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Sensor based nitrogen application impact on productivity, economics and nutrient uptake in maize

AMIT BHATNAGAR* and AJAY KUMAR

Department of Agronomy, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar-263145 (U.S. Nagar, Uttarakhand)
**Corresponding author email id: bhatnagaramit75@gmail.com*

ABSTRACT: The experiment was conducted during kharif 2019 at G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India to study the influence of sensor-based N management on performance of maize. Total eight treatments viz., 100% N (120 kg/ha), 33 % basal N + GreenSeeker based N at knee-height & tasseling stage, 60 % basal N + GreenSeeker based N at knee-height, 70 % basal N + GreenSeeker based N at knee-height, 60 % basal N + GreenSeeker based N at tasseling stage, 70 % basal N + GreenSeeker based N at tasseling stage, 30 % basal N + 30 % N at 25 days after sowing (DAS) + GreenSeeker based N at tasseling stage and 35 % basal N + 35 % N at 25 DAS + GreenSeeker based N at tasseling stage were tested in RBD. Significantly higher plant height, dry matter per plant, grain yield and net return as well as N saving were obtained in 30-35% basal nitrogen + GreenSeeker based N application. Grain yield under 100% RDN was at par with GreenSeeker based N treatments which had 30-35% basal N. Results indicated that GreenSeeker based nitrogen application in maize is not only productive but also saves nitrogen. Higher net return with less requirement of nitrogen can be obtained 30-35 % basal N + 30-35 % N at 25 DAS with GreenSeeker based N application at tasseling stage.

Key words: Cob, Grain, GreenSeeker, Maize, Nitrogen

Blanket application of nutrients results into either excess or deficit amount of nutrients than required by crop. This limits system productivity in terms of yield and monetary returns. More environmental footprints are also registered with blanket application of nutrient. Conventional method of nutrient application do not allow farmers to harness genetic potential of maize. The fixed-time application of fertilizer N doses at critical growth stages do not consider the dynamic soil nutrient supply and crop nutrient requirements and lead to the untimely and inefficient application of fertilizer nutrients (Biradar *et al*., 2012). Therefore, crop need-based fertilizer management in maize can help in improving nutrient use efficiency and reduce losses of nutrients. Precision nutrient management is an approach to apply fertilizers as per nutrient demand of crop, soil or both. It minimizes losses of fertilizers and ensures greater uptake of nutrients. GreenSeeker helps in fulfilling the crop nutrient requirement which leads to higher crop productivity and profitability. GreenSeeker is an active optical crop canopy device with a red (650±10 nm) and a NIR (770±15 nm) sensors. It works on visible and near-infrared (NIR) spectral response from plant canopy to detect N stress and instantly measures Normalized Difference Vegetation Index (NDVI) readings. Localized NDVI value of plants helps in computing fertilizer nitrogen doses as per crop demand (Kaur *et al*., 2020). Little information is available of precision nutrient management through GreenSeeker in maize. Considering these facts, the experiment was carried out with objective to study the effect of real time nitrogen management through GreenSeeker on growth and productivity of maize.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* (rainy) season 2019 in E-2, Maize Agronomy block of the Norman E. Borlaug Crop Research Centre at G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India. Geographically, Pantnagar is situated at an altitude of 243.84 m above mean sea level, at 29° N latitude and 79.5° E longitudes under narrow belt of Shivalik foothills called *Tarai*. The experiment consisting of eight treatments *viz*., T_1:100% recommended dose of nitrogen (RDN), T_2: 33 per cent basal N + GreenSeeker based N at knee-height & tasseling

stage, T_3: 60 per cent basal N + GreenSeeker based N at knee-height , T_4: 70 per cent basal N + GreenSeeker based N at knee-height, T_5: 60 per cent basal N + GreenSeeker based N at tasseling stage, T_6: 70 per cent basal N + GreenSeeker based N at tasseling stage,T_7: 30 per cent basal N + 30 per cent at 25 days after sowing (DAS) + GreenSeeker based N at tasseling stage and T_8: 35 per cent basal N + 35 per cent at 25 DAS + GreenSeeker based N at tasseling stage was laid out in a randomized block design (RBD) with three replications. Recommended dose of nitrogen was 120 kg/ha and in treatment T_1 and was applied in three equal splits in basal, knee height and tasseling stage.

