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NEED BASED NITORGEN MANAGMENT OF MAIZE (*ZEA MAYS* L.) GROWN IN THE DRY ZONE OF SRI LANKA USING A SIX PANEL LEAF COLOUR CHART.

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ABSTRACT

Maize growing farmers in Sri Lanka generally practice fixed time N fertilizer application. Due to high variability of soil fertility in maize growing areas, fixed time nitrogen application may not totally meet the crop demand for the nutrient, and hence a need based N management strategy would improve the crop productivity while increasing the efficiency of the fertilizer input. An experiment was conducted at the Field Crops Research and Development Institute (FCRDI), Maha-Illuppalama to evaluate the applicability of Leaf Color Chart (LCC) for need based N management of maize. Experiment was planned to identify the optimum LCC values for different growth stages of the crop and validate the suitability of identified values. Both open pollinated and hybrid varieties were tested with different levels of N (0, 75, 150, 225, 300 kg/ha) to determine the optimum LCC values. Optimum LCC values identified were validated by conducting field experiments covering both seasons. Results revealed that six panel LCC developed for rice could successfully be used for maize and a LCC value of 4.5 could be used as the optimal LCC value in need based N management strategy for maize. This technique increases N fertilizer efficiency of applied N compared to the fixed time N fertilizer management strategy.

Keywords: Need based N management, Leaf color chart, Maize

INTRODUCTION

Maize is the second most important cereal crop grown in Sri Lanka occupying 67,219 ha of land producing 240,588 tons of grain (AgStat, 2015). Local average maize yield recorded is 3.58 t/ha while the potential yield of the crop is 7 t/ha. Among various reasons accounting such low productivity, inefficient utilization of N can be considered as one of the most critical determinants of maize productivity. Farmers generally apply N fertilizer in fixed times as basal and top dressing (4 weeks after planting) without considering the real N requirement of the crop at different growth stages. Hence, such applications may be either excessive or not adequate to meet the crop N demand.

The optimum use of N can be achieved by matching N supply with crop demand (Bijay Singh *et al*., 2002). There are destructive and non-destructive techniques available to estimate plant N demand. Plant N status can be accurately estimated using a destructive technique. However, foliar sample analysis is time consuming, costly and labor intensive (Lemaire, 2007). Leaf greenness measured using chlorophyll meter is positively correlated with leaf chlorophyll content and leaf N content (Wood *et al*., 1993 and Inada, 1985). Leaf Color Chart (LCC) devised based on chlorophyll meter readings can be considered as non-destructive techniques of determining plant N status. (Ali *et al*., 2012). It can be used as an alternative to chlorophyll meter as well (Varinderpal *et al*., 2004). Hence, LCC is an inexpensive tool and an easy way of monitoring the relative greenness of maize leaf and thereby, the plant N status.

LCC are used for rice in India, Bangladesh, Indonesia, Philippines, Thailand and Vietnam to determine the time and amount of N application for efficient use of N fertilizer and to obtain higher yields. LCC has been tested on maize in India and USA for need based nitrogen management (Anthony Nguy *et. al*., 2015 and Varinderpal *et al*., 2004). However, LCC has not been tested for N management of maize in Sri Lanka. Hence, this experiment was conducted to study the applicability of LCC to determine the need based N requirement of maize grown in Sri Lanka.

MATERIALS AND METHODS

Two experiments were conducted at FCRDI, Maha-Illuppallama, Sri Lanka from 2013 *Yala* season to 2014 *Yala* season. Experimental site was located at DL_{1b} agro ecological region and Reddish Brown Earth soil is the predominant grate soil group, Rhodustalfs (Panabokke, 1996). One experiment was conducted to determine optimum LCC values and the other to validate the use of those optimum LCC values in N management of Maize. Both experiments were repeated in *Yala* and *Maha* seasons during the study period and locally cultivated hybrid (Pacific-999) and open pollinated maize varieties (Badra and Ruwan) were used as test crops.

Determination of optimum LCC value.

