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EVALUATION OF LEAF COLOUR CHART FOR NITROGEN MANAGEMENT IN HYBRID MAIZE (*ZEA MAYS* L.) UNDER IRRIGATED ECOSYSTEM OF VERTISOLS

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ABSTRACT
A field study was conducted at Agricultural Research Station, Siruguppa, University of Agriculture Sciences, Raichur, Karnataka, during *kharif* 2016 to study the "Evaluation of leaf colour chart for nitrogen management in maize (*Zea mays* L.) under irrigated condition of vertisols" and to evaluate and establish LCC threshold values for saving fertilizer N and achieve higher grain yield. Application of nitrogen fertilizer based on LCC threshold ≤ 5 recorded higher grain yield (8339 kg ha^{-1}), stover yield (10424 kg ha^{-1}), hundred seed weight (36.8 g) and cob length (19.2 cm), plant height (210.3 cm), leaf dry weight at harvest (40 g plant^{-1}). Whereas higher agronomic efficiency of N (58 kg/kg of N) and partial factor productivity of N (117.6) were registered under LCC threshold ≤ 4. LCC based N management could adequately take care of field to field and temporal variation in N supply to plant and thus holds promise for efficient fertilizer N use in rice, wheat and maize. So, this study was undertaken to find out the relationship of leaf greenness as measured by LCC with leaf N concentration, nutrient-use efficiency and grain yield and to establish threshold LCC values for guiding crop demand-driven need based-fertilizer N applications in maize.

KEY WORDS: Grain yield, Leaf-colour chart, Maize, Nitrogen management, N-use efficiency and partial productivity of N.

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 150m ha in about 160 countries with wider range of soil, climate, biodiversity and management practices that contributes 36% (782 mt) 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 mt and productivity of 2583 kg ha^{-1} (Anon, 2015). Nutrient management has played a crucial role in achieving self sufficiency in food grain production. The need for precise and responsive management of N fertilizer in Maize is compelling for both economic and environmental reasons. Static fertilizer recommendations based on average response lead to excessive fertilization in some years and inadequate fertilizers in years with high N losses. The uncertainty in optimum N rate poses risks for profit loses which is exacerbating by the asymmetric profit response of maize to N rates (Banerjee *et al*., 2014). The associated higher cost of under fertilization relative to over fertilization drives farmers to apply imbalanced rates. This uncertainty can be addressed by providing more accurate location and time specific recommendations that increase accuracy and reduce uncertainty (Clune *et al*., 2013). Chlorophyll (CHL) is a major pigment involved in plant photosynthesis. Because of its importance and relation with other biophysical properties, there have been multiple methods developed to estimate its concentration nondestructively. These methods utilize the absorption properties of CHL that use either the reflectance or transmittance of light by the leaf (Ciganda *et al.*, 2009 and Wu *et al.*, 2010) Some newer sensors use the fluorescence properties of CHL to estimate its content. These systems in due course of time may be costly and may also face limitations in remote areas due to power constraints (Nguy Robertson *et al*., 2015).

Human eye is amazingly sensitive to changes in greenness and it is not necessary to use a sensor based system to detect the variation of CHL in a leaf. A leaf colour chart (LCC) is a simple and non destructive, easy to use and farmer friendly tool which gives a rapid and reliable monitoring of leaf greenness by visual appearance of spectral properties of leaves as indicated by LCC can be a better guide to the farmers for judicious and right time application of N. The leaf-colour chart is being successfully used to assess the efficient N management under diverse situations of soil, climate, variety, management etc. especially in rice (Witt *et al.*, 2005), but the technology for its use in maize has not been deeply established so far. Keeping all these in view, current study was undertaken to find out the relationship of leaf greenness as measured by LCC with leaf N concentration, nutrient-use efficiency and grain yield and to establish threshold LCC values for guiding crop demand driven need based-fertilizer N applications in maize.

MATERIALS & METHODS

The field experiment was conducted at Agriculture Research Station, Siruguppa, University of Agriculture

Sciences, Raichur and is located at 76°54" East longitude, 15° 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 and clay loam in texture, neutral in soil reaction (8.09) and low in electrical conductivity (0.26 dSm^{-1}). The organic carbon content was 0.43 per cent and 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 recommended dose of N 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 sprayed to control weeds. At 20 days after sowing bicycle weeder was used and hand weeding was done at 35 and 50 days after sowing to manage weeds.

