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Yield and economics of sweet corn (*Zea mays* L. *Saccharata*) as influenced by plant densities and nitrogen management in irrigated condition

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Abstract
A field experiment was conducted during *kharif* 2017-18 to study the yield and economics of sweet corn (*Zea mays* L. *Saccharata*) as influenced by plant densities and nitrogen management in irrigated condition at Agricultural Research Station, Siruguppa, Karnataka. The soil of the experimental site was clay in texture, low in organic carbon, available N, medium in available phosphorus and high in potassium. The experiment consisted of sixteen treatment combinations of four plant densities viz., S_1:1,11,111, S_2:74,074, S_3:83,333 and S_3:55,555 plants ha^{-1} in main plots and four nitrogen levels F_1:150 kg N ha^{-1}, F_2:187.5 kg N ha^{-1}, F_3:225 kg N ha^{-1} and F_4: 262.5 kg N ha^{-1} in sub plots. Plant density 1,11,111 plants ha^{-1} recorded significantly higher fresh cob yield (13350 kg ha^{-1}) and fresh stover yield (25299 kg ha^{-1}) compared to other plant densities. On the contrary yield parameters *viz*., number of grains per row, number of rows per cob, cob girth, cob length, cob weight and test weight were higher in plant density of 55,555 plants ha^{-1} compared to other plant densities. Among the nitrogen levels, application of 262.5 kg N ha^{-1} registered significantly higher fresh cob yield (13866 kg ha^{-1}), fresh stover yield (24873 kg ha^{-1}) and yield parameters viz., number of grains per row, number of rows per cob, cob girth, cob length, cob weight and test weight as compared to other nitrogen levels. Higher net returns (Rs. 1,40,876 ha$^{-1)}$ and minimum B:C (2.95) was recorded with plant density of 1,11,111 plants ha^{-1} compared to rest of the plant densities and it was on par with 83,333 plants ha^{-1} with net returns (Rs.137521 ha$^{-1)}$ and B:C (3.36). Among the nitrogen levels, application of 262.5 kg N ha^{-1} has recorded significantly higher net returns (Rs. 1,59,020 ha^{-1}) and B:C (3.61) compared to other N levels and it was closely followed application of 225 kg N ha$^{-1.}$

Keywords: Plant densities, nitrogen levels, sweet corn, yield and economics

Introduction
Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice. In India also, it stood third rank after rice and wheat. Maize is being cultivated in an area of 10.2 m ha with a production of 26.2 m t and an average productivity of 2.57 t ha^{-1} in our country and it is being the fourth largest producer in the world contributing three percent of the global production (Anon., 2017) [2]. In Karnataka, it occupies an area of 12.67 lakh ha with a production of 3.31 m t and an average productivity of 2.6 t ha^{-1} (Anon., 2016) [1]. Sweet corn (*Zea mays* L. *Saccharata*) also known as sugar corn and it is a hybrid developed from maize (*Zea mays* L.), specifically bred to increase the sugar content. Though sweet corn is not a staple food, it is consumed fresh as a confection. Of various special corns, sweet corn has huge market potential and has great genetic variability and scope to improve its nutritive value. In addition, quality fodder (on the basis of sweetness) derived after harvest may be sold at higher price that brings an additional income to the farmers as it is highly relished by cattle.
It is an established fact that higher grain yield depends on optimum plant density and adequate fertilizer application. The optimum plant spacing provides better conditions for plant growth results in timely commencement of reproductive phase and formation of sink. The establishment of an optimum plant population per unit area of land is the contributory factor, which determines growth and yield of individual plants. Maize being an exhaustive crop, its fertilizers requirement especially nitrogen is prominent. Nitrogen is essential constituent of chlorophyll, protoplasm and enzymes. Further, it governs utilization of phosphorus and potassium. Since spacing and fertilizer levels are most important factors in agriculture and the

information on these interaction effects with other inputs is rather limited. Keeping all these points in mind, the present field experiment was carried out at Agricultural Research Station, Siruguppa.

