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Effect of plant density and nitrogen management on growth, yield and economics of sweet corn (*Zea mays* var. *Saccharata*)

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Abstract
A field experiment was conducted during *kharif*, 2018 at Agricultural College Farm, Mahanandi to assess "Effect of plant density and nitrogen management on yield and quality of sweet corn (*Zea mays* var *Saccharata*)". The experiment comprised of fifteen treatment combinations consisting three levels of plant density (D_1: 60 cm X 15 cm, D_2: 60 cm X 20 cm and D_3: 60 cm X 25 cm) and five nitrogen management levels (T_1: control, T_2: 100% RDN, T_3: 75% RDN + FYM @ 10 t ha^{-1}, T_4: 100% RDN + FYM @ 10 t ha^{-1} and T_5: 125% RDN + FYM @ 10 t ha^{-1}). Plant density of 60 cm x 15 cm and 60 cm x 20 cm attained higher plant height compared to 60 cm x 25 cm. Leaf area index and drymatter production (kg ha^{-1}) also were influenced by different planting density levels. The sweet corn plants exhibited significantly maximum values of yield attributes *viz.,* 100 seed weight (g), Number of cobs per plant and cob length were under spacing of 60 cm x 25 cm. The highest green cob yield was recorded at plant density of 60 cm x 25 cm which was closely followed by 60 cm x 15 cm. Significantly highest stover yield was recorded at 60 cm x 25 cm. The growth of sweet corn in terms of plant height, leaf area index and drymatter were maximum with application of 125% RDN + FYM @ 10 t ha^{-1}. The sweet corn plants exhibited maximum values of yield attributes *viz.,* number of grains per cob under 100% RDN + FYM @ 10 t ha^{-1} and found at par with those recorded under 125% RDN + FYM @ 10 t ha^{-1} and 75% RDN + FYM @ 10 t ha^{-1}. Whereas cob length, number of cobs per plant and 100 grain weight (g) were highest with 125% RDN + FYM @ 10 t ha^{-1} and found were at par with those recorded under 100% RDN + FYM @ 10 t ha^{-1}. Application of 100 - 125% RDN + FYM @ 10 t ha^{-1} significantly increased green cob yield and stover yield over control, 100% RDN and 75% RDN + FYM @ 10 t ha^{-1}.

Keywords: Sweet corn, plant density, nitrogen management, growth, yield and economics

Introduction

Sweet corn (*Zea mays* var. *saccharata*) also known as sugar corn is a variety of maize with high sugar content. Sweet corn is one of the most popular vegetables in the USA, Canada and Australia. It is becoming more popular in India and other Asian countries. Sweet corn vary from other corns (Field maize, popcorn and ornamental) with high sugar content in early dough stage. It is consumed in the immature stage of the crop. The kernels of sweet corn taste considerable sweeter than normal corn, especially at 25-30% maturity. In India maize is cultivated in an area of 9.63 million hectares with grain production of 25.89 million tonnes and productivity of 2689 kg ha^{-1} and in Andhra Pradesh maize is cultivated in an area of 0.25 million hectares with grain production of 1.65 million tonnes and productivity of 6612 kg ha^{-1} (www.indiastat.com) (2016-17). In general the average productivity of maize has to be improved to meet the growing demand. Since there is a bounded scope to enlarge the area under maize cultivation because of competition from other cereals and commercial crops, the only alternative is through enhancement of productivity by various management factors. Among the factors limiting yield of maize in many areas is inadequate nutrition and low plant population.

In order to achieve higher cob yields, maintenance of plant 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.

In addition to optimum plant population, nutrient management also play crucial role in enhancement of crop productivity. Nitrogen plays major role in various physiological activities of maize. It extends the leaf area effectively, delaying senescence and essential for initiation of ear and kernel. Nitrogen is considered as the nutrient that most generally limits yield and plays an key role in quality of maize crops. Sawi *et al.* (2013) [10], revealed that nitrogen had considerable effects on chemical composition of leaves, number of leaves, plant height, and internodes plant^{-1}, dry weight of shoot and root, cob number plant^{-1}, number and weight of cobs m^{-2}, weight of seeds cob^{-1}, final seed yield and straw yield are affected by nutrient levels. FYM not only acts as a source of nutrients, but improves in soil environment.

