K) is a macronutrient because the plant absorbs a lot of it during the growth season. K serves as an activator for several enzymes and metabolic processes, including those involved in photosynthesis, protein synthesis, and starch production in grains, even though the plant does not use it as a building block for organic molecules. Potassium has a function in the flow of water, minerals, and carbohydrates inside the plant. It controls how stomata close and open, which affects how much water and gas are exchanged. Moreover, K is crucial for cell wall strength and cellulose formation. Strong cell walls that increase disease resistance and the capacity of the crop to keep firm, robust stalks are linked to high K fertility. For regulating disease incidence and stalk strength as corn output levels rise, it's critical to maintain a balance between nitrogen (N) and potassium (K) levels. The plant's ability to take N from the soil is constrained when K is a limiting factor, which has an effect on stalk strength, disease resistance, and grain output [2].

2. MATERIALS AND METHODS

The outcomes of a field experiment titled "Study of intra-row spacing and potassium levels on growth, yield, and quality of sweet corn (*Zea mays* L. var. *Saccharata*) under South Saurashtra conditions" carried out at the Farming System Research Centre, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat during *Rabi* season of 2016-17.

2.1 Crop Husbandry

Dry matter accumulation: Five plants were randomly selected from border lines of each experimental plot at 30, 45, 60 DAS and harvest. After chopping, plant samples were placed separately in perforated paper bags and oven dried at 65°C till a constant weight is obtained. Later, these were weighted and dry matter was expressed as g plant^{-1}. *Relative growth rate (RGR):* The values for relative growth rate were calculated for the stage between 30 DAS and 45 DAS, 45 DAS and 60 DAS and then between 60 DAS and at harvest with the help of following formula. RGR g g^{-1} day^{-1} (loge w_2-loge w_1)/(t_2-t_1), Where, Loge w_1 = Loge of dry weight of plant at time interval t_1. Loge w_2 = Loge of dry weight of plant at time interval t_2. *Crop growth rate (CGR):* The values for crop growth rate were calculated for the stage between 30 DAS and 45 DAS, 45 DAS and 60 DAS and then between 60 DAS and harvest with the help of following formula: CGR = 1/p (w_2-w_1)/(t_2-t_1) g m^{-2} day^{-1}. Where, w_1 = weight of dry matter of plant at time t_1. w_2 = weight of dry matter of plant at time t_2. p = ground area (m^2).

Absolute growth rate: The values for absolute growth rate were calculated for the stage between 30 DAS and 45 DAS, 45 DAS and 60 DAS and then between 60 DAS and harvest with the help of following formula AGR = $(w_2-w_1)/(t_2-t_1)$ g day^{-1}. Where, w_1 = dry weight of plant at time t_1. w_2 = dry weight of plant at time t_2.

2.2 Crop Economics

Cost of cultivation: The expenses incurred for all the routine operations from preparatory tillage to harvesting including threshing, cleaning as well as the cost of inputs *viz*. seeds, fertilizers, pesticides, irrigation etc. applied to each treatment were calculated on the basis of prevailing local charges and then cost of cultivation was calculated. *Gross returns:* The gross realization in terms of rupees per hectare was worked out separately for each treatment considering the green cob and green fodder yields from each treatment and local market prices. *Net returns:* The total cost of cultivation was deducted from the gross realization to work out the net income for each treatment combinations and was recorded accordingly. *Benefit: cost ratio (B:C):* The Benefit: Cost ratio (B:C) ratio was calculated with the help of following formula. B:C = Gross returns (₹/ha)/Total cost of cultivation (₹/ha).

2.3 Crop Statistical Analysis

By using the appropriate analysis of variance as suggested by Gomez and Gomez [3] the data was subjected to statistical analysis. The critical difference (CD) values were generated for each instance when the F values were determined to be significant at the 5% level of probability in order to compare the treatment means.

3. RESULTS AND DISCUSSION

3.1 Growth Atributes

Different intra-row spacing levels had no discernible impact on the accumulation of dry matter at 30 and 45 DAS, according to an analysis of the data (Table 1). Nevertheless, intra-row spacing of 20 cm (S_4) recorded considerably greater dry matter accumulation at 60 DAS and harvest (102.46 g and 144.54 g, respectively), which was deemed statistically comparable to treatment S_3 (intra-row spacing of 15 cm).

Due to the consideration of various intra-row spacing values, absolute growth rate between 30-45 DAS was not significantly impacted. Nevertheless, during 45-60 DAS, intra-row spacing of 20 cm (S_4) recorded considerably the higher absolute growth rate (3.07 g/day) which was remained statistically at par with treatment S_3 (15 cm). Nevertheless, between 60 DAS-harvest and treatment S_4 (20 cm), which was discovered statistically at par with treatment S_3, absolute growth rate continued to drop and was recognized to be greater (1.41 g/day) (15 cm). Crop growth is a well-established consequence of environmental interaction. In the current study, it was revealed that intra-row spacing had a significant impact on crop production for each plant, indirectly dictating the amount of rivalry among plants for different growth inputs as well as the availability of different growth nutrients to individual plants in the community.

