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

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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., S1:1,11,111, S2:74,074, S3:83,333 and S4:55,555 plants ha\(^{-1}\) in main plots and with four nitrogen levels F1:150 kg N ha\(^{-1}\), F2:187.5 kg N ha\(^{-1}\), F3:225 kg N ha\(^{-1}\) and F4: 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.

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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) [3]. 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 dS/m). 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., S₁:1,11,111, S₂:74,074, S₃:83,333 and S₄:55,555 plants ha⁻¹ in main plots and nitrogen levels F₁:150 N kg ha⁻¹, F₂:187.5 N kg ha⁻¹, F₃:225 N kg ha⁻¹ and F₄: 262.5 N kg ha⁻¹. The experiment was laid out in split 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 p

**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 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 Basavanapenna (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 Basavanapenna (2019) [14]. Whereas in 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) |
|------------|---------------------------|-----------------------------|---------------------|----------------|
| S₁ - 45 cm x 20 cm (1,11,111) | 13350 | 163.8 | 1.27 | 23.57 |
| S₂ - 45 cm x 30 cm (74,074) | 11553 | 203.7 | 1.36 | 24.77 |
| S₃ - 60 cm x 20 cm (83,333) | 12278 | 188.0 | 1.33 | 24.12 |
| S₄ - 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)

| Treatments | Protein (%) | Oil (%) | Moisture (%) | Starch (%) | Reducing sugar (%) | Non-reducing sugar (%) |
|------------|-------------|---------|--------------|------------|--------------------|------------------------|
| S₁ - 45 cm x 20 cm (1,11,111) | 10.39 | 4.65 | 11.22 | 43.84 | 2.73 | 17.44 |
| S₂ - 45 cm x 30 cm (74,074) | 10.92 | 6.71 | 11.13 | 45.81 | 3.29 | 17.82 |
| S₃ - 60 cm x 20 cm (83,333) | 9.87 | 6.67 | 11.17 | 45.36 | 3.03 | 17.79 |
| S₄ - 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 |

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 (%) |
|------------|-------------|---------|--------------|------------|--------------------|------------------------|
| S₁ - 45 cm x 20 cm (1,11,111) | 9.52 | 6.36 | 11.70 | 42.14 | 2.62 | 17.18 |
| S₂ - 45 cm x 30 cm (74,074) | 9.82 | 6.53 | 11.02 | 44.71 | 2.99 | 17.05 |
| S₃ - 60 cm x 20 cm (83,333) | 10.11 | 6.79 | 10.92 | 46.26 | 3.31 | 18.09 |
| S₄ - 60 cm x 30 cm (55,555) | 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 |

Nitrogen levels (N)

| Treatments | Protein (%) | Oil (%) | Moisture (%) | Starch (%) | Reducing sugar (%) | Non-reducing sugar (%) |
|------------|-------------|---------|--------------|------------|--------------------|------------------------|
| S₁ - 45 cm x 20 cm (1,11,111) | 9.52 | 6.36 | 11.70 | 42.14 | 2.62 | 17.18 |
| S₂ - 45 cm x 30 cm (74,074) | 9.82 | 6.53 | 11.02 | 44.71 | 2.99 | 17.05 |
| S₃ - 60 cm x 20 cm (83,333) | 10.11 | 6.79 | 10.92 | 46.26 | 3.31 | 18.09 |
| S₄ - 60 cm x 30 cm (55,555) | 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 |

Interaction

| Treatments | Protein (%) | Oil (%) | Moisture (%) | Starch (%) | Reducing sugar (%) | Non-reducing sugar (%) |
|------------|-------------|---------|--------------|------------|--------------------|------------------------|
| S₁ - 45 cm x 20 cm (1,11,111) | 9.52 | 6.36 | 11.70 | 42.14 | 2.62 | 17.18 |
| S₂ - 45 cm x 30 cm (74,074) | 9.82 | 6.53 | 11.02 | 44.71 | 2.99 | 17.05 |
| S₃ - 60 cm x 20 cm (83,333) | 10.11 | 6.79 | 10.92 | 46.26 | 3.31 | 18.09 |
| S₄ - 60 cm x 30 cm (55,555) | 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 |

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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