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Effect of plant density and nitrogen management on quality parameters and post - harvest available soil nutrients 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*)". Among the plant densities tried, plant density at (D_1) 60 cm X 15 cm recorded that highest uptake of N, P_2O_5 and K_2O by the crop at all the growth stages. Among the nitrogen levels tried, application of (T_5) 125% RDN + FYM @ 10 t ha^{-1} at 25, 50 DAS and at harvest recorded the highest uptake of N, P_2O_5 and K_2O which was however, found parity with (T_4) 100% RDN + FYM @ 10 t ha^{-1}. Among the plant densities 60 cm X 20 cm recorded higher total sugar, starch and amylose content over the other plant densities. Application 100% RDN + FYM @ 10 t ha^{-1} recorded significantly higher total sugar, starch and amylose content over rest of the treatments. Among the plant densities 60 cm X 20 cm recorded higher available nitrogen and 60 cm X 25 cm recorded higher available phosphorus and potassium available in soil after the harvest over other treatments. The maximum available nitrogen, phosphorus, potassium in soil was recorded with the application of 125% RDN + FYM @ 10 t ha^{-1} and it was on par with 100% RDN + FYM @ 10 t ha^{-1}.

Keywords: Plant density, nitrogen management, total sugar, starch, amylose content, post harvest available soil nutrients, sweet corn

Introduction
Sweet corn (*Zea mays* var. *saccharata*) also known as sugar corn is a variety of maize with high sugar content. Maize is grown under diversified environment unmatched by any another crop as the expansion of maize to new areas and environment still continues. Maize is achieving popularity among the farmers in India due to its flexible characteristics of suitability and adaptability to various agro-climates. Maize is the most productive coarse cereal crop species in utilizing radiant energy and has the highest capacity to produce carbohydrates per day as compared to other cereals. The crop is less susceptible to environmental threats and cost of cultivation per kg of grain is less compared to other cereals, which lead to drawing the attention of the farmers of Andhra Pradesh and India. Majority of the maize cultivated in the country is flint corn. However in recent years sweet corn is also gaining importance due to consumer preference in table purpose maize. Maintenance of plant density is the most important factor to get higher cob yields. Plant density is one of the very important cultural practices which decide grain yield as well as other agronomic attributes of this crop (Songoai, 2001). In addition to optimum plant population, Nitrogen 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. Importance of aroma and flavor in consumer acceptance of sweet corn was documented, with three most important components of flavor response consisting of sweetness, texture and aroma (Adamson *et al.*, 1995) [1]. At 86 calories per 100 g, sugar corn kernels are moderately high in calories in comparison to other vegetables. However, fresh sweet corn has much fewer calories than that of in the field corn and other cereal grains like wheat, rice, etc. Their calorie chiefly comes from simpler carbohydrates like glucose,

sucrose than complex sugars like amylose and amylopectin, which is a case in the cereals.

Since *kharif* sweet corn is achieving importance due to its productivity and stable market price, there is need to establish a relationship between nitrogen levels and plant density. The knowledge on response of highly productive sweet corn hybrids to other levels of nitrogen than the present level of recommendations is meager. By considering these points an experiment was proposed to research on "Effect of Plant density and Nitrogen management on uptake of major nutrients in Sweet corn (*Zea mays* var. *saccharata*)".

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.

1. Analysis of Total Sugars in Sweet corn powder

Total sugars were estimated by the method explained by Somogyi (1952) [7].

Procedure: For the estimation of total sugars, 250 mg finely grinded with 10 ml of boiling ethanol (80%) and the materials was centrifuged at 6000 rpm at room temperature. After the centrifugation the supernatant was collected and to this 5ml of distilled water was added. The tubes were kept in boiling water bath for 15 minutes at 70^0C. 1ml of aliquot was drawn from this aqueous phase and add 1ml of distilled water and 1 ml of 1N H_2SO_4 to the residue and hydrolyze by heating at 49^0C for 30 minutes. Cool the test tubes add 1-2 drops of methyl red indicator and neutralize the contents by adding 1N NaOH drop wise from a pipette. Maintain appropriate reagent blank (1ml water + 1ml H_2SO_4 +2 drops of methyl red indicator =1 ml NaOH) and the solution was made up to 10 ml of final volume with distilled water. The absorbance of the solution was measured in spectrophotometer at 620 nm.

2. Analysis of Starch in corn powder

Estimation of Starch by anthrone reagent method explained by Sadasivam and Manickam (1996) [6].