Materials and Methods

A field experiment was conducted during *kharif* 2017-18 to study the yield and economics of sweet corn (*Zea mays* L. *Saccharata*) as influenced by plant densities and nitrogen management in irrigated condition at Agricultural Research Station, Siruguppa, Karnataka, The experimental area is situated on the latitude $15^0$38' N, longitude $76^0$54'E, 380 m elevation from MSL belongs to Northern Dry Zone (Zone 3) of Karnataka. The soil of the experimental site was clay in texture, neutral pH (8.09) and low in electrical conductivity (0.26 dSm^{-1}). The soil organic carbon content was 0.43 per cent and low in available N (236 kg ha^{-1}), medium in available phosphorus (23.5 kg ha^{-1}) and high potassium (387.4 kg ha^{-1}). The experiment consisted of sixteen treatment combination of four plant densities viz., S_1:1,11,111, S_2:74,074, S_3:83,333 and S_3:55,555 plants ha^{-1} in main plots and nitrogen levels F_1:150 N kg ha^{-1}, F_2:187.5 N kg ha^{-1}, F_3:225 N kg ha^{-1} and F_4: 262.5 N kg ha^{-1}. The experiment was laid out in spilt plot design with three replications. Recommended P and K is common for all the treatments i.e., 75 kg P and 37.5 kg K. At basal, 10 % of nitrogen with entire dose of phosphorus and potassium in the form of Urea, Di ammonium phosphate (DAP), Single super phosphate (SSP) and Muriate of potash (MOP) were applied as per the treatments. Remaining 90 % nitrogen was top dressed in four splits at 20, 35, 50 and 65 days after sowing (DAS). The hybrid Sugar-75 was used in the investigation. Bicycle weeder was used at 10 and 25 DAS and hand weeding has been done at 15 and 30 days after sowing to manage weeds. All yield and yield parameters collected including number of grains per row, number of rows per cob, cob girth, cob length, cob weight and test weight were recorded at harvest of the crop. Fresh cob yield and fresh stover yield from net plot area was converted into per hectare basis. Economic returns were worked out based on the prevailing market prices of inputs, cost of fertilizers and outputs. The experimental data were analyzed statistically.

Results and Discussion

Among the plant densities significantly higher cob length (20.39 cm), cob girth (14.28 cm), cob weight (217.00 g), number grains per row (44.08), number grain rows per cob (15.65), and test weight (26.15 g) were observed at low plant density of 55,555 plants ha^{-1} and decreased with increase in plant density 1,11,111 plants ha^{-1}. However, it was on par with plant density of 74,074 plants ha^{-1}, which indicating a stress-free environment. This clearly indicates that plants at lower plant density exploited maximum natural resources efficiently, besides responding to externally applied inputs and expressed its maximum potential compared to plants at higher plant density where competition would be high. These results are in conformity with findings of Zarapkar (2006) [11] and Sahoo and Mahapatra (2007). Among the nitrogen levels The higher cob length (20.57 cm), cob girth (14.53 cm), cob weight (219.50 g), number of grains per row (45.64), number grain rows per cob (15.90), test weight (26.58 g) were observed with application of 262.5 N kg ha^{-1} and lower values with the 150 N kg ha^{-1} (Table 1). This is because that inorganic fertilizer contains the nutrients in available forms which would have been easily taken up by the plant for growth and development. Similar findings are also reported by Kunjir (2004) [7] and Shranabasappa (2016) [9].

Significantly higher fresh cob yield (13350 kg ha^{-1}) and fresh stover yield (25299 kg ha^{-1}) was recorded with panting density of 1,11,111 plants ha^{-1}. Significantly lower fresh cob yield (10288 kg ha^{-1}) and fresh stover yield (19212 kg ha^{-1}) was registered under plant density of 55,555 plants ha^{-1}. But fresh stover yield was on par with 83,333 plants ha^{-1} (12278 kg ha^{-1}). These results are in agreement with the results obtained by Kar *et al*. (2006) [6] and Ashok Kumar (2009) [3]. The higher yield under higher plant density was due to more number of cobs per unit area. In another study conducted elsewhere, reported that linear increase in fodder yield with increasing in plant density was also noticed by Kar *et al.* (2006) [6] and Ashok Kumar (2009) [3]. In the present study, among the nitrogen levels significantly higher fresh cob yield and fresh stover yield (13866 kg ha^{-1} and 24873 kg ha^{-1}, respectively) were recorded with application of 262.5 N kg ha^{-1} and lower fresh cob yield and fresh stover yield was recorded with application of 150 N kg ha^{-1} (9469 kg ha^{-1} and 19490 kg ha^{-1}, respectively). These results are in accordance with findings of Bhatt (2012) [4] and Sharanabasappa (2016) [9]. The increased fresh cob yield in sweet corn was with application of 262.5 N kg ha^{-1} might be due to readily available from which would have been easily taken up by the plant for growth and development. Harvest index did not differ significantly by varying plant densities and nitrogen levels (Table 1).

