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EFFECT OF INTRA-ROW SPACING AND POTASSIUM LEVELS ON SOIL ANALYSIS AND SWEET CORN QUALITY TRAITS (*ZEA MAYS* L. VAR. SACCHARATA)

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ABSTRACT

A field experiment was carried out in Junagadh (Gujarat) during the Rabi season of 2016–17 to ascertain the effect of intra-row spacing and potassium levels on quality traits of sweet corn. (*Zea mays* L. var. Saccharata). In this study, four intra-row spacings (5, 10, 15, and 20 cm) and four potassium levels (0, 20, 40 and 60 kg K_2O/ha) were evaluated and replicated thrice in factorial randomised black design. Results of the study revealed that among different intra-row spacing levels, significant and maximum protein production (807 kg/ha), crude protein content in fodder (5.0%), K content in cob (1.37%), N comtent in fodder (0.80%) and K content in fodder (1.52%) were recorded at 20 cm intra-row spacing. However among potassium levels, K4 (60 K_2O + 120 N_2O + 60 P_2O_5) kg/ha) recorded with significantly higher soil available N (256.17 kg/ha), K (278.07 kg/ha) contents, and N (1.70 and 0.83%), K (1.39 and 1.60%) content in cob and fodder, respectively. Based on the results of field experiment, it is concluded that planting of sweet corn at 20 cm intra-row spacing and application of K @ 60 kg K_2O/ha along with N@120 kg/ha and P@ 60 kg/ha resulted in the higher quality traits *viz*. crude protein content in cob (10.60%), fodder (5.20%), protein yield (827 kg/ha), reducing sugar (3.75%), non-reducing sugars (7.53%) and total sugars (11.68%).

KEY WORDS : Protein, Cob, Fodder, Corn and nutirent.

INTRODUCTION

Generally, maize (*Zea mays* L.) is cultivated in all seasons successfully as it is classified as C4 type crop. Among the various types of maize, sweet corn is very popular for the use of its green cobs all around the world. Sweet corn is a popular vegetable and ranks second in farm value and fourth in commercial crops. Due to rising in demand, the sweet corn is able to increase the farm income. In order to achieve higher cob yields, maintenance of stand density is the most important factor. A spatial arrangement of plant governs the shape and size of the leaf area per plant, which in turn influences efficient interception of radiant energy, proliferation, growth of roots and their activity. Maximum yield can be expected only when plant population allows individual plant to achieve their maximum inherent potential. Thus, there is need to work out an optimum population density by adjusting inter and intra row spacing in relation to other agronomic factors (Bavalgave *et al.*, 2021).

Potassium is a vital macronutrient for plant growth and plays a key role in activation of numerous metabolic processes such as protein synthesis, photosynthesis and enzymes, as well as disease, pest and abiotic stress tolerance. Soil microbes play a key role in iron cycling and soil fertility by influencing the availability of soil minerals. Plants can use only a small portion of this potassium because most of the potassium gets fixed in soil as crystalline structure of feldspars, clay minerals and micas which are in insoluble form (Sri and Singh, 2022).

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MATERIALS AND METHODS

The field experiment was conducted at the Farming System Research Centre, IIFSR, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during Rabi 2016–17 with the title "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."

Quality parameters

Crude protein content in cob and fodder: Crude protein content of cob and fodder corn were calculated by multiplying the nitrogen content with a factor of 6.25 as proposed by Tsen and Martin (1971). It was expressed in terms of per cent crude protein content. Per cent protein = N % x 6.25 (Factor).

Protein yield: Protein yield was calculated by using following formula- Protein yield (kg/ha) = Protein content (%) × Cob yield (kg/ha)/100.

