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Effect of spacing and INM practices on growth, yield and economics of Rabi sweet corn (*Zea mays* L. var. *saccharata* Sturt) under south Gujarat condition

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Abstract
A field experiment was conducted at college farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (GJ), during *rabi* season in 2016-17 to study the influence of of spacing and integrated nutrient management on sweet corn (*Zea mays* L. *saccharata*) under south Gujarat condition". The experiment was laid out in Factorial randomized blok design (FRBD) with three replications. The factors consisted of three spacing (45 cm x 30 cm, 60 cm x 20 cm and 60 cm x 30 cm), three nutrient management practices (100% RDF (120:60:00 NPK kg/ha, 75% RDF + 25% RDN through Biocompost and 50 % RDF + 50% RDN through Biocompost) and two biofertilizers i.e. with Azotobactor + PSB + KMB and without biofertilizers. The results revealed that, spacing 60 cm x 20 cm recorded significantly higher green cob (91.93 qha^{-1}), fodder yield (318.65 qha^{-1}) and net return (Rs.206430 ha^{-1}) with B:C ratio of 6.04. Application of 100% RDF (120:60:00 NPK kgha^{-1}) recorded the significantly highest green cob (90.13 qha^{-1}), fodder yield (311.74 qha^{-1}) and net return Rs.206156 ha^{-1} with B:C ratio 6.64. Biofertlizers i.e. Azotobacter + PSB + KMB application recorded the significantly highest green cob (86.64 qha^{-1}), fodder yield (299.68 qha^{-1}) and net return (Rs.194488ha^{-1}) with B:C ratio of 6.05.

Keywords: sweet corn, spacing, fertilizer and biofertilizer

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. India has made spectacular breakthrough in production and consumption of fertilizers during the last four decades. But consumption of renewable form of energy (chemical fertilizers) will be quite a limiting factor for increasing agriculture production in future. Because of escalating energy cost, chemical fertilizers are not available at affordable prices to the farmers. Moreover, the problem is compounded by imbalanced and indiscriminate fertilizer use, a decline in soil organic carbon due to prolonged use of chemical fertilizers. The production efficiency gone down appreciably. Thus, higher productivity on a sustained basis can be ensured only through integrated nutrient supply system including combined judicious use of chemical fertilizers, Biocompost, and biofertilizers. Biofertilizers have an advantage over chemical fertilizers, as they provide nutrients in addition to plant growth promoting substances like hormones, vitamins, amino acids etc. (Shivankar *et al*., 2000) [8]. Hence, introduction of biofertilizers is necessery for improving the soil fertility and productivity becides reducing the expenditure on chemical fertilizers. The present study was, therefore, aimed to evaluvate the performance of sweet corn as influenced by spacing and integrated nutrient management

Materials and Methods

A trial was conducted during rabi 2016-17 at College Farm, Department of Agronomy, College of Agriculture, Navsari Agricultural University, Navsari.to assess the response of rabi sweet corn (*Zea mays* L. var. *saccharata* Sturt) to spacing and integrated nutrient management under south Gujarat condition. The experiment comprising eighteen treatment combinations consisting three levels of plant spacing (45 cm x 30 cm, 60 cm x 20 cm and 60 cm x 30 cm), three nutrient management practices (100% RDF (120:60:00 NPK kg/ha, 75% RDF + 25% RDN through Biocompost and 50 % RDF + 50% RDN through Biocompost) and two biofertilizers i.e. with Azotobacter + PSB + KMB and without biofertilizers. These treatments were replicated three times in a Factorial Randomized Block Design. Sweet corn (cv. Sugar 75) was used in the present experiment. The experimental soil was clayey and low in available N, medium in available P and high in available potash. Other agronomical operations were carried out as per recommendation. The growth, yield attributes and yield were recorded at the time of harvest of crop. Economics of the crop was also calculated.

