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Effect of different levels, split and foliar application of nitrogen on growth and yield of sweet corn (*Zea mays* var. *saccharata*)

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Abstract
The goal of this research carried out at Faculty of Agriculture of Navsari Agricultural University of Navsari, during *rabi* season in 2017-18 was to determine the influence of different splits of nitrogen rates with and without foliar application of 2% urea on growth and yield of sweet corn (*Zea mays var.* saccharata). Experiment was laid out in factorial randomized block design with three replications. The research comprised of three level of recommended dose of nitrogen: 50%, 75% and 100% RDN; two levels of split application: basal *fb* 30 DAS, basal *fb* 20 and 40 DAS; and foliar application of nitrogen: control and 2% urea at 50 DAS. The results revealed that plant height at 60 DAS and at harvest, leaf area at 60 DAS, dry matter accumulation at harvest, number of grains and cob weight had significant results when 100% RDN applied in 3 splits while 100% RDN applied with 2% urea at 50 DAS, plant height at harvest, chlorophyll SPAD value at 60 DAS and dry matter accumulation at harvest were found significant superior. Significantly higher cob and fodder yield recorded in case of 100% RDN, 3 splits and foliar application of nitrogen.

Keywords: Sweet corn, nitrogen, split application, foliar application, RDN

Introduction

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. Maize contributes to nearly 9% in the national food basket and more than 400 billion to the agricultural GDP at current prices. Physiologically sweet corn is a form of maize which is incapable of completing the formation of normal corn starch or has been expressed tersely; sweet corn is field corn in an arrested state of development. It has been designated as an agricultural species, *Zea saccharata* by Sturtevant and as distinct species, *Zea rugosa* by Bonafice. Subsequently rugosa was reduced to a sub-species of *Zea maize* by Bailey (Erwin, 1951). It contains energy of 90 kcal, carbohydrates (19 gm), sugar (3.2 gm), dietary fiber (2.7 gm), fat (1.2 gm), protein (3.2 gm), vitamin A (10 µg), folate (Vit.B9) (46 µg), vitamin C (7 mg), iron (0.5 mg), magnesium (37 mg) and potassium (270 mg) nutritional value per 100 g sweet corn seed (USDA Nutrient Database).

Unlike all other food crops, sweet corn also requires proper nutrient management for better growth and development. Nitrogen (N) is a vital plant nutrient and a major determining factor required for maize production (Shanti, *et al.* 1997). It is very essential for plant growth and makes up 1–4% of dry matter of the plants. Nitrogen is a component of protein and nucleic acids and when N is suboptimal, growth is reduced (Haque, 2001) [6]. Its availability in sufficient quantity throughout the growing season is essential for optimum growth and development of sweet corn. But at present, nitrogen is universally deficient in Indian soils with 99% of soils responding to nitrogen application (Chander, 2016) [4]. Nitrogen also mediates the utilization of phosphorus, potassium and other elements in plants (Brady, 1984). Plants uptake nitrogen in the form of nitrate (NO_3) and ammonia (NH_4) (Thornton and Robonson, 2005) [15]. Optimal amount of these elements in the soil cannot be utilized efficiently if nitrogen is deficient in plants. Therefore, nitrogen deficiency can result in losses of sweet corn yields.

Although the deficiency may be cured by applying nitrogen, its use efficiency is not good. Nitrogen use efficiency pertains only 33%, as predicted by the researchers while developing nitrogen management tools and methods. The nitrogen use efficiency depends on soil type, climate, agronomic practices, source of nutrient and other factors, that vulnerable to loss. Denitrification, leaching and volatilization impose costs that include loss in crop productivity and negative environmental impact. Split application of nitrogenous fertilizer is one way to confront these challenges. Split applications can play an important role in a nutrient management strategy that is productive, profitable and environmentally responsible. Dividing total nitrogen application into two or more splits can help growers enhance nutrient efficiency, promote optimum yields and mitigate the loss of nutrients. Specifically, synchronizing nitrogen supply with a plant’s ability to utilize nutrients, split application can be an important component of 4R Nutrient Stewardship - right source, right rate, right time and right place.