TABLE 1. Quantity of fertilizers applied for different treatments (kg ha^{-1}) as influenced by leaf colour chart thresholds under irrigated condition

Treat-ments	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, T9: Recommended nitrogen (190 kg ha^{-1}) T_{10}: Absolute control

RESULTS & DISCUSSION

Significantly higher grain (8339 kg ha^{-1}) and stover yield (10424 kg ha^{-1}) was registered with N application at LCC threshold ≤ 5 but, it was on par with N application at LCC threshold ≤ 5.5 (7799 and 9827 kg ha^{-1}, grain and stover yield, respectively) and recommended nitrogen (7756 and 9696 kg ha^{-1}, grain and stover yield, respectively). Extent of increase in grain yield due to LCC-5 threshold based N application was 7.5 % over recommended N. Significantly lower grain yield (3725 kg ha^{-1}) and stover yield (5264 kg ha^{-1}) was registered under without fertilizer application (Table 3). The higher yield obtained when N was managed at LCC threshold ≤ 5 was obviously due to favourable nutrition or balanced level of nutrient application during the crop growth stages. However, in LCC-1, 2, 3 and 4 the amount of N was less and plant suffer for want of N at critical stages of crop growth (4th leaf, 8th leaf stage, tasseling and silking) where N is most required at these stages as we seen from the uptake of N. This was further evidenced by positive relationship between N applied and grain yield (r^2= 0.59) (Fig. 1). Similarly, these results are in accordance with findings of Roland *et al.* (2013) they reported that, LCC threshold 5 recorded substantially better grain (44 q ha^{-1}) and straw yield (70 ha^{-1}) of maize in comparison to LCC threshold at 4 and 3. In the present study significantly higher growth and yield additives had been located with LCC < 5. These results were also in conformity with findings of Angadi *et al.* (2002);

Datturam and Shashidhar (2012); Sarnaik (2010); Mallikarjuna *et al*. (2016) and Singh *et al*. (2016).

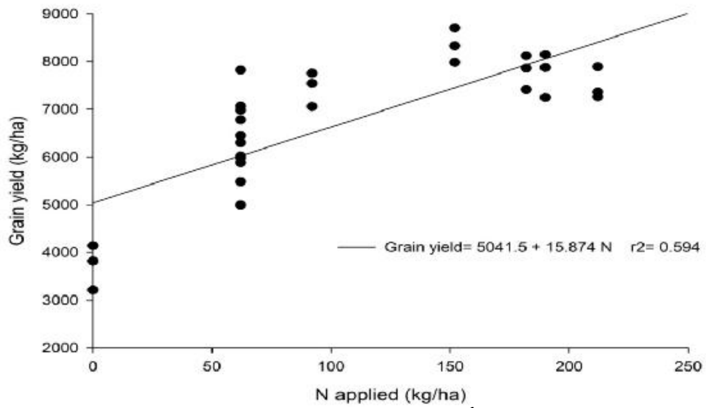

FIGURE 1. Regression and correlations between grain yield (kg ha^{-1}) and N applied rate (kg ha^{-1}) as influenced by N management through leaf colour chart thresholds in maize under irrigated condition

TABLE 2. Growth and yield components of maize as influenced by N application based on leaf colour chart thresholds under irrigated condition

Treatments	Plant height at harvest (cm)	Number of green leaves $plant^{-1}$	Leaf area (cm^2 $plant^{-1}$)	Leaf dry weight (g $plant^{-1}$) at harvest	Cob length (cm)	100-seed weight (g)
T_1: N application at LCC threshold ≤ 1	181.2	5.7	2034	28.1	15.8	31.7
T_2: N application at LCC threshold ≤ 2	182.1	6.0	2180	30.0	16.6	32.7
T_3: N application at LCC threshold ≤ 3	182.5	6.1	2232	31.4	17.2	32.9
T_4: N application at LCC threshold ≤ 4	188.7	6.2	2351	33.0	17.3	33.1
T_5: N application at LCC threshold ≤ 4.5	191.0	6.4	2511	35.3	17.4	33.6
T_6: N application at LCC threshold ≤ 5	210.3	7.7	2962	41.0	19.2	36.8
T_7: N application at LCC threshold ≤ 5.5	209.6	7.2	2711	38.2	18.5	36.6
T_8: N application at LCC threshold ≤ 6	191.6	6.5	2625	35.5	17.6	33.7
T_9: Recommended nitrogen (190 kg ha^{-1})	208.3	7.0	2649	37.6	18.3	35.9
T_{10}: Absolute control	175.8	4.2	1755	20.2	13.1	23.0
S.Em.±	6.2	0.4	113	1.8	0.5	1.0
C.D. (P=0.05)	18.5	1.2	336	5.4	1.5	3.0