For GreenSeeker based nitrogen management NDVI (Normalized Difference in Vegetation Index) values were collected from each experimental plot. The NDVI values reported from GreenSeeker is a ratio of reflected and incident rays. The NDVI formula utilizes the difference in reflectance to assess vegetation:

NDVI = (NIR - Red) / (NIR + Red)
Where: NIR is the value of reflectance observed at near infrared band. Red is the value of reflectance in the red band.

Three nitrogen rich strip was established by applying 300:60:40 kg N: P_2O_5: K_2O/ha to ensure that nitrogen was not limiting. The average of NDVI measurements from the N rich strip and experimental plots were further used to calculate response index (RI) to fertilizer N (Johnson and Raun, 2003). Thereafter estimation of the nitrogen amount to be applied was done following the standard methodology (Singh *et al*., 2011).

The soil of the experimental field was silty clay loam, low in organic carbon and available nitrogen and medium in available phosphorus and available potassium with a neutral reaction (pH 7.2). The field was prepared by two cross harrowing followed by planking. Maize hybrid P 3377 was sown at 75 cm × 20 cm spacing. Recommended dose of nutrients was 120:60:40 kg N:P_2O_5:K_2O/ha. Maize crop was fertilized through NPK grade (12:32:16), urea (46% N) and muriate of potash (60% K_2O). Weeds were managed through pre and post emergence herbicides. Atrazine 50 WP @ 1.0 kg a.i. /ha was sprayed in all plots just after sowing. To control later emerging weeds one spray of Tembotrione 34.4% SC @120 g a.i./ha was done using knapsack sprayer. For herbicide application volume of water used was 500 litre/ha. Plant height and dry matter per plant was recorded at harvest stage. Harvesting was done by removing the cobs and thereafter plants were removed from the field. The cobs were sun dried and then shelling was done with the help of hand operated maize sheller. Grain yield was reported at 15% moisture. The oven dried grain and stover samples were ground to fine powder and passed through 0.5 mm sieve. These ground plant samples were analyzed for nitrogen, phosphorus and potassium in stover and grain as per the procedure described by Jackson (1973).

Cost of cultivation was calculated on the basis of prevailing local charges for different inputs *i.e.,* labors, equipment, seeds, fertilizers, chemicals and others during the crop season. Grain yield was converted into gross return (Rs./ha) on the basis of minimum support price. Net returns of each treatment were calculated by deducting the cost of cultivation from the gross returns. The benefit to cost ratio (B:C) was worked out by dividing net returns with respective cost of cultivation for different treatments. The data obtained from various observations were statistically analyzed as per procedure of RBD by using the standard techniques of Analysis of Variance (Gomez and Gomez, 1984). If "F" test was found significant at 5% level of significance the critical difference (CD) was calculated to compare the means of two treatments.

RESULTS AND DISCUSSION

Growth

Data presented in Table 1 showed that number of cobs varied from 64.2 to 66.7 thousand/ha but remained non-significant. At par differences in number of cobs/ha were observed because of equal plant population as a result of same planting geometry in all treatments. Plant height (182.3 cm)

was maximum in 100% N which was significantly superior to other treatments except GreenSeeker treatments with 30-35% basal N application. Nitrogen plays significant role in cell division and cell elongation and thus influences plant height. Adequate availability of nitrogen under GreenSeeker based treatment caused longer plants as a result of more cell division (Manjunath *et al*., 2021). Dry matter accumulation per plant (223 g) was noted significantly more in 100% RDN which was at par with treatments having 30-35% basal N along with GreenSeeker based N application. Better availability of nitrogen in adequate amount promoted photosynthetic rate which reflected in to dry matter accumulation. Crop took statistically equal number of days to reach 50% tasseling and 50% silking stage in all nitrogen management treatments. Since flowering behavior in maize is largely influenced by genetic traits hence not affected by agronomic management. The findings of Jyothsna *et al*. (2020) showed that GreenSeeker based N management improved growth of maize.

Yield attributes and yield

Significantly higher 100-grain weight (26.8 g) was noted in 100% RDN which was at par with T_2, T_7 and T_8 treatments (Table 2). Translocation of photosynthates from source to sink is responsible for grain filling. Proper supply and availability of nitrogen helped in partitioning of carbohydrates from leaves to grain and thus caused heavier grain weight. Similarly, 100% RDN being at par with T_2, T_7 and T_8 exhibited significantly number of grains per cob (430) than other treatments. Longer and wider cob accommodates more grains. Nitrogen determines cob growth by influencing cell division. In this study higher values of yield attributes of maize were associated with GreenSeeker based nitrogen management (Sujatha *et al*., 2024).

