PRECISION NITROGEN MANAGEMENTIN RAINFED MAIZE (*Zea mays* L.)THROUGH HAND HELD DECISION SUPPORT TOOLS

ABSTRACT: A field study was conducted during *Kharif* 2019-20 at Professor Jayashankar Telangana State Agricultural University (PJTSAU),Rajendranagar, Hyderabad, Telangana, India to evaluate different handheld decision support tools for precision nitrogen management in rainfed maize (*Zea mays*L.).The experiment was laid out in a randomized block design and replicated thrice with eight treatments consisting of the application of nitrogen through State recommended dose of nitrogen @ 200 kg ha^{-1} in three splits (RDN), leaf colour chart (LCC) based N at threshold 3 and 4, soil plant analysis development (SPAD) chlorophyll meter is one of the most commonly used diagnostic tools to measure crop nitrogen status]based N at threshold 35 and 40 and Green Seeker based N at NDVI 0.6 and 0.8 compared with RDN and absolute control. The results revealed that the application of nitrogen-based on Green Seeker NDVI at threshold 0.8 recorded significantly higher maize grain (8408 kg ha^{-1}), stover (9923 kg ha^{-1})yields and harvest index (45.8 %) with higher yield and growth parameter *viz.*, test weight (36.3 g), No. of grain rows row^{-1} (36.7), cob length (18.9 cm), plant height (223.7 cm), leaf area (6385.75 cm^{2}) and dry matter accumulation (18193 kg ha^{-1}) as compared to RDN. Similarly, Green Seeker based N at NDVI 0.8 also registered higher net returns (Rs. 118961 ha^{-1}) and B: C ratio (4.05).

Key words: Grain yield,precision nitrogen management, maize.

Introduction

Maize (*Zea mays.* L) is one of the major cereal crops exhibiting wide adaptability to diverse agro-climatic conditions and stands first in production in the world. In India, it ranks third after rice and wheat. Maize is called "Queen of cereals" due to its higher production potential and wider adaptability. It requires a balanced nutrients supply (N, P and K). Maize is an exhaustive crop and its hybrids are highly responsive to fertilization so the crop requires the application of large quantities of nitrogenous fertilizers. It may result in more greenness and quick growth response to applied fertilizers. When N application is not synchronized with crop demand, N losses from soil-plant system are large leading to low N fertilizer use efficiency. There is a need to synchronize the time of N fertilizer application and crop demand to optimize nutrient use efficiency and minimize environmental pollution. SPAD chlorophyll meter is faster than tissue testing for N and can help to assess when a plant needs more N (Ladha *et al*., 2000). Farmers generally use leaf colour as a visual and subjective indicator of the crop nitrogen status. Leaf colour chart (LCC) can be used as a complementary decision-making tool to determine the need for N requirement of crop. Under farm situations, LCC proved to be as good as the chlorophyll meter (SPAD) in terms of higher yield and improved nitrogen use efficiency (Kumar *et al.*,2014). It is an ideal tool to optimize N use, irrespective of the source of N applied (Balasubramanian *et al.*, 2000; Mahendera*et al.*, 2001). Green Seeker is an improved tool based on optical sensors which emit brief bursts of red and infrared light, and then measures the amount of each type of light that is reflected from the plant, then the sensor continues to sample the scanned area as long as the trigger remains engaged and displays the measured value in terms of an NDVI reading (Mallikarjuna *et al.,* 2016). The strength of detected light is a direct indicator of the health of crop and higher readings indicate better plant health(Rouse *et al.*, 1974). Hence, an experiment was conducted to find out the optimum threshold level of different handheld tools *viz*., LCC, SPAD and Green seeker for N application in rainfed maize.

Materials and methods

A field experiment was carried out at the main farm, Agricultural Research Station, Rajendranagar (17.19'N and 78.23'E) Hyderabad (India) during *Kharif* 2019-20 to know the performance of different decision support tools for effective nitrogen management in rainfed maize. The experiment was laid out in a randomized complete block design (RBCD) with eight treatments and each treatment was replicated thrice. The soil of the experimental site was sandy loam with pH 7.46 and electrical conductivity 0.26 dS m^{-1}. The soil has organic carbon content of 0.45% and was low in available N (238.4 kg ha^{-1}), high in available phosphorus (80.4 kg P_2O_5 ha^{-1}) and available potassium (343.1 kg K_2O ha^{-1}). The hybrid maize cv. DHM-117 was used in the present study. The seeds were dibbled at 60 cm x 20 cm spacing. The treatments consisted of State recommended dose of nitrogen (RDN) @ 200 kg ha^{-1}applied in three splits, LCC based N application at threshold 3 and 4, SPAD based N application at threshold 35 and 40; Green Seeker based N application at NDVI thresholds 0.6 and 0.8 and absolute control(No nitrogen) . The pre-requisite quantity of fertilizer dose was applied as per-treatments. The recommended dose of 60 kg P_2O_5& 50 kg K_2O ha^{-1} in the form SSP and MOP and 35% RDN (except control) through urea were applied as the basal application for all the treatments. The top dose of nitrogen was applied in the remaining treatments *viz.*,except control as per the crop demand from time to time according to the treatments (LCC / SPAD /Green Seeker readings

