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Assessment Of Sensor Based Precision Nitrogen Management For Enhancing Productivity And Profitability Of Maize In Godavari Delta Of Andhra Pradesh

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Abstract

A field study was conducted at Agricultural Research Station, Peddapuram, Kakinada Dist, Andhra Pradesh, India during *kharif* 2018 and 2019 on sandy loam soils to assess effect of sensor-based nitrogen application on growth, yield and economics of maize. The precision nutrient management practices had significant effect on the growth and yield attributes of maize. It was observed that in second year, higher yield level obtained in all treatment and corresponding increase in the N dose under green seeker (GS) guided N application was also observed which shows that this tool optimizes the N application as per yield target/potential. The green seeker (GS) based precision nutrient management practice increased grain yield of maize to the tune of 3.4-5.6 per cent over recommended doses of fertilizers (RDF). The adoption of GS guided nitrogen application increased the net returns by Rs. 4,257-6,273 ha^{-1} over RDF by saving money on costly fertilizer inputs. These GS based treatments gave 7.1 to 10.5 % higher net returns along with 29% to 49% increased agronomic N use efficiency and saving of 23.5 to 61.5 Kg N /ha over blanket RDF of 200 kg N/ha. Our experimental results disclosed that in-season N management based on green seeker sensor-based technology could be a better strategy towards higher yield with optimized N use efficiency and thereby reducing the cost of cultivation than blanket recommendations in maize.

Abbreviations

B:C ratio: Benefit Cost Ratio
DAS: Days After Sowing
DSS: Decision Support System
GS: Green Seeker
INSEY: In-season estimation of yield
N: Nitrogen
NDVI: Normalized Difference Vegetation Index
NE: Nutrient Expert
NUE: Nitrogen Use Efficiency
RDF: Recommended Doses of Fertilizers
RI: Response Index
SSNM: Site Specific Nutrient Management
STCR: Soil-Test Crop Response

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. Among the nutrients, nitrogen is the most limiting nutrient for crop production and has the greatest influence on grain yield. Maize being important cereal requires huge quantities of nitrogen due to its high yield-potential. Effective nitrogen management in maize is a major challenge for researchers as well as for producers. Traditionally, farmers apply nitrogen uniformly as a blanket recommendation in maize. Sometimes, farmers apply nitrogen fertilizers more than the recommended dose to ensure higher yields but over dose of nitrogenous fertilizers leads to low nitrogen use efficiency. Excessive plant-available N produces maize plants that are susceptible to lodging, insect pest and disease resulting in decreased yields and increased input costs. The absorption of N by crops is variable among and between seasons, as well as between locations on the same field, even when the N supplies are high. The N supply from soil to crop varies spatially. Consequently, the demand for N by the crop also varies. Large field to-field variability of soil N supply restricts efficient use of N fertilizer when broad-based blanket fertilizer N recommendations are used. When N application is not synchronized with crop demand, N losses from the soil plant system are large leading to low N use efficiency (Thakur *et al.*, 2015). Hence, there is a need to synchronize N fertilizer application with plant need to optimize the nutrient use and minimize environmental pollution. Under this situation, Green seeker optical sensor, Site specific nutrient management (SSNM) through Soil-test crop response (STCR) or Nutrient expert are some of the precision nitrogen management techniques used for estimation of in-field variation and apply N rates based on temporal and spatial variability within a field resulting in increased N use efficiency. Keeping these considerations in view, the present study was undertaken to calibrate the effect of different precision nitrogen management techniques in maize.

Materials and methods

Study Location and Experimental Design

A Field study was carried out at Agricultural Research Station, Peddapuram in Kakinada Dist of Andhra Pradesh, India during *kharif* 2018 and 2019. The soil was sandy loam low in organic carbon, available nitrogen and potassium and medium in available phosphorus with a neutral pH of 7.0. The experiment was laid out in a randomized block design with eleven treatments and replicated thrice to assess the impact of different precision nitrogen management practices on yield and economics of maize.