Data indicated that 100% RDN recorded significantly more grain yield (5744 kg/ha) but remained at par with GreenSeeker based N treatments where basal N was 30-35%. Compared to 100% N reduction in grain yield under T_2, T_7 and T_8 was only 1.0, 2.3 and 3.6%, respectively. Maximum stover yield (11687 kg/ha) was recorded under 100% RDN followed by T_6 and T_7 but differences were non-significant. However less stover yield was noticed in those treatments where low nitrogen dose was applied. Harvest index ranged from 31.3 to 33.1% but differences were statistically at par. Grain yield is a function of the growth and yield attributes. Therefore, growth and yield attributes in maize led to a better reproductive development and strong source-sink relation that in turn produced higher grain yield due to enhanced and timely supply of nutrients. According to Prakasha *et al*. (2020) the enhanced values of yield attributing characters could be ascribed to the tendency of nitrogen in accelerating growth, photosynthetic activity and translocation efficiency

Table 1: **Effect of sensor based N application on growth and yield attributes of maize**

Treatment	No. of cobs ($\times 10^3$/ha)	Plant height(cm)	Dry matter per plant (g)	Days to 50% Tasseling	Days to 50% Silking	100-grain weight (g)	No. of grains/cob
T_1	64.2	182.3	223.0	53.3	56.7	26.8	430.0
T_2	66.7	177.9	214.1	53.7	57.3	26.2	423.7
T_3	64.6	172.0	186.1	54.0	58.0	24.1	391.0
T_4	64.2	172.4	193.1	53.7	57.3	24.2	399.0
T_5	64.2	172.9	189.7	53.3	57.0	24.4	396.7
T_6	64.2	171.3	194.3	54.0	57.7	24.4	390.7
T_7	66.7	177.1	213.6	53.3	57.0	25.7	430.0
T_8	64.6	177.9	215.7	53.3	57.3	25.9	428.0
SEm±	1216	2.3	8.6	0.3	0.4	0.5	9.7
CD (5%)	NS	6.9	26.3	NS	NS	1.4	29.8

T_1:100% RDN, T_2: 33 % basal N + GreenSeeker (GS) based N at knee-height (KH) & tasseling stage (TS), T_3: 60 % basal N + GS based N at KH , T_4: 70 % basal N + GS based N at KH, T5: 60 % basal N + GS based N at TS,T_6: 70 % basal N + GS based N at TS,T_7: 30 % basal N + 30 % at 25 DAS + GS based N at TS and T_8: 35 % basal N + 35 % at 25 DAS + GS based N at TS

Table 2: Effect of sensor based N application on yield, N amount and economics of maize

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	N amount (kg/ha) over RDN	Net return (Rs./ha)	B:C ratio
T_1	5744	11687	33.0	-	65893	1.87
T_2	5689	11482	33.1	-13.8	64745	1.83
T_3	4860	10165	32.5	-14.3	50143	1.42
T_4	4926	10453	32.0	-24.2	51167	1.44
T_5	4807	10329	32.1	+19.1	49649	1.42
T_6	4773	10535	31.3	+13.4	48964	1.39
T_7	5579	11523	32.8	+31.7	63398	1.82
T_8	5536	11358	32.9	+26.2	62559	1.80
SEm±	237	658	2.0	-	4163	0.12
CD (5%)	724	NS	NS	-	12748	0.36

T_1:100% RDN, T_2: 33 % basal N + GreenSeeker (GS) based N at knee-height (KH) & tasseling stage (TS), T_3: 60 % basal N + GS based N at KH , T_4: 70 % basal N + GS based N at KH, T_5: 60 % basal N + GS based N at TS,T_6: 70 % basal N + GS based N at TS,T_7: 30 % basal N + 30 % at 25 DAS + GS based N at TS and T_8: 35 % basal N + 35 % at 25 DAS + GS based N at TS