Immediately after sowing Atrazine 50% WP @ 1.5 kg *a.i* ha^{-1} was sprayed to control weeds followed by two hand weedings at 25 and 45 days after sowing. During the season earthing up was carried out at 30 days after sowing. The plant population was maintained in all the treatments by thinning out of excess seedlings at 12 DAS and leaving one seedling per spot. Healthy crop stand was ensured by adopting need-based crop protection and recommended packages of practices. Five plants were selected at random and tagged. These plants were used for recording growth parameters, yield attributes and yield. The measurement of threshold readings through different tools was carried out as below:

Measurement of leaf colour chart: A leaf colour chart (LCC) developed by IRRI, Philippines and modified LCC developed by the Indian Institute of Rice Research (IIRR), Hyderabad (5 panel LCC) was used to measure the leaf colour intensity.

Measurement SPAD reading:

The chlorophyll meter developed by the Soil Plant Analysis Development (SPAD) unit of Minolta Camera Company (SPAD 502) was used in this study as it instantly provides an estimate of leaf N status as chlorophyll content.

Measurement of Green seeker based NDVI reading:

Green Seeker TM handheld optical sensor unit Model 505 developed by U.S. Trimble Inc. was used to measure NDVI from the crop canopy.

Normalized Difference Vegetative Index (NDVI) measurements made by Green seeker were computed by the following equation:

$$NDVI = (NIR\ ref - RED\ ref)/ (NIR\ ref + RED\ ref)$$

Where,NIRref or REDref represent reflectance in the near-infrared and red bands. Normalized Difference Vegetative Index is a measure of the total biomass and greenness of leaves and is used for midseason prediction of final grain yield.

The economics was computed based on cost of inputs and presented as Rs ha^{-1}. Net returns were calculated by subtracting the cost of cultivation from gross returns for each treatment and the benefit: cost ratio (BCR) for all the treatments was worked out based on gross returns in terms of rupees after multiplying the grain and stover yield with their respective prevailing market price. All the data were statistically analyzed by using a standard procedure (Gomez and Gomez, 1984).

Results and Discussion:

The amount of N applied for individual treatments and total quantity and the saving in N application is given in Table 1.

Table 1. Quantity of nitrogen (kg ha^{-1}) applied based on LCC, SPAD and Green Seeker readings

Treatments	Basal	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS	49 DAS	56 DAS	No. of splits	Total N applied (kg ha^{-1})	Saving in N fertilizer over RDF
RDN (200 kg ha^{-1} in three equal splits	66.6	-	-	-	66.6	-	-	66.6	3	200	0
LCC based N application at threshold 3	70	-	-		32.5	-	-	32.5	3	135	65

LCC based N application at threshold 4	70			32.5		-	32.5	-	3	135	65
SPAD based N application at threshold 35	70	-	-	-	32.5			32.5	3	135	65
SPAD based N application at threshold 40	70	-	-	32.5	-	-	32.5	-	3	135	65
Green seeker based N application at NDVI value 0.6,	70	32.5	-	32.5	10	-	-	-	4	145	55
Green seeker based N application at NDVI value 0.8	70	32.5	-	32.5	10	10	10	-	6	165	35
Control (No nitrogen)	-	-	-	-	-	-	-	-	0	0	0

Significantly, higher grain yield (8408 kg ha^{-1}) was recorded with Green Seeker based NDVI at 0.8 (35 % RDN as basal and Green seeker based N at weekly intervals after 14 DAS)} which was on par with SPAD based N at threshold 40 (35 % RDN as basal and SPAD based N at weekly intervals after 14 DAS)} and Green Seeker based NDVI at 0.6 (35 % RDN as basal and Green seeker based N at weekly intervals after 14 DAS). The lowest grain yield (4343 kg ha^{-1}) was recorded in Control which was significantly inferior to all other treatments (Table 3). A significantly higher amount of maize stover yield (9923 kg ha^{-1}) was registered under N application at Green Seeker NDVI threshold 0.8 and significantly lower was recorded under without nitrogen fertilizer application (6073 kg ha^{-1}) (Table 3). The higher grain and stover yield obtained when N was managed at Green Seeker NDVI threshold 0.8 was obviously due to favourable nutrition or a balanced level of nutrient application during the crop growth stages. Overall, it indicated that nitrogen application through NDVI value of green seeker 0.8 can be considered for achieving higher yield as they matched with crop N demand. These results are also in line with Kumar *et al*. (1999) and Maiti and Das (2006) who reported higher grain yield with LCC based nitrogen management. It is obvious that nitrogen as a major nutrient can influence leaf N and chlorophyll content and thus consequently SPAD and NDVI values, ultimately in the final yield (Veerendra*et al*., 2017). In present study higher harvest index (45.8 %) was registered with N application at Green Seeker NDVI threshold 0.8 as compared to other treatments (Table 3). Application of nitrogen in splits as per crop need at different crop growth intervals eventually led to better utilization of nitrogen for growth and development that might have resulted in a higher harvest index (Maiti*et al*., 2004). Similar results were reported by Shrabani*et al*. (2017) in LCC based N management in rice.

