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Precision Nitrogen Management in Maize (*Zea mays* L.) through leaf colour chart tool in Tunga Bhadra Command Area

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ABSTRACT
A field experiment was conducted at Agricultural Research Station, Siruguppa, Karnataka, during kharif 2016 to study the "Precision nitrogen management in maize (Zea mays L.) through leaf colour chart tool in Tunga Bhadra Command Area". The soil of experimental site was medium black, neutral in soil reaction (7.34) and low in electrical conductivity (0.26 dSm^{-1}). The organic carbon content was 0.43 per cent and low in available N (225.79 kg ha^{-1}), medium in available phosphorus (24 kg P_2O_5 ha^{-1}) and high in available potassium (391 kg K_2O ha^{-1}).. The experiment consists of ten treatments viz., N application at LCC 1, 2, 3, 4, 4.5, 5, 5.5, 6, Recommended nitrogen (190 kg ha^{-1}) and Absolute control. These treatments were replicated thrice in Randomized Complete Block Design. Application of nitrogen fertilizer based on LCC threshold ≤ 5 recorded significantly higher grain yield (8339 kg ha^{-1}), stover yield (10424 kg ha^{-1}), grain rows per cob (16.9), grains per row (33.1), cob weight per plant (214 g) and grain yield per plant (148.8 g). Total dry matter production (317.5 g plant^{-1}), leaf area per plant (2962cm^2 plant^{-1}), leaf area index (LAI) (2.47) and plant height (209.6 cm) compared to rest of the LCC thresholds, RDN and Absolute control. The increased in grain yield was to the extent of 124 per cent was noticed with LCC threshold ≤ 5 as compared absolute control. Significantly lower grain (3725 kg ha^{-1}) and straw yield (5264 kg ha^{-1}) was recorded with absolute control. Similarly lower growth and yield parameters were also followed the similar trend.

Keywords: *Growth and yield parameters, Total dry matter production, grain and straw yield, Leaf colour chart and Nitrogen management.*

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INTRODUCTION

Maize (*Zea mays* L) is one of the key versatile emerging crop, being wider adaptability under diverse agro-climatic conditions. Globally, maize is recognized as queen of cereals since it has the highest genetic yield potential among the cereals. It is cultivated over 150 m ha in about 160 countries with wider range of soil, climate, biodiversity and management practices that contributes 36 per cent (782 m t) in the global grain production. In India, maize is the third most important food crops next to rice and wheat. It is cultivated over an area of 9.43 m ha with a production of 24.35 m t and productivity of 2583 kg ha^{-1}[2].

The farmers generally use leaf colour as a visual and subjective indicator for N fertilizer need [8]. Since farmers generally prefer to keep leaves of the crop dark green, it leads to over application of fertilizers N resulting in low recovery efficiency. Thus, the spectral properties of leaves should be used in a more rational manner to guide need based fertilizer N applications. Further, in recent years many precision tools are being used in the nitrogen management especially in maize. Among these precision tools, leaf colour chart (LCC) is one and it was developed for rice and it is also suitable for maize as indicated by spectral reflectance measurement performance on rice [4, 6] and maize leaves [12]. LCC helps in promoting need based variable N application to rice crop based on soil N-supply and crop demand. It is an ideal tool to optimize N use, irrespective of the source of N applied [3, 5].

MATERIAL AND METHODS

The field experiment was conducted at Agriculture Research Station, Siruguppa, and is located at 76^{o}54'' East longitude,15^o 38'' North Latitude and at an elevation of 380 m from MSL. The station is situated in Northern Dry zone (Region–II, Zone –3) of Karnataka. The experiment was laid out in Randomized

Complete Block Design and soil was medium black, neutral in soil reaction (7.34) and low in electrical conductivity (0.26 dSm^{-1}). The organic carbon content was 0.43 per cent, low in available N (225.80 kg ha^{-1}), medium in available phosphorus (24 kg P_2O_5 ha^{-1}) and high in available potassium (391 kg K_2O ha^{-1}). The hybrid maize NK 6240 used in the investigation and seeds were dibbled at 60 cm x 20 cm spacing. The N was managed through leaf colour chart thresholds. Irrespective of LCC levels, at basal 25 kg N full dose of P and K (75:37.5 kg P_2O_5 K_2O ha^{-1}) was applied to the soil in the form of single super phosphate and muriate of potash. For T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_8 followed intermittent N applications as guided by LCC threshold 1, 2, 3, 4, 4.5, 5, 5.5 and 6, respectively. The subsequent N applications were carried out by matching the colour of youngest fully expanded top leaf of ten randomly selected maize plants from each plot at 15 days interval, starting from 15 days after sowing of maize till initiation of silking. If the greenness of 6 or more out of ten leaves is less than LCC threshold, top-dressing 20 per cent recommended dose of nitrogen. Whereas the greenness of 5 or more out of ten leaves is more than LCC threshold, no N was applied. During analysis colour of the leaf with LCC under shade of the body was matched visually with LCC and disease/insect free leaves of normal crop. Matching of the leaf was discontinued and no further N was applied after initiation of silking. Total quantity of nitrogen applied was based on observing LCC values. In RDN treatment the 50 per cent N is applied as basal and remaining half dose of nitrogen in the form of urea was top dressed at 30 and 45 days after sowing (DAS) (Table 1). Immediately after sowing, Atrazine 50 per cent WP @ 1.00 kg a.i ha^{-1} was applied to manage the weeds. Further, at 20 days after sowing bicycle weeder was used and hand weeding was also done at 35 and 50 days after sowing to keep the plot free from weeds.