Experimental treatments

The treatments consisted of T_1- Control, T_2- RDF (200:60:50 N:P_2O_5:K_2O kg ha^{-1}, 1/3+1/3+/1/3 N splitting at basal, knee high and tasseling), T_3- STCR (118:41:45 N:P_2O_5:K_2O kg ha^{-1},1/3+1/3+/1/3 N splitting at basal, knee high and tasseling), T_4 - Nutrient expert (120:51:37 N:P_2O_5:K_2O kg ha^{-1}, 1/3+1/3+/1/3 N splitting at basal, knee high and tasseling), T_5 -33% basal N + Green Seeker based N at knee high and tasseling stage , T_6 -60% basal N + Green Seeker based N at knee high stage, T_7 -70% basal N + Green Seeker based N at knee high , T_8 -60% basal N + Green Seeker based N at tasseling stage, T_9 -70% basal N + Green Seeker based N at tasseling stage, T_{10}- 30% Basal N + 30% at 25 DAS + Green Seeker based N at tasseling stage, T_{11} - 35% Basal N + 35% at 25 DAS + Green Seeker based N at tasseling stage. A N rich strip (300:60:40 N:P_2O_5:K_2O kg ha^{-1},1/3+1/3+/1/3 N splitting at basal, knee high and tasseling) was also maintained in each replication.

Nutrient management methods

STCR Equation:

The STCR equation developed by All India Coordinated Research Project (AICRP) on Soil Test Crop Response (STCR), Hyderabad was used in the study for calculation of nutrient doses were as follows:

$$FN = 4.19\ T - 0.40SN\ (KMnO_4 - N)$$

$$FP_2O_5 = 1.50\ T - 1.55\ S\ P_2O_5\ (Olsen's - P_2O_5)$$

$$FK_2O = 1.49\ T - 0.16\ S\ K_2O\ (NH_4OAC - K_2O)$$

Where,

FN= Nitrogen supplied through fertilizer in kg ha^{-1}

FP_2O_5 = Phosphorus supplied through fertilizer in kg ha^{-1}

FK_2O = Potassium supplied through fertilizer in kg ha^{-1}

T= Target yield

S N, S P_2O_5, S K_2O = Initial soil test value for available N, P_2O_5 and K_2O (kg ha^{-1}), respectively.

Nutrient Expert

For nutrient expert-based fertilizer recommendation ready reckoner software developed by International Plant Nutrition Institute (IPNI) and CIMMYT, Mexico was used. Nutrient Expert, a new nutrient decision support system (DSS) based on the principles of site-specific nutrient management (SSNM). It provides nutrient recommendation for an individual farmer field both in presence or absence of soil testing data and current INM practices, plant density, SSNM rates, source, splitting and profit analysis. It also works on the 4R principle right method, right amount, right dose, and right time. This will help to increase yield and profit by target enabled fertilizer management strategy (Pompolino *et al.*, 2012).

Green Seeker Sensor

The Green seeker handheld crop sensor (GS) was developed by Trimble agriculture as an active light source optical sensor used to measure plant biomass and displayed as NDVI (normalized difference vegetation index), which is used for N prescription recommendation The Green Seeker sensor utilizes spectral radiance measurements in red (671 nm) and near infrared (780 nm) wavelengths.

The NDVI was measured in each plot using a Green Seeker hand held Crop Sensor (Raun *et al.*, 2005). Nitrogen doses using Green Seeker were calculated as per the procedure developed by Raun *et al.* (2002) and Raun *et al.* (2005) using the standard curve developed by ICAR-IIMR and CIMMYT for India.

Calculation methods

In-season Estimation of yield (INSEY) was calculated by using following formula:

$$\text{INSEY} = \frac{\text{NDVI}}{\text{Days from planting to sensing}}$$

Yield potential (YP0) with no added fertilizer was calculated from following equation:

YP0 = Potential yield ×(INSEY)$^{\wedge b}$

Where the respective values of constants b were used as depicted from graphs showing relationship between grain yield and INSEY developed by ICAR-IIMR and CIMMYT for India for two different crop stages.

The response index (RI) was calculated as the ratio of NDVI in N-rich to test treatment. The yield with fertilization of N (YN) was obtained by multiplication of Y0 with RI. The doses of fertilizer N were calculated as follows:

$$Fertilizer\ N\ (kg/ha) = \frac{((\text{YN-Y0})\times 1.75)}{(100\times 0.5)}$$

Nitrogen use efficiency (NUE) was calculated by using following formula and expressed in kg kg^{-1} (Crasswell and Godwin, 1984).

$$\text{NUE} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Nitrogen applied (kg ha}^{-1}\text{)}}$$