Among the plant densities the higher cost of cultivation was recorded with 1,11,111 plants ha^{-1} (Rs. 72,021 ha^{-1}) than rest of the plant densities and lower cost of cultivation was observed in 55,555 plants ha^{-1} (Rs. 51,171 ha^{-1}). The higher cost of cultivation (Rs. 61,412 ha^{-1}) was recorded by application of 262.5 kg N ha^{-1} compared to other nitrogen levels and lower cost of cultivation (Rs. 60,043 ha^{-1}) incurred under 150 N kg ha^{-1}. Among the plant densities higher gross returns and net returns (Rs. 2,12,898 ha^{-1} and Rs. 1,40876 ha^{-1}, respectively) was registered with the plant density of 1,11,111 plants ha^{-1} compared to other plant densities and net returns was on par with plant density of 83,333 plants ha^{-1} (Rs.1,37,521 ha^{-1}). Minimum gross returns and net returns were noticed with plant density of 55,555 plants ha^{-1} (Rs. 1,63,925 ha^{-1} and Rs. 1,12,754 ha^{-1}, respectively). These higher gross and net returns were mainly attributed to higher fresh cob and fresh stover yield. These results are in conformity with findings of Dutta *et al.* (2015) [5] and Thakur *et al.* (2015) [10]. Maximum gross returns and net returns (Rs. 2,20,432 ha^{-1} and Rs. 1,59,020 ha^{-1}, respectively) was recorded with the application of 262.5 N kg ha^{-1} compared to other nitrogen levels and minimum gross returns and net returns (Rs. 1,51,776 ha^{-1} and Rs. 91,733 ha^{-1}, respectively) was registered under the application of 150 N kg ha^{-1} were due to lowest yield (Table 2). These results are in conformity with findings of Ashok Kumar (2009) [3] and Dutta *et al.* (2015) [5]. Interaction effect between plant densities and nitrogen levels were shown non-significant. Significantly higher benefit cost ratio (3.36) was recorded with plant density of 83,333 plants ha^{-1} and it was on par with plant density of 55,555 plants ha^{-1} (3.20). Significantly lower benefit cost ratio (2.95) was recorded with plant density of 1,11,111 plants ha^{-1} and similar results were also reported by Dutta *et al.* (2015) [5], Thakur *et al.* (2015) [10] and Sharanabasappa (2016) [9]. Significantly higher benefit cost ratio was recorded with application 262.5 N kg ha^{-1} of (3.61) compared to 150 N kg ha^{-1} (2.54). These results are in

conformity with finding of Ashok Kumar (2009) [3], Dutta *et al*. (2015) [5] and Sharanabasappa (2016) [9]. However, interaction effects between plant densities and nitrogen levels were not differed significantly.

Table 1: Fresh cob yield, stover yield, yield parameters and harvest index of sweet corn as influenced by plant densities and nitrogen management in irrigated condition