Five different levels (0, 75, 150, 225, 300 kg/ha) of N in the form of urea were tested for Open Pollinated Varieties (OPV) (Badra and Ruwan) and hybrid maize (Pacific) in *Yala* 2013 and *Maha* 2013/14 seasons. Nitrogen was applied in equal splits at 2 days before planting, knee height and at pre-tasseling stage. Maize seeds were planted in 4.8 X 4.8 m size plots at 60X30 cm spacing. Treatments were arranged in a split plot design with four replicates. Maize genotypes were used as main plot and level of N was used as sub-plot treatment. All treatments received 45 kg/ha P_2O_5 and 30 kg/ha K_2O as triple supper phosphate and muriate of potash as basal. All other agronomic practices were done as per the Department of Agriculture recommendations. A six panel LCC, manufactured by the International Rice Research Institute was used in this study. LCC readings were taken from fully opened upper most leaves of 10 plants of each treatment at 7 days intervals from the 6th leaf stage. Dry seed yield at 10% moisture content was recorded and relative grain yields were calculated. Cate and Nelson graphical method was modified to establish optimum LCC values (Cate and Nelson, 1987). In this method average LCC values at different growth stages were plotted against the relative grain yield for the corresponding treatments. Relative grain yield beyond which no significant yield increase was observed was selected as the horizontal critical level in the Cate and Nelson plot and the vertical critical level was selected to minimize outliers.

Validation of the optimum LCC values.

Validation experiment was conducted in *Maha* 2013/14 and *Yala* 2014. Following treatments were used for the need based N management and fixed time Management for OPV (Badhra) and hybrid varieties (Pacific 999). Need based treatments were planed based on the optimal LCC values determined after the previous experiment. Silking stage was considered as the R1 stage for need based N management.

1. No Nitrogen
2. 120 kg N/ ha in three equal splits
3. 150 kg N/ ha in three equal splits
4. 30 kg N/ha (basal) + Need based – LCC < 4.5 (6^{th} leaf stage (V6) to before silking (R1) stage).
5. 30 kg N/ha (basal) +Need based – LCC < 5 (V6 to before R1 stage)
6. 30 kg N/ha (basal) +Need based – LCC < 4.5 (V6 to before R1 stage) and LCC < 5 (at R1 stage)
7. 30 kg N/ha (basal) +Need based – LCC <5 (V6 to before R1 stage) and LCC < 5.5 (at R1 stage)

Note: V6 – 6^{th} leaf stage, R1-.silking stage

Experimental design was spit-plot with three replicates. Different varieties were used as main plots while different fertilizer management practices were used as sub- plots. Maize seeds were planted in 3.6X3.6 m size plots giving 60X30 cm spacing (one plant per hill).

In fixed time N management, N fertilizer was applied 2 days before planting, knee height and pre-tussling stage in equal splits. Need-based N application was done based on the LCC values. From the 6^{th} leaf stage onward, LCC values were taken in weekly intervals. When the LCC value of the fully opened upper most leaf was less than the optimum value, 30kg N/ ha was applied. Mean LCC value of each plot was determined after taking the reading from 10 randomly selected plants. All treatments received 45 kg/ha P_2O_5 and 30kg/ha K_2O in the form of triple supper phosphate and muriate of potash as basal fertilizer. All other agronomic practices were done according to the Department of Agriculture (DOA) recommendation. Seed yield, moisture percentage of the seeds and agronomic N use efficiency (AE_N) were measured. AE_N was computed as follows (Rutkowska *et al*., 2014).

$$AE_N \text{ (kgkg-1)} = \frac{Y_N - Y_{NO}}{N_a}$$

Y_N - Grain yield in treatment fertilized with N

Y_{NO}- Grain yield in treatment without N fertilization

N_a -Quantity of N fertilizer applied for N fertilized treatment

Statistical analysis was performed using SAS. Duncan's multiple range test for mean separation. The correlation coefficients (r) were determined using MS EXCEL

RESULTS AND DISCUSSION

Characteristics of the soils.

Soil properties of the experimental sites of the surface soil (0 – 30cm) are given in Table 1. Data in Table 1 shows that soils at both experimental sites were neutral in reaction and showed no salinity buildup.

Table 1. Soil properties of experimental sites.

Property	Site I		Site II	
	***Yala* 2013**	***Maha* 2013/14**	***Maha* 2013/14**	***Yala* 2014**
pH (1:1)	7.7	7.4	7.3	7.6
EC (1:5)(dS/m)	0.05	0.07	0.08	0.09
Organic matter % (Walkely and Black)	2.5	1.5	1.1	1.2
Exchangeble K(mg/kg) (1 M Am acetate)	235	200	250	200
Available P mg/kg) (Olsen)	12	11	14	32

Organic matter contents observed were normal to that of the Dry zone soils found in Sri Lanka having a moderate P content. Exchangeable K contents were towards slightly high side which is a usual phenomenon in the Rhodustalfs in the Dry zone in Sri Lanka.

Optimum LCC value.

Leaf color in all maize varieties changed with the rate of N application and also with the time. Figure 1 shows that the mean LCC value of maize varieties as affected by the level of N application for *Yala* 2013 and *Maha* 2013/14 as a function of time. LCC values varied depending on the growth stage and it increased with increasing N level. At the initial growth stage up to three weeks, LCC values were very similar irrespective of the N level applied (Figure 1).