Crop management and data collection

Maize hybrid P-3396 was sown manually by dibbling seeds at a spacing of 60 cm x 20 cm. The crop was fertilized based on calculation made using Nutrient Expert (NE), STCR and green seeker. The nitrogen, phosphorus and potassium in the form of urea, single super phosphate and muriate of potash were applied as per the treatments. A good crop was raised duly following recommended agronomic and plant protection measures. Five plants were selected at random and tagged for recording growth parameters, yield and yield attributes. Grain and stover yield from net plot area was converted into per hectare basis. Economic returns were worked out based on the prevailing market prices of inputs, cost of fertilizers and outputs. Returns per rupee invested were worked out by considering net returns and cost of cultivation. The details of amount of N applied for individual treatments and total quantity is given in Table 1.

Statistical analysis

The data on various characters studied during the investigation were statistically analyzed in a randomized block design as per the procedure described by Gomez and Gomez (1984). The treatment difference was compared using the critical difference at 5 per cent level of significance

Results and discussion

Growth and yield attributes of maize

The plant height varied significantly among the nitrogen management practices during both the years of experimentation (Table 2). The pooled data of two years revealed that significantly higher plant height (219.5 cm) was recorded with the application of 35% N as basal + 35% at 25 DAS + GS based N application at tasseling stage which was at par with 30% N as basal + 30% at 25 DAS + GS based N application at tasseling stage (216.0 cm) and RDF (210.8 cm). The increase in plant height was mainly attributed to synchronized supply and better utilization of applied nitrogen throughout the growth stages of maize which in turn augmented the cell division and cell elongation. These results are in

Table 1 - Quantity of Nitrogen applied for different treatments (kg ha^{-1}) based STCR, Nutrient Expert and Green Seeker values

Treatment	2018				2019				Pooled	Saving of N fertilizer over RDF (Pooled)
	Basal (kg ha^{-1})	Knee high stage (kg ha^{-1})	Tasseling stage (kg ha^{-1})	Total (kg ha^{-1})	Basal (kg ha^{-1})	Knee high stage (kg ha^{-1})	Tasseling stage (kg ha^{-1})	Total (kg ha^{-1})		
T1	-	-	-	-	-	-	-	-	-	
T2	66.6	66.6	66.6	200	66.6	66.6	66.6	200	200.0	0.00
T3	39.3	39.3	39.3	118	39.3	39.3	39.3	118	118.0	82.0
T4	40.0	40.0	40.0	120	40.0	40.0	40.0	120	120.0	80.0
T5	66.0	36.0	12.0	114	66.0	41.0	23.2	131	122.5	77.5
T6	120.0	20.0		140	120.0	34.4		155	147.5	52.5
T7	140.0	24.0		164	140.0	24.0		164	164.0	36.0
T8	120.0		31.0	151	120.0		44.0	164	157.5	42.5
T9	140.0		27.0	167	140.0		46.2	186	176.5	23.5
T10	60.0	60.0	17.0	137	60.0	60.0	20.3	140	138.5	61.5
T11	70.0	70.0	27.0	167	70.0	70.0	22.0	162	164.5	35.5

Table 2 - Growth of maize as influenced by different precision nitrogen management techniques (Pooled data of two years)