Result and Discussion

Effect of spacing

The results revealed that, Growth characters like plant height (219.61 cm) was recorded significantly higher with spacing 60 cm x 20 cm. The increased plant height in narrow plant spacing might be due to thick plant stand. While 60 cm x 30 cm was recorded significantly the highest number of leaves per plant (14.19) and stem girth (2.12 cm). The stem girth is reduced as compared to wider plant spacing. In wider plant spacing there is abundance of available resources and hence the plants were healthier than thick plant stands. In narrow spacing there was more competition for available resources and hence plants were tall but weaker than wider plant spacing. Almost similar results were observed by Sharma and Gupta (1968) [7]. (Table 1)

In case of yield attributes viz. cob length per plant with (27.18 cm) and without husk (18.19 cm), cob girth per plant with (14.94 cm) and without husk (10.96 cm), cob weight per plant with husk (202.22 g) and without husk (146.22 g), number of grains per row of cob (38.94), number of grains per cob (459.78), fresh weight of grain per cob (122.28 g) was recorded significantly higher in spacing 60 cm x 30 cm. While, green cob (91.93 q ha^{-1}) and fodder yield (318.65 q ha^{-1}) was recorded significantly higher in spacing 60 cm x 20 cm. The data showed that the cob length decreased as the plant population increased. These results indicate that there is a positive relationship between plant spacing and cob length of maize, probably due to variable plant competition. A wider spacing of 60 cm x 30 cm can significantly increase almost all the growth and yield attributes in sweet corn but could not compensate yield obtained in narrower spacing (Thakur *et al*. 1997) [9]. Under high density, more numbers of plants per unit area was responsible for higher yield. higher plant population utilized the production resources more efficiently towards plant development. The lowest being recorded with the wider spacing. An increase in plant density there was increase in green fodder yield in sweet corn, Hence higher plant population 60 cm x 20 cm (S_2) increased the cob yield by 10.7 per cent, while green fodder yield by 13.6 per cent over S_1 and S_3. These findings are in agreement with those of Thakur *et al*. (1998) [8], Raja (2001) [5], and Kar *et al*. (2006) [2]. (Table 2)

The economics indicating gross realization, total cost of cultivation and benefit cost ratio under different spacing, were influenced by spacing (Table 3). The maximum net return (Rs. 206430 ha^{-1}) with B:C ratio of 6.04 was accrued with spacing 60 cm x 20 cm (S_2), which was followed by 45 cm x 30 cm with net return of Rs. 185422 ha^{-1} and B:C ratio 5.78. The lowest net return (Rs.155463 ha^{-1}) with B:C ratio of 5.38 was recorded with spacing 60 cm x 30 cm (S_3). This was attributed to remarkable increase in gross realization with comparatively lower cost in this treatment resulted in higher net realization and B:C ratio. These results are in conformity with those reported by Thakur *et al.* (1998) [10], Sahoo and Mahapatra (2004) [6], Kar *et al*. (2006) [2] and Paygonde *et al*. (2008) [4] in sweet corn.

Table 1: Effect of spacing and INM practices on growth characters

Treatments	Plant height (cm)	Leaves pant^{-1} (no.)	Stem girth(cm)	Cob length(cm)		Cob girth(cm)	
				With husk	Without husk	With husk	Without Husk
Spacing (S)							
S_1 - 45 cm x 30 cm	211.39	13.22	2.07	25.51	17.17	14.10	9.99
S_2 - 60 cm x 20 cm	219.61	11.93	2.03	24.05	16.90	13.16	10.03
S_3 - 60 cm x 30 cm	188.28	14.19	2.12	27.18	18.11	14.94	10.67
S.Em.±	2.61	0.31	0.01	0.46	0.13	0.17	0.15
C.D. at 5%	7.80	0.89	0.02	1.34	0.37	0.49	0.43
Nutrient management (N)							
N_1 - 100% RDF (120:60:00 NPK kg ha^{-1})	216.72	13.37	2.11	26.64	17.99	14.81	10.64
N_2 - 75% RDF + 25% RDN through Bio-compost	204.22	13.14	2.08	25.20	17.76	14.07	10.12
N_3 - 50% RDF + 50% RDN through Bio-compost	198.33	12.83	2.04	24.92	16.96	13.30	9.85
S.Em.±	3.06	0.31	0.01	0.46	0.13	0.17	0.15
C.D. at 5%	8.80	0.92	0.02	1.34	0.37	0.49	0.43
Bio-fertilizers (B)							
B_0 - No Bio-fertilizers	201.96	12.89	2.05	24.80	17.07	13.61	9.91
B_1 - *Azotobactor* + PSB + KMB (10 ml each kg^{-1} seed)	210.89	13.34	2.10	26.37	18.07	14.53	10.53
S.Em.±	2.50	0.25	0.01	0.38	0.10	0.14	0.12
C.D. at 5%	7.19	0.76	0.01	1.09	0.30	0.41	0.35