Total sugar content in kernel: The filtrate obtained in the estimation of reducing sugar was used. An aliquot of 50 ml from the filtrate was taken in a 250 ml volumetric flask in which 5 ml of dilute hydrochloric acid (1:1) was added and then kept for inversion for 24 hours at room temperature. Then the solution was neutralized with 40 per cent sodium hydroxide till pink color appear using phenolphthalein as indicator and the final volume was made upto 100 ml with distilled water. The solution was titrated against boiling Fehling's mixture. The percentage of total sugar was expressed as invert sugar and calculated by using following formula. Total sugar = Glucose equivalent (0.05) x Total volume made up x volume made up after inversion/ Titer x volume of sample taken x aliquote taken for inversion × 100.

Reducing sugar content in kernel: The titrimetric method of Lane and Eynon described by Ranganna (1979) was adopted for the estimation of reducing sugars. Invert sugars or reducing sugars reduces copper in the Fehling's solution to red insoluble cuprous oxide. The sugar content in sample was estimated by determining the volume of unknown sugar solution required to completely reduce a measured volume of standard Fehling's solution. Before actual titration, the mixture of Fehling's solution A ($CuSO_4*5H_2O$) and B (Potassium – Sodium tartrate and NaOH) (5 ml each) were standardized against standard glucose for obtaining glucose equivalent and to arrive at a conversion factor. The percent reducing sugar was calculated from following formula- Reducing sugar (%) = Glucose equivalent (0.05) x Total volume made up/ Titer x volume of sample x 100. ***Non reducing sugar content in kernel:*** The amount of non reducing sugar was obtained by subtracting reducing sugar from the amount of total sugars and multiplying the resultant by the factor 0.95.

Soil analysis

Soil analysis for available N, P_2O_5 and K_2O and organic carbon were estimated before sowing and after harvest of the crop. Representative soil sample up to 0-30 cm depth was taken from each net plot and used for estimation of soil chemical properties. The samples were grind to pass through 2 mm sieve for analysis. ***Organic Carbon:*** Estimation of organic carbon in soil was carried out by Walkley and Black method as describes by Jackson (1974). ***Available Nitrogen:*** Estimation of available N content in soil were analyzed by Alkaline $KMnO_4$ method as described by Jackson (1974). ***Available Phosphorus:*** Available phosphorous in soil was extracted with 0.5 M sodium bicarbonate (1:20) and determined by Olsen's method as described by Olsen *et al.* (1954). ***Available Potassium:*** Available potassium in soil was determined by flame photometer method as given by Jackson (1974). ***Nitrogen content:*** Nitrogen content in cob and fodder were determined on per cent dry weight basis by Kjeldahl's method described by Jackson (1974). ***Phosphorus content:*** Phosphorus content in the cob and straw were determined by Venedomolybdo phosphoric acid yellow colour method using spectrophotometer at 640 nm suggested by Jackson (1974) and was expressed as percentage of phosphorous. Using the phosphorous content at harvest was calculated and expressed in kg /ha. ***Potassium content:*** Potassium was extracted by normal neutral ammonium acetate (1:40) and then determined by Flame photometer method as described by Jackson (1974). Based on potassium content at harvest was computed and expressed in kg /ha.

Crop statistical analysis

The data was statistically analysed using the proper analysis of variance, as recommended by Gomez and Gomez (1984). When the F values were found to be significant at the 5% level of probability, the critical difference (CD) values were computed for each case in order to compare the treatment means.

RESULTS AND DISCUSSION

Nutrient status of soil after harvest

An appraisal of data (Table 1) revealed that different levels of intra-row spacing did not exerted their significant influence on available nitrogen, available phosphorus and available potassium and organic carbon content in soil after harvest**.** An examination of data revealed that different levels of intra-row spacing did not manifested their significant influence on nitrogen, phosphorus and potassium content in cob.

At intra-row spacing of 20 cm (S_4) significantly higher potassium content in cob (1.37 %) was recorded, which remained at par with treatment S_3 (15 cm), whereas, significantly lower potassium content in cob (1.18 %) was observed under treatment S_1 (5 cm).