Treatments	Plant height (cm)			Plants ('000/ha)			Cobs ('000/ha)			Days to 50% tasseling			Days to 50% Silking			Cob length (cm)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T1	187.3	173.7	180.5	65.0	74.1	69.6	63.4	72.4	67.9	58.0	58.3	58.2	61.0	61.0	61.0	14.4	14.2	14.3
T2	217.3	204.3	210.8	65.4	75.4	70.4	65.0	73.6	69.3	56.0	55.7	55.9	59.3	58.7	59.0	17.3	17.4	17.4
T3	209.2	192.3	200.8	65.0	75.0	70.0	64.0	72.8	68.4	57.0	56.3	56.7	60.3	59.7	60.0	16.5	16.6	16.6
T4	210.7	193.3	202.0	65.4	75.4	70.4	64.3	74.3	69.3	56.7	56.3	56.5	60.0	59.3	59.7	16.5	16.6	16.6
T5	213.0	196.7	204.9	64.1	74.1	69.1	63.6	72.5	68.1	56.3	56.0	56.2	59.7	59.0	59.4	16.8	16.7	16.8
T6	208.3	191.3	199.8	64.1	74.1	69.1	63.2	73.2	68.2	55.3	56.0	55.7	58.3	59.0	58.7	16.2	16.5	16.4
T7	208.7	191.0	199.9	64.6	74.6	69.6	62.6	72.4	67.5	55.0	56.3	55.7	58.0	59.3	58.7	16.1	16.3	16.2
T8	205.3	190.3	197.8	64.6	74.2	69.4	63.0	73.5	68.3	56.0	56.3	56.2	59.7	59.7	59.7	15.8	15.7	15.8
T9	203.3	188.7	196.0	65.0	74.0	69.5	64.6	73.2	68.9	55.3	56.7	56.0	58.3	60.0	59.2	15.6	15.6	15.6
T10	223.7	208.3	216.0	65.0	75.0	70.0	64.0	73.2	68.6	56.0	55.3	55.7	59.7	58.3	59.0	17.6	17.6	17.6
T11	228.3	210.7	219.5	65.0	75.0	70.0	63.0	73.1	68.1	55.7	55.0	55.4	58.0	58.0	58.0	17.9	17.8	17.9
N rich strip	235.0	216.3	225.7	66.6	76.6	71.6	65.6	74.3	70.0	54.3	54.3	54.3	57.7	57.3	57.5	18.4	18.1	18.3
SEm ±	3.7	5.87	3.51	1.37	1.36	1.34	1.44	1.56	1.35	0.45	0.38	0.28	0.44	0.35	0.29	0.34	0.36	0.32
CD (P=0.05)	10.8	17.2	10.3	NS	NS	NS	NS	NS	NS	1.3	1.12	0.8	1.31	1.03	0.90	1.01	1.07	0.90
CV%	3.0	5.2	3.0	3.6	3.2	3.4	3.9	3.7	3.5	1.4	1.2	1.0	1.3	1.0	1.0	3.6	3.8	3.3

agreement with the findings of Nagarjun *et al.* (2016), Singh *et al.* (2019), Bhuiya *et al.* (2020). Whereas, the lowest plant height was observed in control (180.5 cm).

The yield attributing parameters *viz.*, cob length, cob girth, number of kernel rows per cob, number of kernels per cob and 100 kernel weight were influenced significantly due to precision nitrogen management practices in both the experimental years (Table 2 & 3).

Among the precision nitrogen management practices, T11 i.e., application of 35% N as basal + 35% at 25 DAS + GS based N application at tasseling stage recorded significantly higher cob length (17.9 cm), higher cob girth (14.9 cm), higher number of kernel rows per cob (14.9), higher number of kernels per cob 40.3) and higher 100 kernel weight (33.9 g) as compared to other treatments. However, T11was on par withT10 i.e., 30% N as basal + 30% at 25 DAS + GS based N at tasseling stage (17.6 cm, 14.7 cm, 14.8, 39.5 and 33.1g, respec-

Table 3 - Yield attributes and grain yield of maize as influenced by different precision nitrogen management techniques (Mean data of two years)

Treatments	Cob girth (cm)			Grain rows/cob			Grains/row			100-seed weight (g)			Grain yield (t/ha)			% yield change over RDF
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	
T1	12.3	13.1	12.7	12.0	13.2	12.6	27.2	28.5	27.9	20.4	27.3	23.9	3.13	4.26	3.69	
T2	14.3	14.7	14.5	14.1	14.8	14.5	39.4	38.2	38.8	30.4	34.4	32.4	5.65	7.84	6.75	0
T3	14.0	14.3	14.2	13.6	14.4	14.0	38.2	35.2	36.7	28.2	32.2	30.2	5.36	7.37	6.37	-5.6
T4	14.0	14.4	14.2	13.6	14.4	14.0	38.5	35.4	37.0	28.4	32.3	30.4	5.38	7.45	6.41	-5.0
T5	14.2	14.6	14.4	14.0	14.4	14.2	39.3	36.3	37.8	29.3	33.1	31.2	5.42	7.53	6.48	-4.0
T6	13.6	14.1	13.9	13.3	13.9	13.6	36.4	35.0	35.7	26.0	31.4	28.7	5.08	7.04	6.06	-10.2
T7	13.4	14.0	13.7	13.3	13.9	13.6	35.2	34.2	34.7	25.5	31.2	28.4	4.93	6.91	5.92	-12.3
T8	13.2	13.7	13.5	13.1	13.6	13.4	33.0	33.4	33.2	25.0	31.0	28.0	4.68	6.44	5.56	-17.6
T9	13.1	13.6	13.4	12.8	13.5	13.2	32.4	31.8	32.1	24.3	30.6	27.5	4.55	6.32	5.44	-19.4
T10	14.5	14.8	14.7	14.4	15.1	14.8	39.6	39.4	39.5	31.2	35.0	33.1	5.97	7.98	6.98	3.4
T11	14.8	15.0	14.9	14.6	15.2	14.9	41.0	39.6	40.3	32.5	35.3	33.9	6.11	8.14	7.13	5.6
N rich strip	15.0	15.3	15.2	15.1	15.5	15.3	42.2	40.7	41.5	34.7	36.5	35.6	6.63	8.67	7.65	13.3
SEm ±	0.17	0.18	0.14	0.28	0.17	1.75	0.85	1.00	0.77	1.03	1.02	0.61	0.25	0.37	0.25	
CD (P=0.05)	0.5	0.53	0.4	0.84	0.51	0.5	2.51	2.94	2.3	3.02	3.0	1.8	0.72	1.10	0.75	
CV%	2.2	2.2	1.8	3.6	2.1	2.2	4.0	4.9	3.7	6.4	5.4	3.5	8.1	9.0	8.3	