The agronomic requirement like optimum plant density, nitrogen management and farm yard manure requirement for maize crop has been worked out but the recommended plant density, nitrogen levels and FYM dose for hybrid and composites of normal maize may not be applicable to the sweet corn. In India considerable work has not been done so far for the sweet corn (Kumar, 2009) [6]. The requirements of plant density and nitrogen doses are yet to be standardized for sweet corn. Therefore, the present experiment was proposed to work out the planting density and nitrogen requirement of sweet corn.

Materials and Methods

A field experiment entitled "Effect of plant density and nitrogen management on yield and quality of sweet corn (*Zea mays* var *Saccharata*)" was conducted at Agricultural College Farm, Mahanandi during *kharif*, 2018. The experiment was carried out in randomized block design with factorial concept and the each treatment was replicated thrice. The treatments consisted of combination of three plant densities (D_1 : 60 cm X 15 cm, D_2 : 60 cm X 20 cm, and D_3 : 60 cm X 25 cm) and five nitrogen management levels (T_1: control, T_2: 100% RDN, T_3: 75% RDN + FYM @ 10 t ha^{-1}, T_4: 100% RDN + FYM @ 10 t ha^{-1} and T_5 : 125% RDN + FYM @ 10 t ha^{-1}) in Factor – I and Factor – II respectively. The soil was sandy loam and it was slightly alkaline in reaction with a pH of 8.08; EC of 0.25 dSm^{-1}, low in organic carbon (0.49%) and available nitrogen (166 kg ha^{-1}), medium in available phosphorus (46.6 kg ha^{-1}) and high in potassium (675.3 kg ha^{-1}). A popular sweet corn hybrid in this region, sugar-75, released by a private company M/s Syngenta India Limited, Baner, Pune, Maharashtra, was used for the study. The fertilizers such as urea, single super phosphate and muriate of potash were supply of NPK and the entire quantity of phosphorous as basal and potassium and nitrogen were applied in three equal splits at 10, 30 and 50 DAS and other agronomical operations were carried out as per recommendation. The growth, yield attributes and yield were recorded at the time of harvest of crop.

Results and Discussion

The results obtained from the present experiment as well as relevant discussion have been summarized under following heads:

Growth characters

The plant height at harvest (Table 1) was failed to show perceptible variation under the influence of plant density. The highest value of this growth parameter was observed with treatment D_1 (60cm x 15cm), which remained closer with other treatment. The leaf area index at harvest (Table 1) was significantly influenced by plant density. Significantly the highest value of this growth parameter was observed with treatment (D_1) 60 cm x 15 cm, which remained at par with treatment (D_2) 60 cm x 20 cm. The drymatter accumulation (kg ha^{-1}) at harvest (Table 1) was significantly influenced by plant density. Significantly the highest value of this growth parameter was observed with treatment (D_1) 60 cm x 15 cm, which is superior over other treatments. Under present investigation the profound influence of plant density on performance of sweet corn crop could be an area available for each plant which indirectly dictated the availability of various growth inputs to individual plants in the population and also the extent of competition between and within the plants for various growth inputs. The significant increase in plant height with decreased intra row spacing seems to be the resultant of competition for light. The result is in close accordance with findings of Gozubenli (2003) [3] and Ummed Singh *et al*. (2012) [11].