LCC: Leaf Colour Chart

The grain yield of maize is a function of many yield attributing characters like cob length and hundred seed weight which were significantly influenced by different LCC threshold levels. Significantly higher cob length (19.2 cm) and hundred seed weight (36.8 g) were recorded with N application at LCC threshold ≤ 5, than the other LCC threshold levels (Table 2). However, it was at on par with N application at LCC threshold ≤5.5 and recommended nitrogen. These yield parameters are improved mainly due to increased growth performance represented by plant height, number of leaves per plant, leaf area and leaf dry matter production. Need-based N application showed higher leaf weight than to applying N at fixed time intervals (Table 2). These results are in conformity with findings of Datturam and Shashidhar (2012) they reported that application of 40 and 30 kg N ha^{-1} per dressing by maintaining LCC-5 has resulted in higher cob yield and it was greatly influenced by yield attributing characters such as cob length, cob girth, grain rows, number of kernels and grain weight per cob. Similar results were also reported by Roland *et al.,* 2013. Availability of nutrients in soil with N application at LCC threshold ≤5 resulted in higher yield and uptake of nutrients, which in turn led to lower soil available nitrogen (178.4 kg ha^{-1}) (Table 3). Similar results on nutrient uptake and soil available nitrogen was reported by Arun Kumar *et al.* (2009) in baby corn. Thus the enhanced values of yield attributing characters witnessed the tendency of nitrogen in accelerating growth, photosynthetic activity and translocation efficiency which might have contributed for higher nutrient uptake. These results are in accordance with the findings of Rana and Choudhary (2006) in maize and Shukla *et al.* (2006) in wheat. Significantly higher agronomic efficiency of nitrogen was recorded with nitrogen application based on LCC threshold 4 (58 kg grain kg^{-1} N) as compared to rest of the treatments (Table 3). Lower was recorded in N application at LCC threshold ≤6 (18kg grain kg^{-1} N). These results are in conformity with the findings of Biradar *et al.* (2005). They reported that the agronomic performance of implemented N (AEN) (expanded rice yield in per kg of N applied) have been generally better at decrease LCC threshold values. In the present investigation, significantly higher partial factor productivity of nitrogen was recorded with nitrogen application based on LCC threshold 4 (117.6 kg kg^{-1} N applied) as compared to other treatments (Table 3). Lower was recorded in N application at LCC threshold ≤ 6 (35.4 kg kg^{-1} N applied).

TABLE 3. Grain and straw yield, total N application, available N, Partial factor productivity of N and Agronomic efficiency of N as influenced by N application based on leaf colour chart thresholds under irrigated condition

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Total N applied (kg ha^{-1})	Available N (kg ha^{-1}) at harvest	PFP_N ((kg kg^{-1}N applied)	AE_N(kg grain kg^{-1} N applied)
T1: N application at LCC threshold ≤ 1	5157	6652	62	205.6	83.2	23
T2: N application at LCC threshold ≤ 2	6104	7835	62	204.4	98.5	38
T3: N application at LCC threshold ≤ 3	6369	8191	62	204.1	102.7	43
T4: N application at LCC threshold ≤ 4	7289	9184	62	201.1	117.6	58
T5: N application at LCC threshold ≤ 4.5	7453	9316	92	188.6	81.0	41
T6: N application at LCC threshold ≤ 5	8339	10424	152	178.4	54.9	30
T7: N application at LCC threshold ≤ 5.5	7799	9827	182	180.0	42.9	22
T8: N application at LCC threshold ≤ 6	7504	9455	212	183.4	35.4	18
T9: Recommended nitrogen (190 kg ha^{-1})	7756	9696	190	181.4	40.8	21
T10: Absolute control	3725	5264	-	141.3	0.0	0.0
S.Em.±	227	314		5.6	2.6	1.6
C.D. (P=0.05)	674	934		16.8	7.8	4.8

NUE: Nitrogen use efficiency, **LCC:** Leaf Colour Chart, **PFP_N:** Partial factor productivity of N **AE_N :** Agronomic efficiency of N

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