Furthermore, research has shown that combining foliar nitrogen fertilization with a soil based fertility program improves crop production and quality. Foliar fertilization means applying nutrients to plant leaves or aerial parts. Foliar fertilization can correct nitrogen deficiencies at immediate effect, decrease the amount of total nitrogen necessary and minimize nitrogen runoff. Leaves can absorb inorganic and organic nitrogen sources. Small pores within leaf cuticles can take up urea, ammonium and nitrate (Guihong and Scagel, 2007) [5]. The use of foliar fertilizer is more economical and effective than the granulated form of fertilizer. The use of both foliar and soil application of NPK have been found to increase grain yield in maize (Ghaffari *et al*., 2011) [1].

Materials and Methods

Location and soil of experimental site

A field experiment was conducted during *rabi* season of the year 2017-18 at Navsari Agricultural University, India. It is geographically located at 20o57′ N latitude and 72o54′ E longitude at an altitude of 10 m above the mean sea level. The soil of the experimental field was clay in texture and showed low moderately high and very high rating for available nitrogen (180 kg/ha), phosphorus (34 kg/ha), potassium (346 kg/ha), respectively. The soil was slightly alkaline (pH 7.8) with normal electric conductivity (0.38 dS/m) and having 0.72% organic carbon.

Climatic conditions

Navsari falls in south Gujarat heavy rainfall zone - I (Agro-ecological situation - 3). The climate of this region is characterized by fairly hot summer, moderately cold winter and warm humid monsoon with heavy rainfall. In general, monsoon commences from the third week of June and ends up to last week of September. Pre-monsoon rains in the first week of June and post monsoon rains in the month of October-November are not uncommon. The winter season sets in usually by the first week of November and continues till the middle of February. December and January are the coldest months of winter. Usually the summer season commences during the middle of February and ends by the middle of June. The temperature is increasing from February and reaches the maximum in the month of April or May.

Method of N application

The experiment was laid out in Factorial randomized block design with three replications. The factors consisted of three level of nitrogen (F_1: 50% RDN, F_2: 75% RDN and F_3: 100% RDN) and two levels of split application (S_1: two splits with basal and 30 DAS, S_2: three splits with basal, 20 and 40 DAS) with and without foliar application of nitrogen (N_0: control and N_1: 2% urea at 50 DAS).

Agronomic practices

Sweet corn variety Sugar-75 was sown by dibbling method at spacing 60cm row to row and 20cm plant to plant. The seed rate of 10 kg/ha was used and seeds treated with Azotobacter 2 ml/kg seed before sowing. The entire recommended dose of 60 kg/ha phosphorus and 60 kg/ha potassium was applied as basal application in form of single super phosphate and murate of potash just before sowing. Nitrogen was applied as per treatment. In order to minimize crop-weed competition, atrazine 1.0 kg/ha was applied as pre-emergence followed by one hand weeding at 30 DAS commonly in all plots.

The quantity of nitrogenous fertilizer required in the form of commercial product for different treatments were calculated for sweet corn crop depending on the amount of nutrient present in the product using following formula.

$$F = \frac{R \times 100}{N\ (\%)} \times \frac{A}{10,000}$$

Where

F = Fertilizer product required in kg or l/ha.
R = Kg/ha recommended rate in the treatment
N = Amount of nutrient present in the product
A = Area of application (m^2)

Thus, calculated amount of fertilizer was applied for different levels of nitrogen treatments (50% RDN: 60 kg N/ha, 75% RDN: 90 kg N/ha and 100% RDN: 120 kg N/ha) with two different splits treatments. Urea (46% N) was used for application of nitrogen. Split application was done with application of equal proportion of nitrogenous fertilizer at basal *fb* 30 DAS in S_1 and at basal *fb* 20 & 40 DAS in S_2 treatment. In case of foliar application of nitrogen, 2% urea was applied by knapsack sprayer with a spray volume of 400 litters of water per hectare at 50 DAS.

