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Effect of different levels and split application of nitrogen with and without foliar spray of urea on nutrient uptake and economics of sweet corn

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Abstract
This paper briefly discusses the effect of different levels and split application of nitrogen with and without foliar spray of urea on nutrient uptake, yield and economics of sweet corn. Experiment was laid out in factorial randomized block design with three replications at Faculty of Agriculture of Navsari Agricultural University of Navsari, during *rabi* season in 2017-18. 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 result showed that significantly higher N content and N, P and K uptake in grain and fodder was recorded with application of 100% RDN and three splits with foliar application of urea. N uptake in grain and fodder showed significant interaction effects. While maximum gross realization, net return and B:C ratio were obtained with application of 100% RDN and three splits with foliar application of urea.

Keywords: sweet corn, nitrogen, split application, foliar application, gross realization, net return

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.
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) [14]. 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) [7]. 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) [3]. Plants uptake nitrogen in the form of nitrate (NO_3) and ammonia (NH_4) (Thornton and Robonson, 2005) [17]. 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) [6]. 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.

Materials and Methods

Location

A field experiment entitled "Effect of different levels and split application of nitrogen with and without foliar spray of urea on nutrient uptake, yield and economics of sweet corn" was conducted during *rabi* season of the year 2017-18. The Navsari Agricultural University campus is geographically located at 20º57′ N latitude and 72º54′ E longitude at an altitude of 10 m above the mean sea level.

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. 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.

Treatment details

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). The seed rate of 10 kg/ha was used for the sweet corn variety Sugar-75 and seeds treated with Azotobacter 2 ml/kg seed before sowing. The entire 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 (120 kg/ha) was applied as per treatment.

Chemical analysis

Representative sample from grain and fodder were taken separately from each net plot for estimation of N, P and K content and analyzed for respective nutrient content using following procedures:

Particulars	Procedure used	Reference
Nitrogen (%)	Kjeldahl's Method	Jackson (1973) [8]
Phosphorus (%)	Vanadomolybdo phosphoric acid Yellow colour method	
Potassium (%)	Flame photometric Method	

The nutrient uptake (kg/ha) by grain and fodder of sweet corn was calculated by using the following formula.

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content in grain or fodder (\%)} \times \text{grain or fodder yield (kg/ha)}}{100}$$

Economics

The gross and net realization of maize was calculated based on the cob and straw yield and the prevailing market prices of maize during the crop season. Benefit:cost ratio (B : C) was calculated by dividing the net realization from total cost of cultivation.

Statistical analysis

The field experiment was conducted in factorial randomized block design. The different factors as three levels of N, two levels of split and with or without foliar application of N were tested with three replication. 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) [12]. 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

The application of different levels of nitrogen brought out significant variation in nitrogen content and uptake by sweet corn (Table 1 and Table 2). Significantly the highest N content and uptake by sweet corn were recorded under higher level of nitrogen 100% RDN (F_3) as compared to 75% RDN (F_2) and 50% RDN (F_1). It might be due to favorable growth at optimum level of nitrogen. The increasing content and uptake of N was due to increased absorption of nitrogen by sweet corn. Application of higher levels of nitrogen increased the N content of the plant and thereby N uptake. Kar *et al.* (2006), Bindani *et.al.* (2008) [2], Tetarwal *et al.* (2011) [16], Chaudhary *et al.* (2013) [5], Meena *et al.* (2013) [11] and Ramchandiran and Pazhanivelan (2016) [13] also reported similar trend of nitrogen application. P and K content in grain and fodder did not differed significantly due to various levels of N, but numerically higher P and K content were recorded under higher level of nitrogen (100% RDN). However, P and K uptake was found significantly higher in case of 100% RDN (F_3). This might be due to yield of cob and fodder, which were significantly higher under treatment of 100% RDN (F_3).

The cost benefit analysis of the crop as influenced by different levels of N indicated that maximum cost of cultivation (₹

55346/ha), net return (₹ 218554/ha) with highest BCR value 4.95 was accrued with treatment 100% RDN (F_3) than all other treatments presented in Table 5. This might be due to higher yields of cobs and fodder of sweet corn gained from F_3 treatment. Similar economics benefit of nitrogen was reported by Meena *et al.* (2013) [11], Mathukia *et al.* (2014) [10] and verma and tomar (2014).