Treatments	Fresh cob yield (kg ha^{-1})	Fresh stover yield (kg ha^{-1})	Cob weight (g cob^{-1})	Cob length (cm)	Cob girth (cm)	No. of grain rows cob^{-1}	No. of grains row^{-1}	Test weight (g)	Harvest index
Spacings / plant densities (plants ha^{-1}) (S)									
S_1 - 45 cm x 20 cm (1,11,111)	13350	25299	178.83	18.82	13.58	14.81	38.60	23.57	0.34
S_2 - 45 cm x 30 cm (74,074)	11553	22156	202.13	19.61	13.96	15.41	42.73	24.77	0.34
S_3 - 60 cm x 20 cm (83,333)	12278	22935	195.17	19.26	13.76	15.09	41.12	24.12	0.35
S_4 - 60 cm x 30 cm (55,555)	10288	19212	217.00	20.39	14.28	15.65	44.08	26.15	0.35
S.Em.±	317	402	5.49	0.24	0.12	0.09	0.40	0.42	0.11
C.D (P=0.05)	1097	1390	19.00	0.83	0.41	0.31	1.39	1.46	NS
Nitrogen levels (N)									
F_1 - 100 % (150 kg N ha^{-1})	9469	19490	171.83	18.29	13.25	14.39	36.59	23.32	0.33
F_2 - 125 % (187.5 kg N ha^{-1})	11480	21644	192.33	19.27	13.71	15.15	40.33	23.89	0.35
F_3 - 150 % (225 kg N ha^{-1})	12654	23595	209.47	19.95	14.08	15.52	43.98	24.82	0.35
F_4 - 175 % (262.5 kg N ha^{-1})	13866	24873	219.50	20.57	14.53	15.90	45.64	26.58	0.36
S.Em.±	294	321	5.05	0.22	0.06	0.10	0.32	0.33	0.13
C.D (P=0.05)	857	935	14.74	0.60	0.16	0.28	0.93	0.95	NS
Interaction									
N at same level of S									
S.Em.±	588	641	10.10	0.44	0.11	0.19	0.64	0.65	0.27
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
S at same or different levels of N									
S.Em.±	599	685	10.33	0.45	0.15	0.19	0.69	0.71	0.27
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

RDF: 150:75:37.5 kg NPK ha^{-1}, P & K as per the recommendation to all the treatment

Table 2: Economics of sweet corn as influenced by plant densities and nitrogen management in irrigated condition

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C
Spacings / plant densities (plants ha^{-1}) (S)				
S_1 - 45 cm x 20 cm (1,11,111)	72021	212898	140876	2.95
S_2 - 45 cm x 30 cm (74,074)	61596	184370	122774	2.99
S_3 - 60 cm x 20 cm (83,333)	58121	195643	137521	3.36
S_4 - 60 cm x 30 cm (55,555)	51171	163925	112754	3.20
S.Em.±	-	4954	4954	0.08
C.D (P=0.05)	-	17143	17143	0.28
Nitrogen levels (N)				
F_1 - 100 % (150 kg N ha^{-1})	60043	151776	91733	2.54
F_2 - 125 % (187.5 kg N ha^{-1})	60498	183018	122520	3.03
F_3 - 150 % (225 kg N ha^{-1})	60957	201610	140653	3.32
F_4 - 175 % (262.5 kg N ha^{-1})	61412	220432	159020	3.61
S.Em.±	-	4597	4597	0.08
C.D (P=0.05)	-	13418	13418	0.22
Interaction				
N at same level of S				
S.Em.±	-	9194	9194	0.15
C.D (P=0.05)	-	NS	NS	NS
S at same or different levels of N				
S.Em.±	-	9378	9378	0.15
C.D (P=0.05)	-	NS	NS	NS

RDF: 150:75:37.5 kg NPK ha^{-1}, P & K as per the recommendation to all the treatment

Conclusion

Significantly higher fresh cob yield (13350 kg ha^{-1}) and fresh stover yield (25299 kg ha^{-1}) in sweet corn recorded with plant density of 1,11,111 plants ha^{-1} compared to other plant densities. Application of 262.5 N kg ha^{-1} recorded significantly higher fresh cob (13866 kg ha^{-1}) and fresh stover yield (24873 kg ha^{-1}) compared to other nitrogen levels. Plant density of 1,11,111 plants ha^{-1} and application of 262.5 N kg ha^{-1} registered maximum gross returns (Rs. 2,12,898 and 2,20,432 ha $^{-1}$, respectively) and net returns (Rs. 1,40,879 and 1,59,020 ha^{-1}, respectively) than rest of the plant densities and nitrogen levels. Maximum BC ratio (3.36) recorded with plant density of 83,333 plants ha^{-1} compared to rest of the plant densities and it was closely followed by plant density of 55,555 plants ha^{-1} (3.20). Application of 262.5 N kg ha^{-1} registered significantly higher BC ratio (3.61) compared to application of 150 N kg ha^{-1} (2.54).

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