Significantly higher cob length (18.9 cm), No. of grain per row (36.7) and hundred seed weight (36.3g) were recorded with N application at Green Seeker NDVI threshold 0.8 than the other treatments (Table 2). However, it was on par with N application at SPAD threshold 40 and Green Seeker NDVI threshold 0.6. These yield parameters wereimproved mainly due to increased growth performance represented by plant height, leaf area and dry matter accumulation. Similar results were reported by Premalatha (2017) and Jayanthi *et al*. (2007),Puneet (2011) and Sruthi (2018).

The increased yield under N application at Green Seeker NDVI threshold 0.8 resulted in an improvement of economic returns of maize production. The higher gross returns and net returns were registered with N application at Green Seeker NDVI threshold 0.8 (Rs. 157903ha^{-1} and Rs. 118961ha^{-1},respectively) compared to the rest of the treatments and it was followed by N application at SPAD threshold 40 and Green Seeker NDVI threshold 0.6 as compared to the recommended dose of nitrogen. Relatively lower gross returns and net returns were recorded in absolute control (Rs. 82515 ha^{-1}and Rs.47196 ha^{-1}, respectively) (Table 3). These higher gross and net returns were mainly attributed to higher grain and stover yield. A significantly higher benefit-cost ratio (4.05) was recorded with N application at Green Seeker NDVI threshold 0.8 compared to rest of the treatments and it was statistically on par with N application at SPAD threshold 40 (3.83) and N application at Green Seeker NDVI threshold 0.6 (3.80) (Table 3). Similar results were also reported by Maiti and Das (2006), Ravi *et al*. (2007). A higher economic return was realized in sweet corn by the use of green Seeker based NDVI value 0.8 as reported by Mallikarjuna Swamy *et al*. (2016).

Table 2. Growth and yield components of maize as influenced by N management through different decision support tools.

Treatments	**Plant height at harvest (cm)**	**Leaf area (cm^2 plant^{-1})**	**Dry matter accumulation (kg ha^{-1})**	**Cob length (cm)**	**No. of grains row-^{1}**	**100-seed weight (g)**
RDN (200 kg ha^{-1} in three equal splits	216.4	4806.99	16326	17.8	34.0	34.1
LCC based N application at threshold 3	212.9	4542.83	15124	17.5	33.3	33.9
LCC based N application at threshold 4	217.6	4878.02	16244	17.9	34.6	34.2
SPAD based N application at threshold 35	213.4	4631.66	15476	17.6	34.2	34.0
SPAD based N application at threshold 40	222.4	6088.47	16880	18.8	35.8	36.1
Green seeker based N application at NDVI value 0.6,	219.4	5859.37	17136	18.6	35.6	35.9
Green seeker based N application at NDVI value 0.8	223.7	6385.75	18193	18.9	36.7	36.3
Control (no nitrogen)	176.5	3524.13	10303	11.8	22.7	23.7
SE(m) ±	1.6	392.53	497	0.30	0.64	0.70
CD (p=0.05)	4.8	1202.17	1523	0.9	2.0	2.1
CV (%)	5.6	13.3	5.5	3.0	3.4	3.6

Table 3. Grain yield, stover yield, harvest index and economics in hybrid maize as influenced by N management through decision support tools.

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BC ratio
RDN (200 kg ha^{-1} in three equal splits	7361	9015	44.9	39394	138493	96064	3.51
LCC based N application at threshold 3	7020	8761	44.4	38350	132313	93963	3.45
LCC based N application at threshold 4	7401	9069	44.9	38350	139326	100976	3.63
SPAD based N application at threshold 35	7051	8518	45.2	38350	132616	94266	3.46
SPAD based N application at threshold 40	7809	9386	45.4	38350	146825	108529	3.83
Green seeker based N application at NDVI value 0.6,	7783	9419	45.0	38483	146400	108212	3.80
Green seeker based N application at NDVI value 0.8	8408	9923	45.8	38942	157903	118961	4.05
Control (No nitrogen)	4343	6073	41.6	35319	82515	47196	2.33
SE(m) ±	1007	375	1.1	-	5798	5993	-
CD (p=0.05)	329	122	NS	-	17758	18353	-
CV (%)	8.1	6.4	4.2	-	7.6	11.1	-

Conclusion: In present study, the treatment supplied with 70 kg N ha^{-1} as basal + remaining N (95 kg) as guided by Green Seeker at NDVI threshold 0.8 proved to be a superior treatment for the best management of N for rainfed maize in sandy loam soils over the recommended dose of nitrogen (RDN) 200 kg N ha^{-1} in terms of growth parameters, yield attributes and yield of medium duration hybrid maize with a saving of 35 kg of N.

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