Also, between 45 and 60 DAS, the treatment with a 20 cm intra-row spacing (S_4) recorded statistically equivalent results to treatment S_3 but with a much greater crop growth rate (0.00275 g m^{-2} day^{-1}) (15 cm). Nevertheless, between 60 DAS-harvest and treatment S_4 (20 cm), which was found statistically at par with treatment S_3, the crop growth rate started to drop and was recorded higher (0.00126 g m^{-2} day^{-1}) (15 cm).

It is common knowledge that N, P, and K are key nutrients for crop growth and development. The greatest levels of N, P, and K in the crop's plant portion at the recommended intra-row spacing (S_4) of 20 cm may have aided in the promotion of plant development through active cell division and elongation. Under 20 cm of spacing, there appears to be a larger accumulation of photosynthates and ultimately a higher accumulation of dry matter by individual plants as a result of the enhanced nutritional state. In comparison to limited intra-spacing, higher values of growth characteristics were seen with broader intra-row spacing. The increase seen with greater intra-row separation may be related to a reduction in plant competition for nutrients and light under equidistant spatial arrangement [4]. The result is in close accordance with findings of Bozorgi et al. [5], Gozubenli and Konuskan [6], Hamni and Dadari [7] and Paradkar [8].

Application of treatment K_4 (60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha) resulted in considerably larger dry matter accumulation at 60 DAS and harvest than treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha) (96.93 g and 142.00 g respectively). Significantly reduced levels of dry matter accumulation (73.11 g and 108.14 g) were observed at 60 DAS and harvest, respectively,

Table 1. Effect of intra-row spacing and potassium levels on dry matter accumulation on relative growth rate, absolute growth rate and crop growth rate of sweet corn

Treatments	Dry matter accumulation at (g $plant^{-1}$)				Relative growth rate at (g $g^{-1}day^{-1}$)			Absolute growth rate at (g/day)			Crop growth rate at (g $m^{-2}day^{-1}$)		
	30 DAS	45 DAS	60 DAS	Harvest	30-45 DAS	45-60 DAS	60 DAS-Harvest	30-45 DAS	45-60 DAS	60 DAS-Harvest	30-45 DAS	45-60 DAS	60 DAS-Harvest
Intra-row spacing (cm)													
S_1: 5 Intra-row + 45 Inter-rows	24.37	51.02	70.72	106.33	0.0535	0.0497	0.0135	1.81	2.58	1.11	0.00163	0.00231	0.00100
S_2: 10 Intra-row + 45 Inter-rows	25.84	52.75	82.90	122.73	0.0561	0.0505	0.0139	1.84	2.64	1.18	0.00165	0.00237	0.00106
S_3: 15 Intra-row + 45 Inter-rows	25.85	55.75	92.96	133.62	0.0562	0.0525	0.0140	1.85	2.89	1.38	0.00166	0.00259	0.00124
S_4: 20 Intra-row + 45 Inter-rows	27.48	57.94	102.46	144.54	0.0609	0.0571	0.0141	1.88	3.07	1.41	0.00168	0.00275	0.00126
S.Em.±	0.75	2.14	3.42	4.27	0.0020	0.0023	0.0003	0.06	0.11	0.05	0.00005	0.00010	0.00004
C.D. at 5%	NS	NS	9.87	12.32	NS	NS	NS	NS	0.32	0.14	NS	0.00029	0.00013
Potassium levels (kg/ha)													
K_1: 0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	24.95	51.01	73.11	108.14	0.0535	0.0478	0.0136	1.82	2.55	1.14	0.00163	0.00229	0.00102
K_2: 20 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	25.31	53.48	85.10	122.34	0.0561	0.0517	0.0139	1.83	2.69	1.20	0.00165	0.00241	0.00107
K_3: 40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	26.55	56.25	93.89	134.74	0.0576	0.0534	0.0140	1.85	2.90	1.36	0.00166	0.00260	0.00122
K_4: 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	26.72	56.73	96.93	142.00	0.0595	0.0569	0.0141	1.87	3.03	1.39	0.00168	0.00272	0.00124
S.Em.±	0.75	2.14	3.42	4.27	0.0020	0.0023	0.0003	0.06	0.11	0.05	0.00005	0.00010	0.00004
C.D. at 5%	NS	NS	9.87	12.32	NS	NS	NS	NS	0.32	0.14	NS	0.00029	0.00013
Interaction (S × K)													
S.Em.±	1.51	4.27	6.84	8.53	0.0039	0.0045	0.0006	0.12	0.22	0.10	0.00010	0.00020	0.00009
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	10.08	13.62	13.57	11.65	11.99	14.99	7.80	10.85	13.91	13.36	10.76	13.91	13.36

with treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). The application of 60 K_2O + 120 N_2O + 60 P_2O_5 (K_4) between 45 and 60 DAS also recorded a considerably greater absolute growth rate (3.03 g/day), which was statistically comparable to treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). However, between 60 DAS-harvest and treatment K_4 (60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha), which was found statistically at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha), the absolute growth rate continued to drop and was recorded higher (1.39 g/day). When treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha), which was statistically comparable to treatment K_4, applied 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha, it considerably increased crop growth rate (0.00272 g m^{-2} day^{-1}) between 45 and 60 DAS. Nevertheless, between 60 DAS-harvest and treatment K_4 (60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha), which was found statistically at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha), the crop growth rate started to fall and was recorded higher (0.00124 g m^{-2} day^{-1}).

