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Abhishek N
Department of Agronomy, University of Agricultural Sciences, Raichur, Karnataka, India

Basavanneppa MA
Chief Agronomist and Head, Agriculture Research Station, Siruguppa, Karnataka, India

Corresponding Author:
Abhishek N
Department of Agronomy, University of Agricultural Sciences, Raichur, Karnataka, India

Effect of plant densities and nitrogen levels on cob yield and quality parameters of sweet corn (*Zea mays* L. Saccharata) in irrigated ecosystem

Abhishek N and Basavanneppa MA

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Abstract
A field trail was conducted during *kharif* 2017-18 to study the effect of plant densities and nitrogen levels on cob yield and quality parameters of sweet corn (*Zea mays* L. Saccharata) in irrigated ecosystem at Agricultural Research Station, Siruguppa, Karnataka. The soil of the experimental site was medium deep black soil, low in organic carbon, available N, medium in available phosphorus and high in potassium. The experiment consisted 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 with 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. The Sugar-75 hybrid was used in the trial. The experimental results revealed that among the plant densities, higher plant density (1,11,111 plants ha^{-1}) recorded significantly higher fresh cob yield (13350 kg ha^{-1}) compared to other plant densities. Whereas quality parameters, protein (10.31%), oil (6.93%), reducing (3.36%) and non-reducing sugar (18.36%) contents in sweet corn were significantly higher with plant density of 55,555 plants ha^{-1}. Among nitrogen levels, application of 262.5 kg N ha^{-1} registered significantly higher fresh cob yield (13866 kg ha^{-1}), protein (10.39%), starch (47.97%), oil (7.07%), reducing (3.48%) and non-reducing sugar (18.49%) contents in sweet corn compared to 150 N kg ha^{-1}.

Keywords: Sweet corn, plant densities, nitrogen levels, fresh cob yield and quality parameters

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice. In India also, it stand third position 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 India. It is also being the fourth largest producer in the world contributing three percent of the global production (Anon., 2017) [2]. In Karnataka, it occupied 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].

Out of different groups of maize, sweet corn is one of the commercially used types of maize, 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. It is gaining popularity both in rural and urban areas because of its high sugar (14-20%), low starch and vitamin C and A content. Hence, sweet corn is usually eaten in the immature stage as a fresh vegetable, boiled, steamed or roasted and also used in a wide variety of vegetable mixtures, soups and canning purposes. Similarly, sweet corn fodder is green, succulent which fetches higher price in market and maximum profit to farmers. Therefore, sweet corn is mainly grown by farmers due to short duration, green fodder at harvest and high market price for various sweet corn products (Kurne *et al*., 2017) [11].

It is an established fact that higher grain yields and quality parameters are primarily depends on optimum plant density and adequate nutrient supply. 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 nutrients requirement especially nitrogen is prominent. Nitrogen is essential constituent of chlorophyll, protoplasm and enzymes which in turn led to better quality parameters. Further, it governs utilization of phosphorus and potassium. Since spacing and nitrogen levels are most important factors in agriculture.

However, no systematic research has been conducted to develop site and situation specific production technology for this crop, there is need to establish a relationship between plant densities and nitrogen (Bhatt, 2012) [5]. The information on response of highly productive maize hybrids to higher levels of nitrogen beyond the present level of recommendation is meager. Keeping all these points in mind, the present field trail was conducted at Agricultural Research Station, Siruguppa.

Materials and Methods

A field experiment was conducted during *kharif* 2017-18 to study the effect of plant densities and nitrogen levels on cob yield and quality parameters of sweet corn (*Zea mays* L. *Saccharata*) in irrigated ecosystem at Agricultural Research Station, Siruguppa, 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 are 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 carried out at 15 and 30 days after sowing to keep the plots weed free. The yield, yield parameters and quality parameters were recorded at harvest of the crop. Fresh cob yield from net plot area was converted into per hectare basis. The experimental data were analyzed statistically.

