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Maximizing nutrient uptake in hybrid maize *via* advanced nitrogen management techniques

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Abstract
A field study at PJTSAU, Telangana, during *Kharif* 2019-20, investigated nitrogen management in hybrid maize using hand-held decision tools. Treatments included various nitrogen rates and thresholds for NDVI, LCC, and SPAD meters. Green Seeker at NDVI 0.8 significantly improved N, P, and K uptake (225.5, 35.9, 333.9 kg/ha) compared to recommended nitrogen doses and control. Results indicated precision nitrogen management's effectiveness in enhancing nutrient uptake, crucial for maize productivity.

Keywords: Nutrient uptake, maize

Introduction
Maize, globally renowned for adaptability, ranks third in India after rice and wheat. Its high production potential demands balanced nutrients. Timely nitrogen (N) application is crucial to prevent losses and maximize efficiency, synchronizing with peak crop demand for enhanced uptake and reduced environmental impact. According to Furuya (1987) [5], farmers traditionally use leaf color as a visual cue for N application, often resulting in excessive use and poor recovery efficiency. Utilizing leaf spectral features helps determine need-based N treatments. Precision tools, such as the Leaf Colour Chart (LCC) and SPAD chlorophyll meter, have become essential in nitrogen management for maize. Originally designed for rice, the LCC can also be applied to maize, as supported by research (Balasubramanian *et al.,* 1999 and 2000; Witt *et al.,* 2005) [1, 2,. 11]. The LCC aids in need-based N application by considering crop demand and soil N availability. The SPAD meter, according to Mohanty *et al.* (2016) [7], assesses crop N status and optimizes application timing. Recent advancements in optical sensor technology, like the Green Seeker, use visible and near-infrared (NIR) radiation to detect N stress and measure crop vigor (NDVI). Higher NDVI values indicate better plant health and potential yield, as noted by Harrell *et al.* (2011) [6]. This experiment aims to identify the optimal LCC, SPAD, and NDVI thresholds for N application in hybrid maize.

Materials and Methods
A field trial was conducted at the Agricultural Research Station in Rajendranagar, Hyderabad (17.19'N, 78.23'E) during the *Kharif* season of 2019-20 to evaluate hybrid maize under different nitrogen management tools. The experiment used a Randomized Complete Block Design with eight treatments and three replications. The soil was sandy loam with a pH of 7.46, low electrical conductivity (0.26 dS/m), 0.45% organic carbon, low nitrogen (238.4 kg/ha), high phosphorus (80.4 kg P_2O_5/ha), and high potassium (343.1 kg K_2O/ha). Hybrid maize DHM-117 was planted at 60 cm x 20 cm spacing. Treatments included recommended nitrogen (RDN) at 200 kg/ha in three splits, LCC thresholds 3 and 4, SPAD thresholds 35 and 40, and Green Seeker NDVI thresholds 0.6 and 0.8, compared to absolute control. Fertilizers included 60 kg P_2O_5/ha and 50 kg K_2O/ha, with 35% RDN as basal. Nitrogen application for remaining treatments was adjusted based on LCC, SPAD, and Green Seeker. Atrazine 50% WP was applied post-sowing, followed by manual weeding. Data on growth, yield, and nutrient uptake were collected and analyzed statistically.

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

Treatments	Basal	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS	49 DAS	56 DAS	63 DAS	No. of splits	Total N applied (kg ha^{-1})	Saving in N fertilizer over RDF
T$_1$	66.6	-	-	-	66.6	-	-	66.6		3	200	0
T$_2$	70	-	-	-	32.5	-	-	32.5	-	3	135	65
T$_3$	70		32.5		-	32.5	-	-	-	3	135	65
T$_4$	70	-	-	-	32.5			32.5	-	3	135	65
T$_5$	70	-	-	32.5	-	-	32.5	-	-	3	135	65
T$_6$	70	32.5	-	32.5	10	-	-	-	-	4	145	55
T$_7$	70	32.5	-	32.5	10	10	10	-	-	6	165	35
T$_8$	-	-	-	-	-	-	-	-	-	0	0	0

T$_1$-RDN (200 kg/ha in three equal splits), T$_2$- LCC based N application at threshold 3, T$_3$- LCC based N application at threshold 4, T$_4$- SPAD based N application at threshold 35, T$_5$- SPAD based N application at threshold 40, T$_6$-Green seeker based N application at NDVI value 0.6, T$_7$-Green seeker based N application at NDVI value 0.8, T$_8$- Absolute control (no nitrogen) only P$_2$O$_5$ and K$_2$O as basal.

Results and Discussion

Nitrogen uptake by plant at 30, 60, 90 DAS and harvest and major nutrient uptake by plants after harvest

Table 2 shows nitrogen uptake by plants under precision nitrogen management. Green Seeker-based N application at NDVI 0.8 led to higher uptake, comparable to SPAD-based N at threshold 40 and lower NDVI thresholds, surpassing RDN. Improved scheduling and split application enhanced N uptake, benefiting dry matter production and N accumulation. According to De Datta (1981) [3], synchronizing applied fertilizer N with crop needs ensures efficient N use. Reena et al. (2017) [9] noted that higher N uptake is due to better N availability for growth. Similar results are obtained by Singh et al. (2016) [10]. Nutrient uptake after harvest, with Green Seeker-based N at NDVI 0.8 achieving higher N, P, and K uptake (225.5, 35.9, and 333.9 kg/ha, respectively). SPAD-based N at threshold 40 followed, outperforming RDN. Poorer uptake was noted in the absolute control. The synchronicity between N demand and supply boosted P and K uptake (Dobermann et al., 2002) [4], with nitrogen's quick availability aiding P and K absorption, consistent with Ravi et al. (2007) [8].

Table 2: Quantity of nitrogen applied, Nitrogen uptake (kg/ha) at different stages, and Phosphorus and potassium uptake at harvest as influenced by precision nitrogen management in maize.

Treatments	N applied (kg/ha)	Nitrogen Uptake				Phosphorus (kg/ha)	Potassium (kg/ha)
		30 DAS	60 DAS	90 DAS	At harvest		
T$_1$	200	25.8	85.6	177.3	159.7	29.6	259.9
T$_2$	135	19.6	65.8	154.4	155.6	23.1	226.3
T$_3$	135	27.7	104.3	189.9	203.6	30.3	269.0
T$_4$	135	22.7	85.2	182.4	172.3	25.8	240.2
T$_5$	135	30.8	114.9	199.1	211.2	34.5	286.9
T$_6$	145	27.9	111.4	198.5	201.5	29.5	275.4
T$_7$	165	33.3	125.7	233.3	225.5	35.9	333.9
T$_8$	0	11.8	36.3	74.6	76.5	16.1	164.1
SE(m) ±		0.9	1.2	2.6	4.5	0.8	5.2
CD (p=0.05)		2.8	3.6	8.0	13.7	2.4	15.9

Findings suggest SPAD-based N at threshold 40 and Green Seeker-based N at NDVI 0.8 enhance nitrogen, phosphorus, and potassium uptake in hybrid maize.

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