Growth parameters viz., plant height, LAI and drymatter at 25, 50 DAS and harvest, (Table 1) were significantly influenced by nitrogen levels. Significantly the highest values of these growth parameters were observed with application of 125% RDN (312.5 N kg ha^{-1}) + FYM @ 10 t ha^{-1}. While, significantly the lowest value were recorded under treatment control. The improvement in growth parameters with application of 125% RDN (312.5 N kg ha^{-1}) + FYM @ 10 t ha^{-1} might have resulted in better and timely availability of Nitrogen for their utilization by plant as judged from nitrogen content of cob and stover. Under the present investigation, profound influence of Nitrogen, a component of nitrogen management, on crop growth seem to be due to maintaining congenial nutritional environment of plant system on account of its greater availability from soil media. The significant improvement in nutrient status of plant parts (cob and stover) might have resulted in greater synthesis of proteins, amino acids and growth promoting substances, which seems to have enhanced the meristematic activity and increased cell division and cell elongation. The enhanced growth with nitrogen was also reported by Chillar *et al*., (2006) [1] in sweet corn.

Table 1: Effect of plant density and nitrogen management on growth parameters of sweet corn at harvest

Treatments	Plant height (cm)	Leaf Area Index (LAI)	Drymatter Production (kg ha^{-1})
Plant density			
D_1: 60 cm X 15 cm	208.40	6.14	7658.90
D_1: 60 cm X 20 cm	205.39	5.76	5770.30
D_1: 60 cm X 25 cm	202.32	4.53	5042.68
SEm ±	2.11	0.19	213.45
CD (p = 0.05)	NS	0.55	618.53
Nitrogen management			
T_1: Control	185.30	5.07	4798.70
T_2: 100% RDN	197.71	5.68	6425.17
T_3: 75 % RDN + FYM @ 10 t ha^{-1}	204.10	4.90	6179.77
T_4: 100% RDN + FYM @ 10 t ha^{-1}	213.81	5.71	6667.17
T_5: 125% RDN + FYM @ 10 t ha^{-1}	225.93	6.02	6715.57
SEm ±	2.73	0.24	275.57
CD (p = 0.05)	7.92	0.72	798.52
(Interaction) DXT			
SEm ±	4.73	0.43	477.30
CD (p = 0.05)	NS	NS	NS

Yield attributes

The yield attributes such as number of grains per cobs, 100 grain weight differed significantly due to alteration in crop geometry. The yield attributes *viz.,* cob length and number of cobs per plant (Table 2) was significantly higher under 60 cm X 25 cm (D_3) over 60 cm x 20 cm (D_2) and 60 cm x 15 cm (D_1). Whereas cobs per plant and cob yield per plant were significantly higher under 60 cm x 25 cm (D_3). The enhanced yield components under 60 cm X 25 cm (D_3) might be due to increased number of leaves, leading to higher photosynthetic rate and accumulation of more assimilates which in turn increased the sink size. Higher nutrient uptake by sweet corn was also evident in the present investigation. The present findings are in line with the results obtained by Kar *et al.* (2006) [5] in sweet corn.

The yield attributes *viz.,* number of cobs per plant, cob length, 100 grain weight and number of grains per cob (Table 2) was significantly influenced by nitrogen levels. Significantly the highest number of cobs per plant, cob length and 100 grain weight values of these yield attributes were observed under treatment 125% RDN + FYM @ 10 t ha^{-1} (T_5). Significantly the highest number of grains per cob were observed in 100% RDN + FYM @ 10 t ha^{-1} and were at par with 75% RDN + FYM @ 10 t ha^{-1} and 125% RDN + FYM @ 10 t ha^{-1}. Greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased number of cobs per plant, cob length, 100 grain weight and number of grains per cob with these nitrogen levels. The present findings are in line of those reported by Kumar *et al.* (2007) [7] and Kumar (2009) [6].

Table 2: Effect of plant density and nitrogen management on yield attributes of sweet corn at harvest