Table 2: yield attributes as influenced by different spacing and INM practices

Treatments	Cob weight plant^{-1} (g)		Grain row cob^{-1} (no.)	Grains cob^{-1} (no.)	Fresh weight of grain cob^{-1} (g)
	With husk	Without husk			
Spacing (S)					
S_1 - 45 cm x 30 cm	184.72	135.83	36.43	408.89	110.55
S_2 - 60 cm x 20 cm	174.39	123.16	34.78	403.75	93.61
S_3 - 60 cm x 30 cm	202.22	146.22	38.94	459.78	122.28
S.Em.±	5.61	3.69	0.68	11.89	3.06
C.D. at 5%	16.13	10.61	1.96	34.21	8.80
Nutrient management (N)					
N_1 - 100% RDF (120:60:00 NPK kg ha^{-1})	200.50	154.50	38.50	479.00	118.11
N_2 - 75% RDF + 25% RDN through Bio-compost	181.67	138.27	36.00	409.05	109.44
N_3 - 50% RDF + 50% RDN through Bio-compost	179.17	112.44	35.67	384.37	98.88
S.Em.±	5.61	3.69	0.68	11.89	3.06
C.D. at 5%	16.13	10.61	1.96	34.21	8.80
Bio-fertilizers (B)					
B_0 - No Bio-fertilizers	187.11	125.07	35.77	389.40	101.51
B_1 - *Azotobacter* + PSB + KMB (10 ml each kg^{-1} seed)	201.51	145.07	37.66	458.88	116.11
S.Em.±	2.50	3.01	0.55	9.71	2.50
C.D. at 5%	7.19	8.66	1.60	27.93	7.19

Table 3: Influence of different treatments on economics of sweet corn

Treatment	Green Cob Yield (q ha^{-1})	Green fodder Yield (q ha^{-1})	Gross income (Rs.ha^{-1})	Total Fixed Cost (Rs.ha^{-1})	Total Variable Cost (Rs.ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Net Returns (Rs.ha^{-1})	B:C ratio
Spacing (S)								
S_1 - 45 cm x 30 cm	83.68	285.62	224475	20153	18899	39052	185422	5.78
S_2 - 60 cm x 20 cm	91.93	318.65	247586	20153	21002	41155	206430	6.04
S_3 - 60 cm x 30 cm	70.51	251.68	191360	20153	15743	35896	155463	5.38
S.Em.±	2.14	5.42	-	-	-	-	-	-
C.D. at 5%	6.15	15.60	-	-	-	-	-	-
Nutrient management (N)								
N_1 - 100% RDF (120:60:00 NPK kg ha^{-1})	90.13	311.74	242598	20153	16289	36442	206156	6.64
N_2 - 75% RDF + 25% RDN through Bio-compost	81.74	285.79	220635	20153	18549	38702	181933	5.70
N_3 - 50% RDF + 50% RDN through Bio-compost	74.25	258.42	200188	20153	20807	40960	159228	4.86
S.Em.±	2.14	5.42	-	-	-	-	-	-
C.D. at 5%	6.15	15.60	-	-	-	-	-	-
Bio-fertilizers (B)								
B_0 - No Bio-fertilizers	77.44	270.96	209066	20153	18524	38677	170389	5.42
B_1 - *Azotobacter* + PSB + KMB (10 ml each kg^{-1} seed)	86.64	299.68	233214	20153	18572	38725	194488	6.05
S.Em.±	1.75	4.43	-	-	-	-	-	-
C.D. at 5%	5.02	12.74	-	-	-	-	-	-

Selling Price: Green cob- 20 Rs. kg^{-1}, Green fodder- 2 Rs. kg^{-1}

Effect of nutrient management

Application of 100% RDF (120:60:00 NPK kg ha^{-1}) recorded the significantly highest plant height (216.72 cm), number of leaves per plant (13.37) and stem girth (2.11 cm), cob length per plant with (26.64 cm) and without husk (17.99 cm), cob girth per plant with (14.81cm) and without husk (10.64cm), cob weight per plant with husk (200.50 g) and without husk (154.50 g), number of grains per row of cob (38.50), number of grains per cob (479), fresh weight of grain per cob (118.11 g), green cob (90.13 q ha^{-1}) and fodder yield (311.74 q ha^{-1}). The improvement in growth and yield attributes with the application of 100 % RDF might have resulted in better and timely availability of N and P for their utilization by plant as judged from nitrogen and phosphorous content of cob and fodder. Nitrogen is considered to be a vitally important plant nutrient. It is an integral part of chlorophyll which is the primary absorber of light energy needed for photosynthesis. Besides these, it is also a constituent of certain organic compounds of physiological importance. Further, phosphorous fertilization also improves the metabolic and physiological processes and thus known as "energy currency" which is subsequently used for vegetative and reproductive growth through phosphorylation. In addition to vital metabolic role, P is an important structural component of nucleic acid, phytein, phospholipids and enzymes. An adequate supply of phosphorous early in the life cycle of plant is important in laying down the primordia of its reproductive part. The present findings are in close confirmation with those of Raja (2001) [5] on sweet corn, Pathak *et al.* (2002) [3] on winter maize and Kar *et al.* (2006) [2] on sweet corn. The significant improvement in overall growth resulted in higher photosynthetic activity has eventually gave higher yield.