Since potassium has a favourable influence on growth and enhances cell division and cell expansion, it has a beneficial effect on growth. Potassium's impact on the production of phytohormones plays a significant part in meristematic growth. Cytokinin, one of several plant hormones, is crucial for the development of tillers and buds. High spikelet fertility is a result of improved pollen germination in the florets due to potassium feeding. Such an increase may also be attributable to the root systems of plants receiving enough potassium from the soil, which increases photosynthesis and the production of metabolites and enzymes in plants [9]. According to Kumar et al. [10] potassium boosts the plant's potential resistance to illnesses and insect pests. [11,12] both indicated that K had positive impacts on growth.

3.2 Economics

According to a review of the data (Table 2), treatment S_4 (intra-row spacing of 20 cm) considerably produced greater gross returns, which were ₹ 92734/ha, whereas treatment S_1 (intra-row spacing of ₹ 65575/ha) significantly produced lower gross returns (5 cm). Net return considerably was secured with an intra-row spacing of 20 cm (S_4), which stayed on the same bar as treatment S_3 (15 cm), and the lower net returns of ₹ 39719/ha were accumulated under S_1 (5 cm). Due to greater availability of nutrients, moisture, solar radiation, and room for growth and development, population maintenance at intra-row spacing of 20 cm (S_4) provided greatest net returns of ₹ 67408/ha and BCR 3.7.

Table 2. Effect of intra-row spacing and potassium levels on economics of sweet corn

Treatments	Gross returns (₹ /ha)	Cost of cultivation (₹ /ha)	Net returns (₹ /ha)	BCR
Intra-row spacing (cm)				
S_1: 5 Intra-row + 45 Inter-rows	51.02	70.72	106.33	0.0535
S_2: 10 Intra-row + 45 Inter-rows	52.75	82.90	122.73	0.0561
S_3: 15 Intra-row + 45 Inter-rows	55.75	92.96	133.62	0.0562
S_4: 20 Intra-row + 45 Inter-rows	57.94	102.46	144.54	0.0609
S.Em.±	2.14	3.42	4.27	0.0020
C.D. at 5%	NS	9.87	12.32	NS
Potassium levels (kg /ha)				
K_1: 0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	51.01	73.11	108.14	0.0535
K_2: 20 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	53.48	85.10	122.34	0.0561
K_3: 40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	56.25	93.89	134.74	0.0576
K_4: 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	56.73	96.93	142.00	0.0595
S.Em.±	2.14	3.42	4.27	0.0020
C.D. at 5%	NS	9.87	12.32	NS
Interaction (S × K)				
S.Em.±	4.27	6.84	8.53	0.0039
C.D. at 5%	NS	NS	NS	NS
C.V. %	13.62	13.57	11.65	11.99

Also, S_4 with an intra-row spacing of 20 cm acquired the greatest benefit cost ratio of 3.7, while S_1 with an intra-row spacing of 25 cm accumulated the lowest benefit cost ratio of 2.5. (5 cm). It is clear from the data (Table 2) that the application of 60 K_2O + 120 N_2O + 60 P_2O_5 (K_4), which remained equivalent to treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5), was responsible for the higher gross returns of ₹ 93513/ha. Treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha) had lower gross yields, with a total of ₹ 66242/ha. When potassium was applied at a rate of 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4), the cost of culture was found to be greatest (₹ 26193/ha), whereas treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha) recorded the lowest cost of cultivation (₹ 24841/ha) [13].

It is clear from the data (Table 2) that treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5), which came in second, and application of 60 K_2O + 120 N_2O + 60 P_2O_5 (K_4), which recorded much higher net returns of (₹ 67319/ha), respectively. The lower net yields of (₹ 41401/ha) were seen with no potassium treatment. The highest observed 3.6 was in the benefit cost ratio application for 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4). Use of K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha) resulted in the lowest benefit cost ratio of 2.7.

4. CONCLUSIONS

Sweet corn (Sweet-16) may be planted with an intra-row spacing of 20 cm and an inter-row spacing of 45 cm, and it can be fertilised with 60 kg/ha of K_2O, 120 kg/ha of N_2O, and 60 kg/ha of P_2O_5 in addition to the recommended amounts of N and P_2O_5.

CONFERENCE DISCLAIMER

Some part of this manuscript was previously presented in the conference: 3rd International Conference IAAHAS-2023 "Innovative Approaches in Agriculture, Horticulture & Allied Sciences" on March 29-31, 2023 in SGT University, Gurugram, India. Web Link of the proceeding: https://wikifarmer.com/event/iaahas-2023-innovative-approaches-in-agriculture-horticulture-allied-sciences/

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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