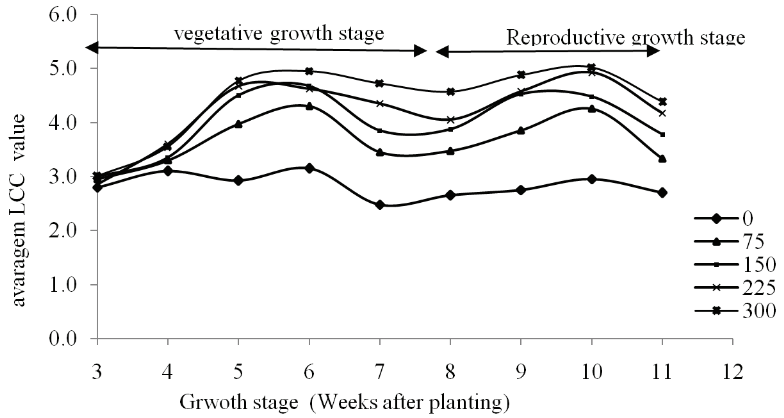


Figure1. Mean LCC values of different maize varieties as influenced by different N rates.

From 3rd week onward, LCC values increased until 6th week and then again decreased up to 8th week depending on the rate of N application. Thereafter, it started increasing again. In general results showed that vegetative and reproductive phase had different LCC values (Figure 1). LCC values and seed yield at different growth stages were positively correlated (Table 2). Since leaf greenness is positively correlated with plant N status (Wood *et al.*, 1993), LCC which determines the leaf greenness could be used as a tool to determine the N requirement of the crop. Thus, LCC values at different growth sages can be used as an indicator of the plant N status. These results are in agreement with Varinderpal *et al.*, (2004). Variation of LCC values at vegetative and reproductive stages indicate the requirement of maintaining different optimum LCC values for the two growth stages

Table 2. Correlation coefficient (r) between grain yield and LCC values at different growth stages

Growth stage (weeks after planting)	Seed yield vs LCC value	
	***Yala* 2013**	***Maha* 2013/14**
4	0.82 *	0.70 *
5	0.76 *	0.64 *
6	0.86 *	0.89 *
7	0.80 *	0.92 *
8	0.91 *	0.91 *
9	0.86 *	0.96 *
10	0.91 *	0.89 *

* Significant at $p < 0.01$ level

Interaction between variety and level of N was not significantly different for both seasons. In *Yala* 2013, seed yield was significantly increased only up to150 kg/ha N (Table 3). This was the behavior in all tested seasons except 2013/14 *Maha* season at which seed yield increased up to 225 kg/ha N. Hence, relative grain yield of 0.91 (Table 3) was taken as the horizontal critical level for the Cate and Nelson graphical method.

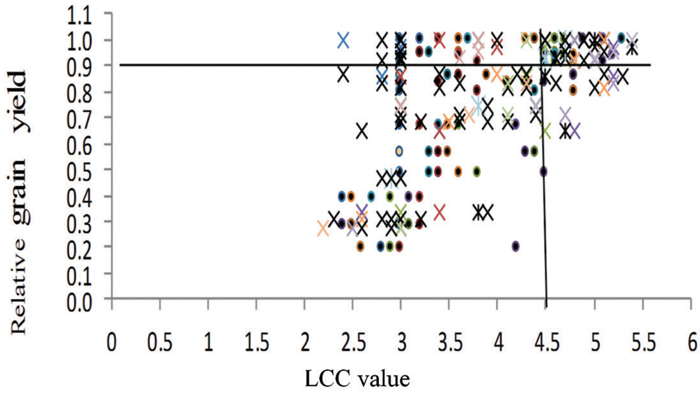
Table 3. Seed yield and relative grain yield with different N levels at *Yala* 2013 and *Maha* 2013/14

N level kg/ha	Seed yield (t/ha)		Relative grain yield	
	***Yala* 2013**	***Maha* 2013/14**	***Yala* 2013**	***Maha* 2013/14**
0	3.96 c	2.56 d	0.30 c	0.31 d
75	6.41 b	5.03 c	0.63 b	0.61 c
150	8.62 a	6.75 b	0.91 a	0.81 b
225	8.95 a	7.55 a	0.92 a	0.91 a
300	9.08 a	8.18 a	0.94 a	0.98 a
Variety				
Hybrid	7.97 a	6.72 a	0.75 a	0.75 a
OPV	6.84 b	5.31 b	0.73 a	0.70 a
CV%	20	12	9	10

Note: In each column, means followed by the same letter are not significantly different at 5% probability level

Cate and Nelson plots for LCC and relative grain yield of vegetative stage and reproductive stage are shown in Figure 2a and 2b, respectively. Accordingly, LCC value of 4.5 could be selected as optimum LCC value for vegetative growth stage (Figure 2a) while for reproductive growth stage, LCC value of 5 is the optimum value to obtain relative grain yield of 0.91 (Figure 2b).