Table 3: **Effect of sensor based N application on NPK uptake by maize**

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
T_1	76.0	47.9	124.0	17.8	16.4	34.2	18.9	105.0	124.0
T_2	75.5	47.1	122.6	16.6	14.2	30.8	17.7	102.7	120.4
T_3	65.0	40.9	105.9	14.2	13.0	27.2	14.8	89.9	104.7
T_4	65.8	43.4	109.2	14.9	13.2	28.1	14.9	96.2	111.1
T_5	59.6	36.1	95.7	13.7	11.3	25.1	13.8	84.2	98.0
T_6	59.7	37.3	97.0	14.3	12.3	26.6	13.3	88.8	102.1
T_7	69.3	37.6	106.8	17.0	12.3	29.3	13.6	93.0	106.6
T_8	68.9	40.7	109.5	17.2	12.7	29.9	14.9	94.2	109.1
SEm±	3.3	3.0	4.2	1.1	2.4	2.7	1.3	7.1	6.7
CD (5%)	10.2	NS	12.8	NS	NS	NS	NS	NS	NS

T_1:100% RDN, T_2: 33 % basal N + GreenSeeker (GS) based N at knee-height (KH) & tasseling stage (TS), T_3: 60 % basal N + GS based N at KH , T_4: 70 % basal N + GS based N at KH, T_5: 60 % basal N + GS based N at TS,T_6: 70 % basal N + GS based N at TS,T_7: 30 % basal N + 30 % at 25 DAS + GS based N at TS and T_8: 35 % basal N + 35 % at 25 DAS + GS based N at TS

for photosynthates in presence of increasing NPK rates. Prakasha and Mudalagiriyappa (2018) clearly indicated that sensor based nutrient application had pronounced effect on yield.

Nitrogen amount

Treatments 30 % Basal N + 30 % N at 25 DAS + GreenSeeker based N at tasseling stage and 35 % Basal N + 35 % N at 25 DAS + GreenSeeker based N at tasseling stage saved 31.7 and 26.2 kg N/ha compared to RDN (Table 2). These two treatments were at par with 100% N for grain yield and net return. Study made by Attia *et al*. (2015) indicated that nitrogen application guided by NDVI value results in better synchronization of N supply with crop demand and thus saved nitrogen. Nitrogen saving of 19.1 kg/ha and 13.4 kg/ha was also recorded in 60 per cent basal N + GreenSeeker based N at tasseling stage and 70 per cent basal N + GreenSeeker based N at tasseling stage, respectively. But these treatments were significantly inferior in terms of grain yield and net return compared to RDN.

Nutrient uptake

Data related to nutrient uptake (Table 3) showed that N uptake by grain (76 kg/ha) was maximum in 100% RDN which was significantly superior to other treatments except T2, T7 and T8. N uptake by stover was also maximum in 100% RDN but differences were non-significant. Application of 100% RDN being at par with T2 recorded significantly more total N uptake (124 kg/ha). Non-significant differences were observed for P uptake by grain, stover and total uptake. Potassium uptake by grain, stover and total

K uptake did not influence statistically by different treatments. Nutrient uptake is product of dry matter produced and its nutrient content. Variation in nitrogen dose in different treatments caused significant differences in grain and stover yield therefore exhibited significant differences in nitrogen uptake. But phosphorus and potassium doses in all treatments were same which led to at par availability of these nutrients and had non-significant differences in their uptake.

Economics

Economic analysis showed that the maximum net return (Rs. 65893/ha) was recorded in RDN which was significantly more than other treatments except 30-35 % basal N + GreenSeeker based N. Significantly more B:C ratio (1.87) was recorded in RDN and was at par with 30-35 % basal N + GreenSeeker based N application. Variation in net returns were due to differences in gross return obtained from grain yield and cost of cultivation particularly incurred on nitrogenous fertilizers under different treatments. Results revealed that GreenSeeker fetched more net return and had higher B:C ratio due to less use of nitrogen and higher grain yield (Hasanain *et al*., 2024).

CONCLUSION

The study showed that GreenSeeker based nitrogen application in maize is superior to blanket recommendation. Critical growth stages in maize such as knee height and tasseling are responsive to nitrogen. Adequate fertilization with precision at these stages is helpful for increasing growth and yield. The results of this study showed that GreenSeeker based nitrogen application in maize saves nitrogen compared to recommended dose without reduction in grain yield. Moreover, GreenSeeker based nitrogen application is economically viable preposition. Higher grain yield and profit in maize can be achieved by nitrogen application as 30-35 % basal followed by 30-35 % at 25 days after sowing and after that nitrogen application at tasseling stage based on GreenSeeker values. The study concludes that use of GreenSeeker in maize can be a preferred option to reduce nitrogen use without compromising productivity.

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