RESULTS AND DISCUSSION

Plant height of maize was significantly higher (210.3cm) with the N application at LCC threshold ≤ 5. Significantly lower plant height was recorded under without application of nutrients (175.8 cm) compared to rest of the treatments (Table 2). The increase in plant height might be attributed to favourable N supply. The level of N encourages the carbohydrate synthesis that resulted in the taller plants. These results are in line with the earlier findings of Sarnaik [10] who reported that higher plant height was noticed with application of N based on LCC-5 in maize. In the present study, the maximum number of green leaves per plant was observed by N application at LCC threshold ≤ 5 (7.7). Minimum number of green leaves per plant was recorded in absolute control (4.2) (Table 2). This was mainly due to favorable nutrition and moisture in turn led to better utilization of available resources. Higher leaf area per plant was noticed in N application at LCC threshold ≤ 5 (2962 cm^2 $plant^{-1}$). The lower leaf area per plant was recorded in absolute control (1755 cm^2) (Table 2). It was mainly due to favorable nutrition and moisture in turn led to better utilization of available resources.

TABLE 1. QUANTITY OF FERTILIZERS APPLIED FOR DIFFERENT TREATMENTS (KG HA^{-1}) AS INFLUENCED BY LEAF COLOUR CHART THRESHOLDS UNDER IRRIGATED CONDITION

Treatments	Basal			15 DAS			30 DAS			45 DAS			60 DAS			75 DAS			Total			Saving of fertilizers over RDF		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1	62	75	37.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	62	75	37.5	128	0	0
T_2	62	75	37.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	62	75	37.5	128	0	0
T_3	62	75	37.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	62	75	37.5	128	0	0
T_4	62	75	37.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	62	75	37.5	128	0	0
T_5	62	75	37.5	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92	75	37.5	98	0	0
T_6	62	75	37.5	30	-	-	30	-	-	30	-	-	-	-	-	-	-	-	152	75	37.5	38	0	0
T_7	62	75	37.5	30	-	-	30	-	-	30	-	-	30	-	-	-	-	-	182	75	37.5	8	0	0
T_8	62	75	37.5	30	-	-	30	-	-	30	-	-	30	-	-	30	-	-	212	75	37.5	-22	0	0
T_9	94	75	37.5	24	-	-	24	-	-	24	-	-	24	-	-	-	-	-	190	75	37.5	0	0	0
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0

T_1: N application at LCC threshold ≤ 1 ; T_2: N application at LCC threshold ≤ 2; T_3: N application at LCC threshold ≤ 3
T_4: N application at LCC threshold ≤ 4 T_5: N application at LCC threshold ≤ 4.5 T_6: N application at LCC threshold ≤ 5
T_7: N application at LCC threshold ≤ 5.5 T_8: N application at LCC threshold ≤ 6
T_9: Recommended nitrogen (190 kg ha^{-1}) T_{10}: Absolute control

TABLE 2. GROWTH COMPONENTS OF MAIZE AS INFLUENCED BY N APPLICATION BASED ON LEAF COLOUR CHART THRESHOLDS UNDER IRRIGATED CONDITION

Treatments	Plant height (cm)	Number of green leaves plant^{-1}	Leaf area (cm^2 plant^{-1})	Leaf area index	Total dry matter production (g plant^{-1})	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
T1: N application at LCC threshold ≤ 1	181.2	5.7	2034	1.70	191.7	5157	6652	43.7
T2: N application at LCC threshold ≤ 2	182.1	6.0	2180	1.82	199.7	6104	7835	43.8
T3: N application at LCC threshold ≤ 3	182.5	6.1	2232	1.86	212.9	6369	8191	43.7
T4: N application at LCC threshold ≤ 4	188.7	6.2	2351	1.96	232.9	7289	9184	44.2
T5: N application at LCC threshold ≤ 4.5	191.0	6.4	2511	2.09	261.2	7453	9316	44.4
T6: N application at LCC threshold ≤ 5	210.3	7.7	2962	2.47	317.5	8339	10424	44.4
T7: N application at LCC threshold ≤ 5.5	209.6	7.2	2711	2.26	310.9	7799	9827	44.2
T8: N application at LCC threshold ≤ 6	191.6	6.5	2625	2.19	286.2	7504	9455	44.2
T9: Recommended nitrogen (190 kg ha^{-1})	208.3	7.0	2649	2.21	308.6	7756	9696	44.4
T10: Absolute control	175.8	4.2	1755	1.46	144.1	3725	5264	41.4
S.Em.±	6.2	0.4	113	0.09	9.0	227	314	0.0
C.D. (P=0.05)	18.5	1.2	336	0.27	26.9	674	934	NS