An examination of data revealed that different levels of intra-row spacing had significant influence on nitrogen content in fodder. At intra-row spacing of 20 cm (S_4) significantly higher nitrogen content in fodder (0.80 %) was recorded, which remained at par with treatment S_3 (15 cm). Narrow intra-row spacing of 5 cm (S_1) recorded to significantly lower nitrogen content (0.65 %) in fodder. An examination of data revealed that different levels of intra-row spacing did not manifest their significant influence on phosphorus content in fodder. An assessment of data revealed that different levels of intra-row spacing exerted their significant influence on potassium content in fodder. At intra-row spacing of 20 cm (S_4) significantly higher potassium content in fodder (1.52 %) was recorded, which remained at par with treatment S_3 (15 cm) and S_2 (10 cm) whereas, significantly lower potassium content in cob (1.31 %) was observed under treatment S_1 (5 cm).

An examination of data mentioned that different potassium levels exerted their significant influence on available potassium in soil. Application of 40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_3) recorded significantly higher available potassium in soil (280.01 kg/ha) which remained statistically at par with treatment K_4 (60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha) whereas, significantly lower available

Table 1. Effect of intra-row spacing and potassium levels on available nutrients (kg/ha), nutrient content in cob (%) and nutrient content in fodder (%) of sweet corn

Treatments	Available nutrients(kg /ha)				Nutrient content in cob (%)			Nutrient content in fodder (%)		
	Nitrogen	Phosphorus	Potassium	Organic carbon (%)	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Intra-row spacing (cm)										
S_1: 5 Intra-row + 45 Inter-rows	234.66	34.78	267.00	0.68	1.59	0.52	1.18	0.65	0.25	1.31
S_2: 10 Intra-row + 45 Inter-rows	245.35	35.54	268.19	0.72	1.57	0.52	1.27	0.72	0.26	1.44
S_3: 15 Intra-row + 45 Inter-rows	257.47	36.23	272.81	0.74	1.59	0.54	1.32	0.75	0.26	1.49
S_4: 20 Intra-row + 45 Inter-rows	248.84	36.22	272.54	0.73	1.65	0.53	**1.37**	**0.80**	0.28	**1.52**
S.Em.±	5.98	1.19	5.60	0.02	0.03	0.01	0.03	0.02	0.01	0.04
C.D. at 5%	NS	NS	NS	NS	NS	NS	0.10	0.07	NS	0.11
Potassium levels (kg/ha)										
K_1: 0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	234.55	34.69	259.67	0.69	1.44	0.51	1.17	0.58	0.25	1.20
K_2: 20 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	238.99	35.86	262.79	0.71	1.59	0.53	1.25	0.71	0.25	1.44
K_3: 40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	256.61	36.59	280.01	0.72	1.67	0.53	1.33	0.80	0.27	1.53
K_4: 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	**256.17**	35.62	**278.07**	0.74	**1.70**	0.55	1.39	**0.83**	0.28	**1.60**
S.Em.±	5.98	1.19	5.60	0.02	0.03	0.01	0.03	0.02	0.01	0.04
C.D. at 5%	17.27	NS	16.16	NS	0.08	NS	0.10	0.07	NS	0.11
Interaction (S x K)										
S.Em.±	11.96	2.39	11.19	0.03	0.06	0.02	0.07	0.05	0.02	0.07
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	8.40	11.58	7.18	8.07	6.11	7.00	8.90	10.77	10.95	8.92

nitrogen in soil (259.67 kg/ha) was recorded under treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). A perusal of data mentioned that different potassium levels did not exert their significant influence on organic carbon content in soil after harvest.