The economics indicating gross realization, total cost of cultivation and benefit cost ratio under different were influenced by nutrient management. Application of 100 % RDF (N_1) was earned the maximum net return (Rs.206156 ha^{-1}) with the B:C ratio of 6.64, which was followed by application of 75% RDF + 25% RDN through Bio-compost (N_2) with net return of Rs. 181933 ha^{-1} and B:C ratio 5.70, whereas the lowest net return (Rs.159228 ha^{-1}) with the B:C ratio of 4.86 was obtained with application of 50 % RDF + 50 % RDN through Bio-compost (N_3). This was attributed to higher cob and fodder yield and also chemical fertilizers are cheaper and required less quantity to supply recommended dose of nutrient hence cost of cultivation was lower with 100 % RDF, ultimately reflected into higher net return and BCR. These results are in partial conformity with those reported by Zende (2007) [12] and Dadarwal *et al.* (2009) [1].

Effect of biofertilizers

Application of Azotobacter + PSB + KMB biofertilizer recorded the significantly highest plant height (210.89 cm), number of leaves per plant (13.34) and stem girth (2.10 cm), cob length per plant with (26.37cm) and without husk (18.07cm), cob girth per plant with (14.53 cm) and without husk (10.53 cm), protein content in cob (6.85%) and fodder (2.85%), Biofertilizer application increased the growth characters by virtue of fixing atmospheric nitrogen, solubulizing and mobilizing nutrients and it secretes growth promoting substances.

The significantly higher cob weight with and without husk per plant (201.51 g and 145.07 g) were found with bio fertilizers i.e. Azotobacter + PSB + KMB (B_1). Whereas, the lowest cob weight with and without husk per plant (187.11 g and 125.07 g) were found under no bio fertilizers (B_0). The higher numbers of grains per row of cob (37.66) were found with biofertilizers i.e. Azotobacter + PSB + KMB (B_1). Whereas, significantly lowest number of grains per row of cob (35.77) were found under no biofertilizers (B_0). The higher numbers of grains per cob (458.88) were found with biofertilizers i.e. Azotobacter + PSB + KMB (B_1). Whereas, the lowest numbers of grains per cob (389.40) were found under no biofertilizers (B_0). The higher fresh weight of grain per cob (116.11 g) found with biofertilizers i.e. Azotobacter + PSB + KMB (B_1). However, the lowest fresh weight of grain per cob (101.51 g) was found under no biofertilizers (B_0). Significantly higher green cob yield (86.64 q ha^{-1}) were found with biofertilizers i.e. Azotobacter + PSB + KMB (B_1). However, the lowest green cob yield (77.44 q ha^{-1}) was found under no biofertilizers (B_0). Significantly higher green fodder yield (299.68 q ha^{-1}) was found with biofertilizers i.e. Azotobacter + PSB + KMB (B_1) over no bio fertilizers (B_0) application (270.96 q ha^{-1}). This could be due to higher nutrient, availability, and higher uptake of nutrients.

The economics indicating gross realization, total cost of cultivation and benefit cost ratio were influenced by biofertilizers application. The maximum net return (Rs.194488 ha^{-1}) with BCR of 6.05 was recorded with biofertilizers i.e. Azotobacter + PSB + KMB (B_1), whereas the lowest net return (Rs.170389 ha^{-1}) with the B:C ratio of 5.42 obtained under no biofertilizers (B_0).

Interaction effect

Combined effect among spacing, nutrient management and biofertilizers did not reach to the level of significance for growth, yield attributes, cob and fodder yield

Conclusion

From the present findings, it could be suggested that rabi sweet corn (var. Sugar-75) crop sown at 60 cm x 20 cm spacing and application of 100% RDF (120:60:00 NPK kg ha^{-1}). It is also seen that biofertilizers i. e. Azotobacter + PSB + KMB (10 ml each kg^{-1} seed) seems to be beneficial on clayey soil under south Gujarat condition.

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