Split application of N

N content and uptake were affected significantly due to split application of nitrogen (Table 1 and Table 2). Nitrogen applied in three splits (at basal, 20 and 40 DAS) (S_2) showed superiority over two splits of N (S_1). This increase in content is attributed to increase in availability of N at all growth stages. While the uptake by plant might be due to increased yields of sweet corn under treatment S_2. These results supported the observations made by Bindani *et al.* (2008) [2]. P and K content in grain and fodder did not significantly differed due to split application of N, but numerically higher P and K content were recorded under three splits (S_2) of nitrogen (Table 2 & 3). However, P and K uptake in grain and fodder found significantly higher under three splits (S_2) treatment (except P uptake in grain) is due to higher yield of cobs and fodder under treatment of S_2.

The net realization and cost benefit ratio were secured higher at higher number of split application (Table 5). Treatment receiving three split of N earned the maximum cost of cultivation (₹ 55668/ha), net return (₹ 206292/ha) with BCR of 4.71. This is due to higher yield produced in S_2 treatment. The results resembled with Bindani *et al.* (2008) [2] and Swamy *et al.* (2016) [15].

Foliar application of N

The data given in Table 2 revealed that foliar application of 2% urea only influenced over N content, while P and K content remained unaffected. This increase in content is attributed to increase in immediate availability of nitrogen at later growth stage through foliar. These results supported the observations made by Woolfolk *et al.* (2002) [18] and Afifi *et al.* (2011) [1]. N, P and K uptake was found significantly higher in case of treatment. This might be due to higher yield of cob and fodder under treatment of N_1 (Table 2).

The cost benefit analysis of the crop as influenced by foliar application of N indicated that the maximum cost of cultivation (₹ 54979/ha) and net return (₹ 205861/ha) was obtained by foliar application of 2% urea at 50 DAS with BCR of 4.74 over control. Similar economics benefit of nitrogen was reported by Manjanaik (2012) [9].

Interaction

P and K content and uptake in grain and fodder were significantly not influenced by different levels, split and foliar application of N but N uptake in grain and fodder showed significant interaction effects. Data presented in Table 3 showed that N uptake in grain and fodder was significantly influenced due to the interaction of levels of N and foliar application of N. The treatment combination of level N with foliar application of 2% urea (F_3N_2) recorded significantly higher uptake of N by grain and fodder. It might be due to higher grain and fodder yields.

Data presented in Table 4 showed that interaction between levels of N (F) and split application of N (S) influenced uptake of N by fodder of sweet corn significantly. The treatment combination of level of N with three split application of N (F_2S_2) gave significantly higher uptake of N by fodder. Application of N in different splits reduced the losses of nitrogen. It becomes available for longer period and increased its use efficiency and efficient uptake.

Economics of treatment combination given in Table 6 showed the maximum net return of ₹ 241100/ha with treatment combination $F_3S_2N_1$ (100% RDN + three splits of N + 2% urea at 50 DAS) with BCR of 5.25 followed by $F_3S_2N_0$ (100% RDN + three splits of N). The lowest net return (₹ 125095/ha) was recorded under the treatment combination of $F_1S_1N_0$ (100% RDN + three splits of N + control) with BCR 3.25.

Table 1: N, P and K content in grain and fodder of sweet corn as influenced by different levels, split and foliar application of nitrogen

Treatments	N (%)		P (%)		K (%)	
	Grain	Fodder	Grain	Fodder	Grain	Fodder
A) Fertilizer level						
F_1 : 50% RDN	1.32	0.58	0.26	0.30	0.26	0.68
F_2 : 75% RDN	1.54	0.64	0.28	0.31	0.27	0.71
F_3 : 100% RDN	1.55	0.65	0.30	0.34	0.27	0.75
S. Em.±	0.04	0.01	0.01	0.01	0.01	0.02
CD at 5%	0.11	0.04	NS	NS	NS	NS
B) Split application of N						
S_1: 2 Splits of N (Basal fb 30 DAS)	1.40	0.60	0.28	0.30	0.26	0.70
S_2: 3 Splits of N (Basal fb 20 and 40 DAS)	1.54	0.65	0.28	0.33	0.27	0.73
S. Em.±	0.03	0.01	0.01	0.01	0.00	0.02
CD at 5%	0.09	0.03	NS	NS	NS	NS
C) Foliar application of N						
N_0: Control (No spray)	1.41	0.61	0.28	0.31	0.27	0.70
N_1: 2% urea at 50 DAS	1.53	0.64	0.28	0.32	0.27	0.73
S. Em.±	0.03	0.01	0.01	0.01	0.00	0.02
CD at 5%	0.09	0.03	NS	NS	NS	NS
Significant Interactions	-	-	-	-	-	-
CV %	8.92	6.73	12.19	12.35	7.19	9.84