Table 4 - Stover yield and Economics and nitrogen use efficiency of maize as influenced by different precision nitrogen management techniques (Mean data of two years)

Treatments	Stover yield (t/ha)			Gross returns ('000 Rs. /ha)			Net Returns ('000 Rs. /ha)			B:C ratio			Nitrogen use efficiency (kg grain/ kg N applied)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T1	4.45	5.28	4.87	43.81	74.95	59.38	13.91	24.90	19.40	1.47	1.50	1.49	-	-	-
T2	8.01	8.78	8.39	79.06	138.04	108.55	40.57	79.21	59.89	2.05	2.35	2.20	28.24	39.22	33.73
T3	7.54	7.91	7.73	75.11	129.69	102.40	37.67	71.88	54.78	2.01	2.24	2.13	45.46	62.45	53.95
T4	7.67	8.02	7.84	75.38	131.03	103.21	37.91	73.20	55.56	2.01	2.27	2.14	44.87	62.04	53.46
T5	7.78	8.31	8.05	75.90	132.58	104.24	38.52	74.83	56.67	2.03	2.30	2.17	47.56	57.50	52.53
T6	7.25	7.66	7.45	71.07	123.98	97.53	33.34	65.89	49.62	1.88	2.13	2.01	36.26	45.45	40.85
T7	7.01	7.53	7.27	68.96	121.55	95.25	30.91	63.15	47.03	1.81	2.08	1.95	30.03	42.11	36.07
T8	6.62	7.25	6.93	65.53	113.28	89.40	27.65	55.04	41.35	1.73	1.95	1.84	31.00	39.25	35.12
T9	6.43	7.12	6.78	63.77	111.22	87.50	25.68	52.78	39.23	1.68	1.90	1.79	27.28	33.98	30.63
T10	8.38	9.03	8.70	83.64	140.39	112.02	45.95	82.34	64.14	2.22	2.42	2.32	43.61	56.98	50.29
T11	8.55	9.16	8.85	85.59	143.26	114.43	47.51	84.81	66.16	2.25	2.45	2.35	36.61	50.24	43.43
N rich strip	9.15	9.76	9.46	92.84	152.60	122.72	53.00	92.42	72.71	2.33	2.54	2.44	22.10	28.90	25.50
SEm ±	0.36	0.49	0.32	3.43	6.57	4.17	3.43	6.57	4.17	0.09	0.11	0.08	3.02	4.00	3.61
CD (P =0.05)	1.06	1.43	0.93	10.06	19.40	12.22	10.06	19.40	12.22	0.27	0.33	0.2	9.01	12.30	10.60
CV%	8.5	10.6	8.2	8.1	9.0	7.2	16.5	16.6	13.8	8.3	8.9	7.0	7.8	10.0	7.2

tively) and RDF (17.4 cm, 14.5 cm, 14.5 and 38.8 and 32.4 g respectively). The cob length, cob girth, number of kernel rows per cob, number of kernels per cob and100 kernel weight in GS based N application under T10 to T11 enhanced by 1.1% to 2.9 %, 1.4 to 2.8 %, 2.1 to 2.8 % ,1.8 to 3.9 % and 2.2% to 4.6 %, respectively over RDF.