Procedure: 0.5 gm of sample is homogenized in 80% hot ethanol to remove sugars, centrifuged at 2500 rpm for 20 minutes and the residue was retained. Washed the residue repeatedly with hot 80% ethanol till the washing did not give color with anthrone reagent. The residue allowed to dry well on a water bath. To the residue 5 ml of water and 6.5 ml perchloric acid were added to extract sugars from starch. Centrifuged at 2500 rpm for 20 min at temperature 4^0C. The supernatant was collected and repeated the extraction using fresh perchloric acid. Centrifuged and pooled the supernatant and made upto 100 ml. Pipette out 0.1 ml of the supernatant and made upto the volume to 1ml with water. 4.0ml of anthrone reagent was added to each tube. Kept in boiling water bath for 8 min. The tubes were cooled rapidly and the intensity of light green to dark green color was recorded at 630 nm using spectrophotometer.

3. Analysis of Amylose in corn powder

Estimation of amylose content in corn powder by Iodine reagent method as suggested by Sadasivam and Mannick (1996) [6].

Procedure: 100mg powdered sample is weighed and add 1ml of distilled ethanol. Add 10 ml of 1N NaOH and leave over night or kept the sample in a water bath for 10 minutes. Made upto 100 ml with the distilled water. Take 2.5 ml of extract from the above solution. Add 20 ml distilled water + three drops phenapthalin indicator. Add 0.1 N HCl drop by drop until pink color just disappear. Add 1ml of iodine reagent and make up to 50 ml by distilled water. Read color at 590 nm. Take 0.2, 0.4, 0.6, 0.8, 1.0 ml of standard solution and develop color like sample. Calculate by placing standard graph. Dilute 1ml of iodine reagent to 50ml with distilled water for a blank.

4. Post-harvest soil nutrients content

Representative soil samples from each treatment plot were gathered after harvest of sweet corn crop. The soil samples were subjected to shade drying, passed through 2 mm sieve and preserved for further analysis. The soil samples were examined for available nitrogen, phosphorus and potassium content of the soil.

4.1 Available nitrogen: In soil, the available nitrogen was estimated by alkaline permanganate oxidation method as outlined by Subbiah and Asija (1956) [9] and is expressed kg ha^{-1}.

4.2 Available phosphorus: In soil, the available phosphorus was determined by Olsen's method using spectrophotometer (660 nm wv) as outlined by Olsen *et al*. (1954) [5] and was expressed in kg ha^{-1}.

4.3 Available potassium: In soil, the available potassium was extracted with neutral normal ammonium acetate (1N NH_4OAC) and by using Flame photometer, the K content in the solution was estimated (Jackson, 1973) [4] and is expressed in kg ha^{-1}.

Results and Discussion

Application of 100% RDN + FYM @ 10 t ha^{-1} recorded significantly higher total sugar (14.72%), starch (23.25%) and amylose (42.44%) content in cob at harvest over the other treatments. The highest total sugar (14.72%), starch (23.25%) and amylose (42.44%) were registered by a plant density of 60cm X 20cm. Total sugar and starch increased significantly with increasing levels of nitrogen upto 100% RDN + FYM @ 10 t ha^{-1}. The highest amylose content (42.44 per cent) was noticed with the application of 100% RDN + FYM @ 10 t ha^{-1}. These results are in line with Ibrahim & Kandil (2007) and Gaurav (2015) [3, 2].

Data on residual available N, P_2O_5 and K_2O status (kg ha^{-1}) of the experimental field after harvest of sweet corn was presented in Table 2. The data indicated that the available nitrogen, phosphorous and potassium was significantly influenced by nitrogen management whereas, the available phosphorus that was alone influenced with plant densities and plant densities could not make any impact on soil available nitrogen and potassium. The interaction between plant density and nitrogen management was significant with regard to post harvest availability of all the soil major nutrients.

After harvest of the sweet corn, available nitrogen was significantly influenced by the treatments tried. With increase in each nitrogen level, there was an increase in the available nitrogen. The maximum soil available nitrogen recorded with (T_4) 100% RDN + FYM @ 10 t ha^{-1} (116.20 kg ha^{-1}) which was however statistically similar with (T_5) 125% RDN + FYM @ 10 t ha^{-1} (116.04 kg ha^{-1}) and (T_3) 75% RDN + FYM @ 10 t ha^{-1} (114.15 kg ha^{-1}) and significantly higher than other nitrogen levels. Similarly highest (155.76, 772.92 kg ha^{-1}) available phosphorus and potassium recorded with (T_5) 125% RDN + FYM @ 10 t ha^{-1}.

The highest (108.63 kg ha^{-1}) available nitrogen was recorded with (D_2) 60 cm X 20 cm and the lowest (104.34 kg ha^{-1}) was recorded with a plant density of (D_1) 60 cm X 15 cm all the treatments were statistically at par with each other. Significantly the highest (136.66 kg ha^{-1}) available phosphorus was recorded with (D_3) 60 cm X 25 cm and the lowest (116.92, 683.93 kg ha^{-1}) was recorded with a plant density of (D_1) 60 cm X 15 cm.