Statistical analysis

The statistical analysis of data recorded for different characters during the course of investigation was carried out through the procedure appropriate to the design of the experiment as described by Panse and Sukhatme (1985) [13]. The significance of difference was tested by ‘F’ test. Five percent level of significance was used to test the significance of results. The critical differences were calculated when the differences among treatments were found significant in ‘F’ test. In the remaining cases, only standard error of means was worked out. The co-efficient of variance (CV %) was also worked out.

Results and Discussion

Levels of N

Growth parameters were influenced significantly by imposing different levels of N. Significantly the highest plant height at 30, 60 DAS and at harvest, leaf area at 30 and 60 DAS, dry matter accumulation at 60 DAS and at harvest, chlorophyll SPAD value at 60 DAS were recorded with application of 100% RDN (F_3) which remained at par with 75% RDN (F_2) at 60 DAS and at harvest in case of plant height, at only 60 DAS in case of dry matter accumulation and chlorophyll SPAD value and at 30 and 60 DAS in case of leaf area. Delayed 50% flowering and days to maturity were observed with 100% RDN (F_3) being at par with 75% RDN (F_2) (Table 1). Significantly highest cob lengths, cob weight, number of grain rows/cob, number of grains/cob and cob (12.71 t/ha) and fodder (22.56 t/ha) yields were recorded with 100% RDN (F_3) treatment and remained at par with 75% RDN (F_2) treatment for cob weight and fodder yield (Table 2). The reason for this might be that the plants got fulfil their requirement of nitrogen under F_3 (100% RDN) treatment which reflected in better growth as compared to F_1 (50% RDN) treatment. Mathukiya *et al.* (2014) [10] observed similar result in sweet corn, Bindani *et al.* (2008) [3] in baby corn and Meena *et al.* (2013) [11] in maize.

Split application of N

The split application of nitrogen had significant effect on growth parameters. Significantly taller plants, higher leaf area at 60 DAS, dry matter accumulation at 60 DAS and at harvest, chlorophyll SPAD value at 30 DAS and days to 50% flowering and maturity was recorded with three splits of N (S_2) than two split application (S_1) (Table 1). The yield attributes *viz*., cob length, number of grain rows/cob, number of grains/cob, cob weight and cob (12.14 t/ha) and fodder (21.72 t/ha) yields were found maximum due to application of nitrogenous fertilizer in three splits (S_2) than two splits (S_1) (Table 2). The improvement of growth and yield parameters with scheduling of N in more number of splits (S_2) might have attributed to frequently and timely availability of nitrogen for its better utilization by plant which indirectly leads to maximum cob and fodder yield. Significantly highest cob yield and fodder yield was recorded with S_2 over S_1 with a tone of 8.68% raise. However, the increase in fodder yield due to S_2 over S_1 was 27.31%. These were in close confirmation with those of Bindani *et al.* (2008) [3] in baby corn, Sharifi and Namvar (2016) [14], Joshi *et al.* (2014), Verma and Kumar (2018) [16] in maize.

Foliar application of N

The foliar application of N had significant effect on growth and yield attributes. Significantly higher plant height 60 DAS and at harvest, leaf area and chlorophyll SPAD value at 60 DAS, dry matter accumulation at harvest, cob length, number of grain rows/cob, number of grains/cob and cob weight was recorded with foliar application 2% urea at 50 DAS (N_1) over control (N_0) (Table 1). The cob (12.21 t/ha) and fodder (20.53 t/ha) yield were influenced significantly by foliar application of 2% urea at 50 DAS (N_1). The favourable effect of foliar application on growth and development might be attributed to presence of readily available N to plant which resulted in significantly maximum cob and fodder yield (Table 2). The raise in cob and fodder yield due to foliar application of 2% urea at 50 DAS (N_1) was 10.00% and 12.55%, respectively over control (N_0). Amanullah *et al*. (2010) [2], Afifi *et al*. (2011) [1] and Iqbal *et al*. (2014) [9] in maize, Paikra *et al*. (2018) [12] in sweet corn and Wagan *et al*. (2018) [17] in wheat observed similar result.