Results and Discussion

The fresh cob yield of sweet corn was significantly influenced by the plant densities. The plant density of 1,11,111 plants ha^{-1} recorded significantly higher fresh cob yield (13350 kg ha^{-1}) when compared to 55,555 plants ha^{-1} (Table 1) and it was on par with 83,333 plants ha^{-1} (12278 kg ha^{-1}). Whereas the plant density of 55,555 plants ha^{-1} recorded significantly lower fresh cob yield (10288 kg ha^{-1}) compared to rest of the plant densities. The increase in fresh cob yield of sweet corn under higher plant density was mainly attributed higher plant population per unit area (1,11,111 plants ha $^{-1}$) and more number of cobs per unit area. The per cent increase in yield was varied to an extent of 29.76, 15.55, and 8.73 per cent over 55,555, 74074 plants ha^{-1} and 83.333 plants ha^{-1}, respectively. Similar results are also reported by Kanakadurga *et al*. (2012) [7] and Kour *et al.* (2017) [10]. Some studies reported that linear increase in fresh fodder yield with increasing in plant densities by Kar *et al.* (2006) [8] and Ashok Kumar (2009) [4]. In the present study significantly higher total dry matter accumulation was observed with plant density of 55,555 ha^{-1} (220.3 g $plant^{-1}$) and lower dry matter accumulation was noticed with 1,11,111 ha^{-1} (163.8 $plant^{-1}$).

Among the nitrogen levels, application of 262.5 N kg ha^{-1} registered significantly higher fresh cob yield (13866 kg ha^{-1}) with yield advantages of 46.43%, 20.78% and 9.57% over nitrogen levels of 150, 187.5 and 225 N kg ha^{-1}, respectively (Table 1). These results are in accordance with findings of Bhatt (2012) [5] and Shranabasappa and Basavanneppa (2019) [14]. The increased fresh cob yield in sweet corn with application of 262.5 N kg ha^{-1} might be due to readily available from of nitrogen which would have been easily taken up by the plant for growth and development. Further it was also greatly influenced by total dry matter production, hundred fresh grain weights and number of cobs per plant. These results are also in line with findings of Bhatt, 2012 [5] and Shranabasappa and Basavanneppa (2019) [14]. In the present study significantly lower fresh cob yield was noticed with application of 150 N kg ha^{-1} (9469 kg ha^{-1}) and this lower yield was mainly due to lower plant population per unit area (55,555 plants ha^{-1}).

The protein content in sweet corn (Table 2) was significantly higher under plant density of 55,555 plants ha^{-1} (10.31%) compared to 1,11,111 plants ha^{-1} (9.66%) but it was on par with plant density of 74,074 plants ha^{-1} (10.0%). This was mainly attributed to the higher nitrogen values in the sweet corn. Similar results were reported by Kar *et al.* (2006) [8], Bhatt (2012) [5] and Raghavendra Shintri (2013) [12]. Whereas, Gosavi and Bhagat (2009) [6] opined that wider spacing of 60 x 20 cm recorded significantly higher protein and sugar content than the narrower spacing. In the present study similarly oil (6.93%), reducing(3.36%) and non-reducing sugar (18.36%) contents in sweet corn was also significantly higher with plant density of 55,555 plants ha^{-1} compared to plant density of 1,11,111 plants ha^{-1} (6.45, 2.73 and 17.44%, respectively), but oil content was on par with plant density of 74,.74 plants ha^{-1} (6.71%). Further, starch content was greatly influenced by plant densities. Lower plant density (55,555 plants ha^{-1}) produced significantly higher starch content (46.08%) when compared to rest of the plant densities. This was due to higher availability of resources and better photosynthetic and other physiological activity of the individual plants under the low plant densities which was reported by Raja (2001) [3], Bhatt (2012) [5], Sobhana *et al*. (2013) [15] and Shranabasappa and Basavanneppa (2019) [14]. While in an another experiment conducted elsewhere by Vishuddha (2015) [16] observed that spacing of 60 cm x 20 cm recorded significantly higher protein content and protein yield than the spacing of 60 cm x 25 cm and 45 cm x 20 cm.

Among the nitrogen levels, application of 262.5 N kg ha^{-1} produced the higher protein (10.39%) and starch content (47.97%) in sweet corn (Table 2) when compared to 150 N kg ha^{-1}. It was mainly attributed to the higher nitrogen availability to the sweet corn. Similarly starch, oil, reducing and non-reducing sugar content in sweet corn was also significantly higher with application of 262.5 N kg ha^{-1} (47.97, 7.07, 3.48 and 18.49%, respectively) compared to 150 N kg ha^{-1} (42.14, 6.36, 2.62 and 17.18%, respectively). These results are in line with findings of Gosavi and Bhagat (2009) [6], Raja (2001) [3], Bhatt (2012) [5] and Shranabasappa and Basavanneppa (2019) [14]. Whereas in an another experiment conducted elsewhere by Khan *et al*. (2018) [9] reported that protein content increased significantly with the increasing N levels from 0 to 120 kg ha^{-1}.