An examination of data mentioned that different potassium levels were able to exert their significant influence on available nitrogen in soil. Significantly higher nitrogen content in soil (256.61 kg /ha) was recorded under application of 40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_3), which remained statistically at par with treatment K_4 (60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). Significantly lower nitrogen content (234.55 kg /ha) in soil was recorded under K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). A perusal of data mentioned that different potassium levels did not exert their significant influence on available phosphorus in soil. The remarkable increase in available nitrogen and potassium status of soil with the application of potassium might be due to increase in soil microbial biomass and due to enhanced transformation of plant residues and soil native status of unavailable forms of the their nutrients due to solubilization of native status of potassium (Gajghane *et al.* 2015) and due to positive interaction with other supplemental nutrients. Such increase in all nutrient status of soil at harvest of the crop may also be due to direct addition of potassium to available pool of the soil. Similar findings were also reported by Murthy *et al.* (2015) and Patel *et al.* (2013). The significant build up of available N and K status under these fertility levels could also be attributed to adequate supply of N and K to meet the crop demand. The results of present investigation strongly support the findings of Prathyusha and Hemlata (2013) in speciality corn, Kumar (2007) and Kumar (2009); Mathukia *et al.* (2014) in sweet corn.

The data presented revealed that different levels of potassium did not exerted their significant influence on nitrogen content of cob. Application of 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4) recorded significantly maximum nitrogen content in cob (1.70 %) which remained at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha), whereas, significantly lower nitrogen content in cob (1.44 %) were recorded under treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). The data revealed that different levels of potassium did not exert their significant influence on phosphorus content in cob. An analysis of data mentioned that different potassium levels exerted their significant influence on potassium content in cob. Application of 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4) recorded significantly highest potassium content in cob (1.39 %) which remained at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha), whereas, significantly lower potassium content in cob (1.17 %) was recorded under treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha).

The data presented revealed that different levels of potassium did not exert their significant influence on nitrogen content of fodder. Application of 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4) recorded significantly the maximum potassium content in fodder (0.83 %) which remained at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha), whereas, significantly the lower potassium content in fodder (0.58 %) was recorded under treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). The data presented in revealed that different levels of potassium did not exert their significant influence on phosphorus content in fodder.

An analysis of data mentioned that different potassium levels exerted their significant influence on potassium content in grain. Application of 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4) recorded significantly higher potassium content in cob (1.60 %) which remained at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha), whereas, significantly lower potassium content in grain (1.20 %) was recorded under treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha).

Quality of crop

Perusal of data (Table 2) revealed that protein content in fodder was significantly affected by varying levels of intra-row spacing. Intra-row spacing of 20 cm (S_4) recorded significantly higher protein content (5.0 %), which was at par with treatment S_3 (15 cm). Whereas, significantly lower protein content of 4.1 % was observed at intra-row spacing of 5 cm (S_1). Scrutiny of data showed that different levels of intra-row spacing imparted their significant influence on protein yield. At intra-row spacing of 20 cm (S_4) significantly higher protein yield (807 kg /ha) was recorded which remained on same bar with treatment S_3 (15 cm), whereas, significantly lower protein yield (561 kg /ha) was observed under treatment S_1 (intra-row spacing of 5 cm).

A perusal of data revealed that different levels of intra-row spacing did not exert their significant influence on reducing sugar content in kernel. An assessment of data revealed that different levels of intra-row spacing did not manifest their significant influence on non-reducing sugar content of kernel. An examination of data revealed that different levels of intra-row spacing did not manifested their significant influence on total sugar content in kernel. Adequate availability of nutrients and subsequent absorption of these nutrients under optimum intra-row spacing of 20 cm might have been responsible for enhanced cob quality. However, reducing and non-reducing sugar in kernel were not remarkably influenced by intra-row spacing. The present findings are in close agreement with the results obtained by Raja (2001) and Massey (2005) in sweet corn.