The improvement in yield attributes was mainly attributed to increased growth parameters due to enhanced photosynthesis. The increased growth and yield attributes which in turn enhanced due to precise application of nitrogen based on the crop requirement. The control treatment was significantly inferior to rest of the treatments as it did not receive any exogenous nutrients. These findings are in conformity with the findings of Boregowda *et al.* (2019), Nagarjun *et al.* (2017), Joshi *et al.* (2017), Anand *et al.* (2017), Shyam *et al.* (2021).

Grain and stover yield

The results obtained from grain and stover yields have been presented in Table 3 and 4. The maize grain yield was significantly affected by the application of various nitrogen management practices during both the years of the experimentation. The pooled data of two years revealed that the application of 35% N as basal + 35% at 25 DAS + GS based N application at tasseling stage recorded significantly higher grain yield (7.13t/ha) and stover yield (8.85tha) which was at par with 30% N as basal + 30% at 25 DAS + GS based N application at tasseling stage (6.98t/ha and 8.7t/ha) and RDF (6.75 t/ha and 8.39 t/ha). The increase in grain yield was 93.22% higher over absolute control and 5.63% , 11.93%and11.23 % higher as compared to RDF, STCR and nutrient expert. This shows the GS guided N application develops a better source-sink relationship as this synchronises the N supply with crop demand. These results are in accordance with those obtained by Manjunath *et al.* (2021), Butchee, *et al.* (2011), Pooniya *et al.* (2015), Baral and Adhikari (2015), Biradar and Aladakatti (2007), Rekha M Gonal *et al.* (2022), Shivashankar *et al.* (2023). Significantly lowest grain yield (3693.7 kg/ha) was recorded from the control plot.

Economics

Economics is the ultimate criteria for acceptance and wider adoption of any technology. Among various nitrogen management treatments, higher gross returns (Rs.114.43 thousands ha^{-1}), net returns (Rs. 66.16 thousands ha^{-1}) and B:C ratio (2.35) were recorded with 35% N as basal + 35% at 25 DAS + GS based N at tasseling stage which was at par with 30% Basal N + 30% at 25 DAS + GS based N at tasseling stage (Rs.112.02 thousands ha^{-1}, Rs.64.14 thousands ha^{-1} and 2.32, respectively) and RDF (Rs.108.55 thousands ha^{-1}, Rs.59.89 thousands ha^{-1} and 2.20, respectively). The net returns in maize cultivation were enhanced by Rs. 4,257to 6,273 ha^{-1} over RDF. The GS guided N application gave7.1 to 10.5 % higher net returns over RDF. This might be due to increase in yield as well as reduction in the application of N fertilizer. These results are in agreement with the findings of Manjunath *et al.* (2021), Prakasha *et al.* (2020), Joshi *et al.* (2018), Swamy *et al.* (2016).

Nitrogen Use Efficiency (NUE)

The data on nitrogen use efficiency under different nitrogen management strategies are presented in Table 4. Application of N fertilizer through STCR recorded significantly higher nitrogen use efficiency (53.95 kg kg^{-1}) over rest of the treatments and it was on par with application of nitrogen based on Nutrient expert, 33% basal N + GS based N at knee high and tasseling stage, 30% Basal N + 30% at 25 DAS + GS based N at tasseling stage and 35% Basal N + 35% at 25 DAS + GS based N at tasseling stage (53.46, 52.53, 50.29 and 43.43 kg ka^{-1}, respectively). The increase was 29 % to 49 % over blanket RDF of 200 kg N/ha. This increase in NUE was mainly due to reduced N application in split doses according to crop demand in turn reduces the losses of N by various means. No nitrogen use efficiency was observed under absolute control. Similar results were observed by Prakasha *et al.* (2020).

Conclusions

Based on the present study, it can be inferred that though yield was at par with RDF green seeker based nitrogen application could be a better option in terms of profitability and nitrogen saving in maize. A combination of prescriptive N dose at planting and knee-high stage and corrective N dose guided by Green Seeker optical sensor at different growth stages holds promise in achieving high grain yield and N use efficiency in maize. Thus, in future precision nitrogen management using green seeker optical sensor can be successfully used for making site specific in - season fertilizer nitrogen management decisions for maize.

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