This high available phsophorus at low plant density might be due to lower absorption due to low plant density and vice versa. Similar trend was observed in available Potassium even though soil vailable potassium could not be influenced by plant spacing. Similar results were also given earlier by Arun Kumar *et al.* (2009).

Table 1: Effect of plant density and nitrogen management on Total Sugar content (%), Starch content (%) and Amylose content (%) in sweet corn cob

Treatments	Total Sugar (%)	Starch (%)	Amylose (%)
Plant density			
D1: 60 cm X 15 cm	12.00	18.87	39.30
D2: 60 cm X 20 cm	12.25	20.74	41.73
D3: 60 cm X 25 cm	11.14	19.42	39.30
SE (m)±	0.51	1.06	1.34
CD (p = 0.05)	NS	NS	NS
Nitrogen management			
T1: Control	9.53	16.71	38.72
T2: 100% RDN	10.80	17.67	42.33
T3: 75% RDN + FYM @ 10 t ha^{-1}	12.69	19.25	39.50
T4: 100% RDN + FYM @ 10 t ha^{-1}	14.72	23.25	42.44
T5: 125% RDN + FYM @ 10 t ha^{-1}	11.69	21.50	37.27
SE (m)±	0.66	1.37	1.34
CD (p = 0.05)	1.91	3.97	NS
(Interaction) D X T			
SE (m)±	1.14	2.37	3.01
CD (p = 0.05)	NS	NS	NS

Plant density
D_1: 60 cm X 15 cm (1, 11, 111 plants ha^{-1})
D_2: 60 cm X 20 cm (83, 333 plants ha^{-1})
D_3: 60 cm X 25 cm (66, 666 plants ha^{-1})

Nitrogen management
T_1: Control
T_2: 100% RDN (250 N kg ha^{-1})
T_3: 75% RDN (187.5 N kg ha^{-1}) + FYM @ 10 t ha^{-1}
T_4: 100% RDN (250 N kg ha^{-1}) + FYM @ 10 t ha^{-1}
T_5: 125% RDN (312.5 N kg ha^{-1}) + FYM @ 10 t ha^{-1}

Table 2: Effect of plant density and nitrogen management on post harvest available soil nutrients

Treatments	Available soil Nitrogen (kg ha^{-1})	Available soil P2O5 (kg ha^{-1})	Available soil K2O (kg ha^{-1})
Plant density			
D1: 60 cm X 15 cm	104.34	119.69	683.93
D2: 60 cm X 20 cm	108.63	116.92	688.87
D3: 60 cm X 25 cm	105.46	136.66	733.56
SE (m)±	3.48	2.80	17.44
CD (p = 0.05)	NS	8.11	NS
Nitrogen management			
T1: Control	82.18	91.78	584.61
T2: 100% RDN	102.15	112.26	682.21
T3: 75% RDN + FYM @ 10 t ha^{-1}	114.15	128.03	712.35
T4: 100% RDN + FYM @ 10 t ha^{-1}	116.20	142.31	758.51
T5: 125% RDN + FYM @ 10 t ha^{-1}	116.04	155.76	772.92
SE (m)±	4.49	3.61	22.52

CD (p = 0.05)	13.03	10.48	65.26
(Interaction) D X T			
SE (m)±	7.78	6.26	39.01
CD (p = 0.05)	22.57	18.15	113.04

Plant density
D_1: 60 cm X 15 cm (1, 11, 111 plants ha^{-1})
D_2: 60 cm X 20 cm (83, 333 plants ha^{-1})
D_3: 60 cm X 25 cm (66, 666 plants ha^{-1})

Nitrogen management
T_1: Control
T_2: 100% RDN (250 N kg ha^{-1})
T_3: 75% RDN (187.5 N kg ha^{-1}) + FYM @ 10 t ha^{-1}
T_4: 100% RDN (250 N kg ha^{-1}) + FYM @ 10 t ha^{-1}
T_5: 125% RDN (312.5 N kg ha^{-1}) + FYM @ 10 t ha^{-1}

Conclusion

Among all the combinations, significantly highest concentration Total Sugar content (%), Starch content (%) and Amylose content (%) of sweet corn were obtained with application of 100% RDN + FYM @ 10 t ha^{-1} at a planting density of 60 cm X 20 cm (83,333 plants ha^{-1}). Among all the combinations, highest post harvest available soil nutrients of sweet corn were obtained with application of 125% RDN + FYM @ 10 t ha^{-1} and it was on par with 100% RDN + FYM @ 10 t ha^{-1} at a planting density of 60 cm X 25 cm (66,666 plants ha^{-1}). Hence the application of 100% RDN + FYM @ 10 t ha^{-1} at a planting density of 60 cm X 20 cm (86,666 plants ha^{-1}) for sweet corn may be recommended. However the results will have to be confirmed by conducting extensive field trails in farmer's fields on long term basis.

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