Table 2: N, P and K uptake in grain and fodder of sweet corn as influenced by different levels, split and foliar application of nitrogen

Treatments	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	Grain	Fodder	Grain	Fodder	Grain	Fodder
A) Fertilizer level						
F_1 : 50% RDN	141.16	84.54	28.31	43.43	28.09	100.11
F_2 : 75% RDN	178.76	136.56	32.46	67.20	31.13	149.48
F_3 : 100% RDN	197.82	145.97	37.95	75.86	34.47	170.55
S. Em.±	5.25	4.48	1.33	3.43	0.75	6.08
CD at 5%	15.39	13.15	3.90	10.05	2.19	17.85
B) Split application of N						
S_1: 2 Splits of N (Basal *fb* 30 DAS)	157.21	102.73	31.33	53.14	29.12	120.36
S_2: 3 Splits of N (Basal *fb* 20 and 40 DAS)	187.95	141.98	34.48	71.19	33.34	159.74
S. Em.±	4.29	3.66	1.08	2.80	0.61	4.97
CD at 5%	12.57	10.74	NS	8.21	1.79	14.57
C) Foliar application of N						
N_0: Control (No spray)	157.97	112.65	31.28	57.39	29.70	130.06
N_1: 2% urea at 50 DAS	187.19	132.06	34.53	66.94	32.76	150.03
S. Em.±	4.29	3.66	1.08	2.80	0.61	4.97
CD at 5%	12.57	10.74	3.18	8.21	1.79	14.57
Significant Interactions	F x N	F x S F x N	-	-	-	-
CV %	10.53	12.7	13.98	19.1	8.28	15.05

Table 3: Interaction effects of levels and foliar application of N on uptake of N by grain and fodder of sweet corn

Treatment	Levels of N (F)					
	by grain			By fodder		
Foliar application of N (N)	**F_1**	**F_2**	**F_3**	**F_1**	**F_2**	**F_3**
N_0	115.63	165.03	193.24	65.33	132.87	139.76
N_1	166.69	192.48	202.40	103.75	140.25	152.19
S.Em.±	7.42			6.34		
CD at 5%	21.77			18.60		

Table 4: N uptake by fodder of sweet corn as influenced by interaction effects of levels of N and split application of N.

Treatment	Levels of N (F)		
Split application of N (S)	**F_1**	**F_2**	**F_3**
S_1	71.32	105.99	130.89
S_2	97.76	167.13	161.06
S.Em.±	6.34		
CD at 5%	18.60		

Table 5: Effect of different levels and split application of nitrogen with and without foliar spray of urea on economics of sweet corn

Treatment	Green cob yield (t/ha)	Fodder yield (t/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
F_1: 50% RDN	10.66	14.43	54973	220740	165767	4.02
F_2: 75% RDN	11.59	21.17	55160	250960	195800	4.55
F_3: 100% RDN	12.71	22.56	55346	273900	218554	4.95
S_1: 2 Splits of N (Basal *fb* 30 DAS)	11.17	17.06	55312	235180	179868	4.25
S_2: 3 Splits of N (Basal *fb* 20 and 40 DAS)	12.14	21.72	55668	261960	206292	4.71
N_0: Control (No spray)	11.1	18.24	54600	236280	181680	4.33
N_1: 2% urea at 50 DAS	12.21	20.53	379	260840	205861	4.74

Table 6: Economics of sweet corn as influenced by various treatment combinations of levels, split and foliar application of N.

Treatment	Green cob yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation (₹/ha)	Gross realization (₹/ha)	Net return (₹/ha)	B:C ratio
$F_1S_1N_0$	8967	9690	55685	180780	125095	3.25
$F_1S_1N_1$	11633	14561	56064	238523	182459	4.25
$F_1S_2N_0$	10600	13693	56041	218187	162146	3.89
$F_1S_2N_1$	11433	19766	56420	245332	188911	4.35
$F_2S_1N_0$	11267	17563	55872	237927	182055	4.26
$F_2S_1N_1$	11733	17383	56251	245967	189716	4.37
$F_2S_2N_0$	10967	24643	56228	246687	190459	4.39
$F_2S_2N_1$	12400	25107	56607	273413	216807	4.83
$F_3S_1N_0$	11367	19697	56058	243993	187935	4.35
$F_3S_1N_1$	12033	23440	56437	263480	207043	4.67
$F_3S_2N_0$	13433	24173	56414	290146	233731	5.14
$F_3S_2N_1$	14000	22947	56793	297893	241100	5.25

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