Interaction

Interaction between levels and split application of N

It is significantly influenced plant height at 60 DAS and at harvest, leaf area at 60 DAS, dry matter accumulation at harvest. The treatment 100% RDN with three splits (F_3S_2) gave significantly higher values in all the above parameters than all other treatment combinations. This might be due to higher dose of N with timely application reduce nitrogen losses and made available to crop. Similar findings obtained by Hassan *et al*., (2003) [7] in cotton and Harikrishna *et al.* (2005) [8] in maize (Table 3).

Interaction between levels of N (F) and split application of N (S) influenced number of grains per cob, cob weight, cob yield, fodder yield significantly. The treatment 100% RDN with three splits (F_3S_2) gave significantly higher values in all the above parameters than all other treatment combinations. It might be due to increased number of split might have helped for increased availability of N by exte3.nding the availability and reducing the losses of N due to slow release. Plant takes more nitrogen turned into more yield and yield attributes. Hassan *et al.*, (2003) [7] in cotton and Harikrishna *et al.* (2005) [8] in maize recorded similar results (Table 4).

Interaction between levels and foliar application of N

Plant height and dry matter accumulation at harvest and chlorophyll SPAD value at 60 DAS were significantly influenced by interaction effect of levels and foliar application of N. The treatment 100% RDN with foliar application of 2% urea at 50 DAS (F_3N_1) gave significantly higher values in all the above parameters than all other treatment combinations. This might be due to additional supply of nitrogen through foliar application with higher dose of nitrogen which leads to taller plants, more dry matter and high chlorophyll content in plants. Similar results obtained by Afifi *et al*. (2011) [1] (Table 5).

Only fodder yield was significantly influenced by interaction effect of levels and foliar application of N. The treatment 100% RDN with foliar application of 2% urea at 50 DAS (F_3N_1) gave significantly higher fodder yield than all other treatment combinations. This might be due to increasing dry matter which leads to higher fodder yield (Table 5)

Table 1: Effect of different levels, split and foliar application of nitrogen on growth attributes of sweetcorn

Treatments	Plant height (cm)			Leaf area (cm^2)		Chlorophyll SPAD value		Dry matter accumulation (g/plant)			Days to 50% flowering	Days to maturity
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	At harvest		
A) Levels of N												
F_1:50% RDN	33.5	127.3	198.0	206.40	469.73	37.20	43.37	8.18	54.85	80.00	206	37
F_2:75% RDN	35.4	135.1	208.1	217.10	563.37	38.79	47.16	8.28	58.31	82.17	217	39
F_3:100%RDN	38.8	142.3	220.3	222.76	579.04	39.90	51.83	8.90	62.71	95.17	223	40
S. E S. Em.±	1.00	3.6	4.7	4.40	13.06	0.88	0.89	0.22	1.57	3.13	4.40	0.88
CD at 5%	2.93	10.6	14.0	12.91	38.30	NS	2.62	NS	4.60	9.19	12.9	NS
B) Split application of N												
S_1: 2 Splits of N	34.7	128.7	200.1	212.69	521.47	37.50	45.83	8.21	56.06	81.17	213	38
S_2:3 Splits of N	37.1	141.0	217.5	218.15	553.29	39.77	49.08	8.69	61.19	90.39	218	40
S. Em.±	0.82	2.9	3.9	3.59	10.66	0.72	0.73	0.18	1.28	2.56	3.59	0.72

CD at 5%	2.39	8.6	11.5	NS	31.27	2.11	2.14	NS	3.75	7.50	NS	2.11
C) Foliar application of N												
N_0:Control	35.4	130.3	197.4	214.54	517.70	38.71	46.10	8.23	58.43	81.89	215	39
N_1: 2% urea	36.4	139.5	220.2	216.30	557.06	38.56	48.81	8.67	58.82	89.67	216	39
S. Em.±	0.82	2.9	3.9	3.59	10.66	0.72	0.73	0.18	1.28	2.56	3.59	0.7
CD at 5%	NS	8.7	11.5	NS	31.27	NS	2.14	NS	NS	7.50	NS	NS
Significant Interactions	-	FxS	FxS FxN	-	FxS	-	FxN	-	-	FxS FxN	-	-