Scrutiny of data revealed that application of 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4) found significantly higher protein content (5.2 %) in fodder, which remained statistically at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). However, lower crude protein content (3.6 % was recorded under treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). An examination of data mentioned that different potassium levels exerted their significant influence on protein yield. Application of 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4) recorded significantly higher protein yield (827 kg /ha) which remained at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha) whereas, significantly lower protein yield (516 kg /ha) were recorded under treatment K_1(0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). An examination of data explained that various levels of potassium imparted their significant influence on reducing sugar content of kernel. Application of 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4) recorded significantly the more reducing sugar content in kernel (3.75 %), which remained at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). While, significantly the lower reducing sugar content in kernel (3.34 %) was registered under treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). The data presented in indicated that various levels of potassium imparted their significant influence on reducing sugar content of kernel. Application of 60 kg K_2O /ha (K_4) recorded significantly the higher non-reducing sugar content in kernel (7.53 %), which remained at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). While, significantly the lower reducing sugar content in kernel (6.50 %) was registered under treatment K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). It is apparent from that application of 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha (K_4) recorded significantly highest total sugar content in kernel (11.68%), which was found statistically at par with treatment K_3 (40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). Significantly the lowest total sugar content of kernel (10.18 %) was recorded in K_1 (0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha). This increase in protein and sugars content might be due to the better utilization of the available nitrogen and increase in nitrogen metabolism in the presence of potassium (Bansal *et al.*, 2001). Potassium helps to avoid biotic and abiotic stresses arises during the

Table 2. Effect of intra-row spacing and potassium levels on crude protein content (%) and Sugar (%) of sweet corn

Treatments	Crude protein content (%)			Sugar (%)		
	Cob	Fodder	Protein yield (kg/ha)	Reducing	Non-reducing	Total
Intra-row spacing (cm)						
S_1: 5 Intra-row + 45 Inter-rows	9.9	4.1	561	3.39	6.40	10.55
S_2: 10 Intra-row + 45 Inter-rows	9.8	4.5	602	3.45	6.89	10.87
S_3: 15 Intra-row + 45 Inter-rows	10.0	4.7	744	3.61	7.07	11.05
S_4: 20 Intra-row + 45 Inter-rows	10.3	**5.0**	**807**	3.72	7.43	11.54
S.Em.±	0.2	0.1	26	0.10	0.26	0.25
C.D. at 5%	NS	0.4	74	NS	NS	NS
Potassium levels (kg /ha)						
K_1: 0 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	9.0	3.6	516	3.34	6.50	10.18
K_2: 20 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	9.9	4.4	605	3.41	6.72	10.61
K_3: 40 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	10.4	5.0	768	3.66	7.05	11.54
K_4: 60 K_2O + 120 N_2O + 60 P_2O_5 kg/ha	**10.6**	**5.2**	**827**	**3.75**	**7.53**	**11.68**
S.Em.±	0.2	0.1	26	0.10	0.26	0.25
C.D. at 5%	0.5	0.4	74	0.30	0.75	0.71
Interaction (S x K)						
S.Em.±	0.4	0.3	52	0.21	0.52	0.49
C.D. at 5%	NS	NS	NS	NS	NS	NS
C.V. %	6.1	10.8	13	10.15	12.92	7.74

production of the crop. Hence plants well supplied with K^+ possessed a high energy status which is relevant to numerous metabolic processes including the resistance of plants against fungi, insects, drought and cold stress. The adequate potassium nutrition resulted due to potassium addition and good absorption and uptake of potassium have also in turn increased content of phenols. The increase in total phenols of rice with increased application of K have also been reported by Bhasker *et al.* (2001).

The improvement in protein content might be due to the improved translocation of nitrogenous compounds from various plant parts to grain caused by potassium. Potassium supply also results in a decrease in crude protein of grain and a reverse effect on grain protein can be expected. The stimulatory effect of K+ on the synthesis of the enzyme may be repressed by the products of RNA hydrolysis. Yadav *et al.* (2012) and Tikkoo *et al.* (2015) also reported that application of K significantly increased the protein content.

CONCLUSION

It came to the conclusion that treatments with intra-row spacing of 20 cm and an inter-row spacing of 45 cm recorded higher levels of readily available nutrients, nutrient content in cob, nutrient content in fodder, crude protein content, and sugar. As compared to other treatments, the crop fertilized with 60 kg/ha of K_2O, 120 kg/ha of N_2O, and 60 kg/ha of P_2O_5 had the highest soil nutrient status and quality metrics.

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