LCC: Leaf Colour Chart NS: Non significant

TABLE 3. NUMBER OF COBS PLANT^{-1}, NUMBER OF GRAIN ROWS COB^{-1}, NUMBER OF GRAINS ROW^{-1}, COB WEIGHT PLANT^{-1}, GRAIN YIELD PLANT^{-1} AND TEST WEIGHT (G) OF MAIZE AS INFLUENCED BY N APPLICATION BASED ON LEAF COLOUR CHART THRESHOLDS UNDER IRRIGATED CONDITION

Treatments	No. of cobs plant^{-1}	No. of grain rows cob^{-1}	No. of grains row^{-1}	Cob weight plant^{-1} (g)	Test weight (g)	Grain yield plant^{-1} (g)
T1: N application at LCC threshold ≤ 1	1.0	12.0	26.9	181.0	31.7	90.8
T2: N application at LCC threshold ≤ 2	1.0	12.5	29.1	182.2	32.7	108.5
T3: N application at LCC threshold ≤ 3	1.1	14.0	29.9	183.0	32.9	113.3
T4: N application at LCC threshold ≤ 4	1.2	14.2	30.2	183.1	33.1	129.9
T5: N application at LCC threshold ≤ 4.5	1.2	14.5	30.4	187.0	33.6	132.8
T6: N application at LCC threshold ≤ 5	2.0	16.9	33.1	214.0	36.8	148.8
T7: N application at LCC threshold ≤ 5.5	1.9	16.5	32.4	209.6	36.6	139.1
T8: N application at LCC threshold ≤ 6	1.6	15.4	30.4	197.0	33.7	133.7
T9: Recommended nitrogen (190 kg ha^{-1})	1.8	16.3	31.8	206.0	35.9	138.3
T10: Absolute control	1.0	10.7	14.2	160.0	23.0	65.7
S.Em.±	0.1	0.5	0.9	5.6	1.0	4.0
C.D. (P=0.05)	0.2	1.6	2.6	16.6	3.0	11.9

LCC: Leaf Colour Chart

Among different LCC thresholds, the N application at LCC threshold ≤ 5 recorded significantly higher leaf area index (2.47). The significantly lower LAI was registered in absolute control (1.46) (Table 2). The increase in LAI was mainly due to the effect of nitrogen on the rate of growth of meristem and the

appearance and development of leaves. The higher photosynthetic apparatus (LA and LAI) in LCC 5 with 30 kg N in each split could be attributed to better need based site specific N management and supply and management through LCC thresholds as per the crop requirement. These results are in conformity with findings of Datturam and Shashidhar [7] who reported that application of 40 and 30 kg N ha^{-1} per dressing by maintaining LCC-5 has recorded higher growth attributing characters such as LAI and DMP.

Significantly superior maize grain yield was recorded with N application at LCC threshold ≤ 5 (8339 kg ha^{-1}) and it was on par with N application at LCC threshold ≤ 5.5 (7799 kg ha^{-1}) and recommended nitrogen (7756 kg ha^{-1}) compared to rest of the treatments. Significantly lower maize grain yield was registered under without fertilizer application (3725 kg ha^{-1}). Significantly higher amount of maize stover yield (10424 kg ha^{-1}) was recorded under N application at LCC threshold ≤ 5 and significantly lower was recorded under without fertilizer application (5264 kg ha^{-1}) (Table 2). The higher grain and stover yields of maize was mainly due to better translocation of photosynthates from source to sink and higher growth attributing characters like higher number of leaves, leaf area and higher dry matter production and its accumulation into different parts of plant and yield attributing characters like cobs per plant, rows per cob, grains per row, cob weight, grain yield per plant and test weight (Table 3). This was evidenced through these findings of Angadi *et al.* [1]; Datturam and Shashidhar [7]; Sarnaik [10]; Mallikarjuna *et al*. [9] and Singh *et al*. [11].

Among yield attributes, grain yield per plant, grains per row and test weight were important in deciding the grain yield of maize. Yield attributes which are significantly higher in application of nitrogen fertilizer based on LCC threshold ≤ 5 and lowest value were in absolute control. This was obviously due to favourable nutrition or balanced level of nutrient application during the crop growth stages. These results corroborate with findings of Sarnaik [10]; Mallikarjuna *et al*. [9] and Singh *et al*. [11].

CONCLUSION

From the results of the experiment, it is clearly reveald that, application of N fertilizers based on leaf colour chart at threshold ≤ 5 was found optimum to achieve higher grain and straw yields, with a saving of 40 kg N ha^{-1} over recommended N for the region. LCC-5 with 30 kg N per dressing (total 152 kg N ha^{-1}) recorded 5800 kg ha^{-1} higher grain yield over recommended dose of nitrogen.

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