Treatments	No. of Cobs per plant	Cob Length (cm)	100 Grain Weight (gm)	No. of grains per cob
Plant density				
D_1: 60 cm X 15 cm	1.39	20.35	67.85	544.90
D_1: 60 cm X 20 cm	1.41	20.39	68.29	496.04
D_1: 60 cm X 25 cm	1.42	21.26	71.24	546.08
SEm ±	0.05	0.36	8.94	14.93
CD (p = 0.05)	NS	NS	2.74	43.28
Nitrogen management				
T_1: Control	1.06	19.81	60.03	472.19
T_2: 100% RDN	1.37	20.72	67.42	490.54
T_3: 75% RDN+FYM @ 10 t ha^{-1}	1.37	20.88	69.50	561.00
T_4: 100% RDN+FYM @ 10 t ha^{-1}	1.59	20.91	72.84	567.50
T_5: 125% RDN+FYM @ 10 t ha^{-1}	1.64	21.02	75.85	553.79
SEm ±	0.07	0.47	1.22	19.28
CD (p = 0.05)	0.21	NS	3.55	55.87
(Interaction) D X T				
SEm ±	0.13	0.82	2.12	33.40
CD (p = 0.05)	NS	NS	NS	NS

Yield and Economics

Among the plant density levels (Table 3), 60 cm x 25 cm recorded significantly higher green cob yield of sweet corn (11.28 t ha^{-1}), and highest stover yield was obtained at 60 x 15 cm^2. The higher values of yield attributing characters and yield of sweet corn were recorded under wider plant density of 60 cm x 25 cm, which may be due more space available for plant growth and also efficient utilization of natural resources. Similar results were reported by Kar *et al.* (2006) [5] and Massey and Gaur (2006) [8]. The plant density of 60 cm x 25 cm also recorded higher gross and net monetary returns (≠ 1, 12, 858 and 83,547 ha^{-1}, respectively) with benefit cost ratio of 3.8 over rest of plant density levels. Similar, results were reported by Chougale (2003) [2] and Paygonde *et al.* (2008) [9].

The effect of different nitrogen levels on yield of sweet corn was found significant (Table-3). Application of 125% RDN + FYM @ 10 t ha^{-1} recorded significantly higher green cob and stover yields of sweet corn (13.37 t ha^{-1} and 5.49 t ha^{-1}, respectively) than remaining nitrogen levels. The higher nitrogen level increased nutrients availability to plants, which resulted into higher values of yield attributes and yield under treatment of 125% RDN + FYM @ 10 t ha^{-1}. The results corroborated with those reported by Ummed Singh *et al.* (2012) [11]. Similarly, 125% RDN + FYM @ 10 t ha^{-1} recorded higher gross and net monetary returns (Rs. 1,33,719 and 98,606 ha^{-1}, respectively) and benefit cost ratio of 3.8 over other nitrogen levels. Similar, results were reported earlier by Jadhav and Shelke (2012) [4].

Table 3: Effect of plant density and nitrogen management on yield and economics of sweet corn at harvest

Treatments	Green cob yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C ratio
Plant Density					
D_1: 60 cm X 15 cm	11042.4	5207.4	110422	77667	3.3
D_1: 60 cm X 20 cm	9680.6	4255.0	96805	66243	3.1
D_1: 60 cm X 25 cm	11286.9	3999.3	112858	83547	3.8
SEm ±	333.4	96.1	3334.7	3334.7	0.1
CD (p = 0.05)	966.3	279.9	9662.9	9662.9	0.3
Nitrogen Management					
T_1: Control	7249.5	3455.2	72495	48383	3.0
T_2: 100% RDN	9908.7	4077.2	99087	71767	3.6
T_3: 75% RDN+FYM @ 10 t ha^{-1}	10734.3	4475.1	107342	73827	3.2
T_4: 100% RDN+FYM @ 10 t ha^{-1}	12083.5	4929.6	120833	86512	3.5
T_5: 125% RDN+FYM @ 10 t ha^{-1}	13372.1	5499.1	133719	98606	3.8
SEm ±	430.5	124.7	4305.0	4305.0	0.1
CD (p = 0.05)	1247.5	361.4	12474.7	12474.7	0.4
(Interaction) D X T					
SEm ±	7455.6	216.04	7456.5	7456.6	0.3
CD (p = 0.05)	NS	NS	NS	NS	NS

Conclusion

It can be concluded that, the application of 100% RDN + FYM @ 10 t ha^{-1} found remunerative for higher productivity of sweet corn. Similarly, plant spacing of 60 cm x 25 cm found suitable for higher productivity and monetary returns of sweet corn during *kharif* season.

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