Table 2: Effect of different levels, split and foliar application of nitrogen on yield attributes and yields of sweet corn

Treatments	Cob length (cm)	No. of grain rows/cob	No. of grains/cob	Cob weight (g)	Cobyield (t/ha)	Fodder yield (t/ha)
A) Levels of N						
F_1: 50% RDN	16.01	15	419	336.25	10.66	14.43
F_2: 75% RDN	16.83	15	440	367.50	11.59	21.17
F_3: 100% RDN	18.91	16	478	396.67	12.71	22.56
S. Em.±	0.32	0.34	9.28	9.60	0.25	0.72
CD at 5%	0.93	1.01	27.22	28.16	0.74	2.11
B) Split application of N						
S_1: 2 Splits of N	16.73	15	431	351.67	11.17	17.06
S_2: 3 Splits of N	17.77	16	460	381.94	12.14	21.72
S. Em.±	0.26	0.28	7.58	7.84	0.21	0.59
CD at 5%	0.76	0.82	22.22	22.99	0.6	1.72
C) Foliar application of N						
N_0: Control (No spray)	16.83	15	431	355.28	11.1	18.24
N_1: 2% urea at 50 DAS	17.67	16	460	378.33	12.21	20.53
S. Em.±	0.26	0.28	7.58	7.84	0.21	0.59
CD at 5%	0.76	0.82	22.22	22.99	0.6	1.72
Significant Interactions	-	-	FxS	FxS	FxS	FxS

Table 3: Interaction effects of levels and split application of N on growth attributes, yield attributes of sweet corn

Treatment	Plant height (cm)						Leaf area (cm^2)			Dry matter accumulation (g)		
	At 60 DAS			At harvest			at 60 DAS			At harvest		
Split application of N (S)	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
S_1	124.1	133.9	128.2	191.3	207.2	201.9	448.76	574.46	541.19	78.83	80.83	83.83
S_2	130.4	136.3	156.3	204.7	209.0	238.7	490.70	552.28	616.89	81.17	83.50	106.50
S.Em.±	5.1			6.8			78.83			4.43		
CD at 5%	15.0			19.9			81.17			12.90		

Table 4: Interaction effects of levels and split application of N on yield attributes and yield of sweet corn

Treatment	Number of grains per cob			Cob weight of sweet corn (g)			Cob yield of sweet corn (t/ha)			Fodder yield of sweet corn (t/ha)		
Split application of N (S)	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
S_1	395	445	452	342	340	373	10.3	11.5	11.7	12.1	17.5	21.6
S_2	443	435	504	331	395	420	11.0	11.7	13.7	16.7	24.9	23.6
S.Em.±	13.12			13.58			0.36			1.02		
CD at 5%	38.49			39.82			1.04			2.98		

Table 5: Interaction effects of levels and foliar application of N on growth attributes and fodder yield of sweet corn

Treatment	Plant height at harvest (cm)			Dry matter accumulation at harvest (g)			Chlorophyll SPAD value at 60 DAS			Fodder yield of sweet corn		
Split application of N (S)	**F_1**	**F_2**	**F_3**	**F_1**	**F_2**	**F_3**	**F_1**	**F_2**	**F_3**	**F_1**	**F_2**	**F_3**
N_0	176.8	197.5	217.8	79.67	81.83	84.17	40.11	46.53	51.65	11.69	21.10	21.93
N_1	219.2	218.7	222.7	80.33	82.50	106.17	46.62	47.79	52.02	17.16	21.25	23.19
S.Em.±	6.8			4.43			1.26			1.02		
CD at 5%	19.9			12.99			3.70			2.98		

Conclusion
It can be concluded that 100% RDN (120 kg N/ha) applied in three equal splits at basal, 20 and 40 DAS followed by foliar application of 2% urea at 50 DAS along with full recommended dose of P and K (60:60 kg/ha) improved growth attributes, yield and yield attributes of sweet corn.

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