Table 1: Fresh cob yield and other parameters of sweet corn as influenced by plant densities and nitrogen levels under irrigated condition

Treatments	Fresh cob yield (kg ha^{-1})	Dry matter production (g/pl)	No. of cobs $plant^{-1}$	Test weight (g)
Spacings / plant densities (plants ha^{-1}) (S)				
S_1 - 45 cm x 20 cm (1,11,111)	13350	163.8	1.27	23.57
S_2 - 45 cm x 30 cm (74,074)	11553	203.7	1.36	24.77
S_3 - 60 cm x 20 cm (83,333)	12278	188.0	1.33	24.12
S_4 - 60 cm x 30 cm (55,555)	10288	220.3	1.43	26.15
S.Em.±	317	1.8	0.02	0.42
C.D (P=0.05)	1097	6.1	0.09	1.46
Nitrogen levels (N)				
F_1 - 100% (150 kg N ha^{-1})	9469	155.0	1.20	23.32
F_2 - 125% (187.5 kg N ha^{-1})	11480	185.7	1.33	23.89
F_3 - 150% (225 kg N ha^{-1})	12654	208.2	1.41	24.82
F_4 - 175% (262.5 kg N ha^{-1})	13866	227.0	1.46	26.58
S.Em.±	294	2.0	0.02	0.33
C.D (P=0.05)	857	6.0	0.07	0.95
Interaction				
N at same level of S				
S.Em.±	588	4.1	0.05	0.65
C.D (P=0.05)	NS	NS	NS	NS
S at same or different levels of N				
S.Em.±	599	4.0	0.05	0.71
C.D (P=0.05)	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: Protein, oil, moisture, starch, reducing and non-reducing sugar content of sweet corn as influenced by plant densities and nitrogen levels under irrigated condition

Treatments	Protein (%)	Oil (%)	Moisture (%)	Starch (%)	Reducing sugar (%)	Non-reducing sugar (%)
Spacing/plant densities (plants ha^{-1}) (S)						
S_1 - 45 cm x 20 cm (1,11,111)	9.66	6.45	11.22	43.84	2.73	17.44
S_2 - 45 cm x 30 cm (74,074)	10.00	6.71	11.13	45.81	3.29	17.82
S_3 - 60 cm x 20 cm (83,333)	9.87	6.67	11.17	45.36	3.03	17.79
S_4 - 60 cm x 30 cm (55,555)	10.31	6.93	11.06	46.08	3.36	18.36
S.Em.±	0.12	0.07	0.28	0.31	0.01	0.07
C.D (P=0.05)	0.41	0.24	NS	1.08	0.04	0.25
Nitrogen levels (N)						
F_1 - 100% (150 kg N ha^{-1})	9.52	6.36	11.70	42.14	2.62	17.18
F_2 - 125% (187.5 kg N ha^{-1})	9.82	6.53	11.02	44.71	2.99	17.65
F_3 - 150% (225 kg N ha^{-1})	10.11	6.79	10.92	46.26	3.31	18.09
F_4 - 175% (262.5 kg N ha^{-1})	10.39	7.07	10.89	47.97	3.48	18.49
S.Em.±	0.08	0.06	0.28	0.28	0.04	0.09
C.D (P=0.05)	0.20	0.17	NS	0.82	0.11	0.27
Interactions						
N at same level of S						
S.Em.±	0.16	0.12	0.56	0.56	0.07	0.18
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
S at same or different levels of N						
S.Em.±	0.18	0.12	0.56	0.58	0.07	0.18
C.D (P=0.05)	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

Conclusion

Significantly higher fresh cob yield (13350 kg ha^{-1}) of sweet corn was recorded with plant density of 1,11,111 plants ha^{-1} compared to other plant densities. Whereas higher quality parameters viz., protein, oil, reducing and non reducing sugars and starch contents were observed in lower plant density (55,555 plants ha^{-1}) than higher plant density. Among the nitrogen levels, application of 262.5 N kg ha^{-1} recorded significantly higher fresh cob (13866 kg ha^{-1}), protein, oil, reducing and non reducing sugars and starch contents in sweet corn when compared to application of 150 N kg ha^{-1}.

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