Yala 2013



Maha 2013/14

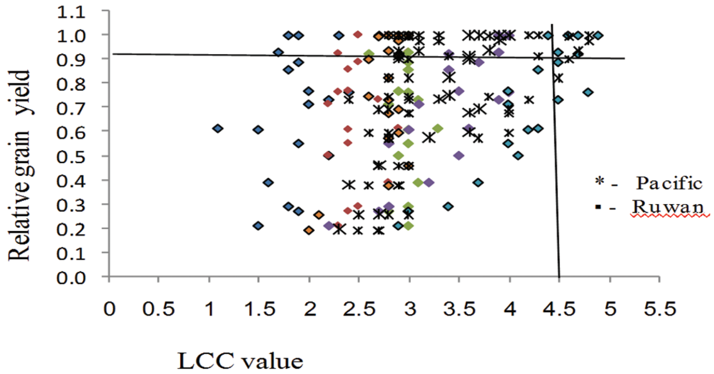
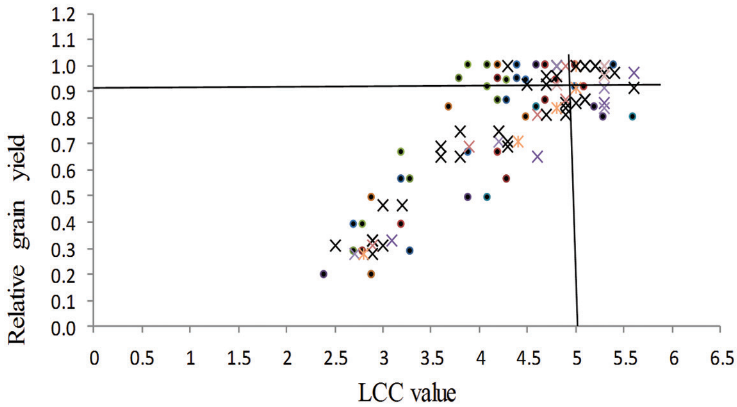


Figure 2a. Relationship between LCC values at vegetative stage and relative grain yield of maize

Yala 2013



Maha 2013/14

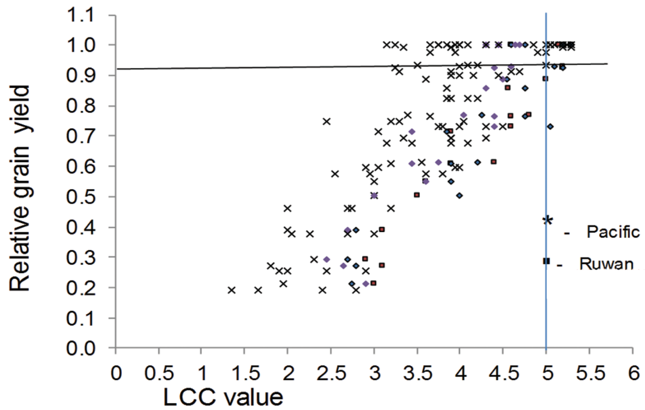


Figure 2b. Relationship between LCC values at reproductive stage and relative grain yield of maize

Validation of the optimum LCC values

During the validation experiment, optimum LCC values determined in the previous experiment was used as a guidance to fertilize N against the fixed time N management. There was no interaction observed between varieties and N fertilizer management treatments indicating that same N management can be practiced irrespective of the type of variety, OPV or Hybrid. In *Maha* 2013/14, fixed time N application produced lower yield than the LCC dependent need based application treatments. There was no significant difference observed in seed yield among the need based application treatments (Table 4) despite the use of two slightly different LCC values of 4.5 and 5.0. Need based

N fertilizer application of vegetative stage treatments; yield produced by the optimum LCC value of 4.5 was comparable to optimum LCC value of 5. This indicates that the identified optimum values are suitable to be used in the need based N management of maize.

Table 4. Total N application and seed yield of different fertilizer application treatments and varieties In *Maha* 2013/14 & *Yala* 2014

N treatment	Total N application (kg/ha)	Seed yield (t/ha)	
		***Maha* 2013/14**	***Yala* 2014**
No Nitrogen	0	3.43 d	2.42 c
120kg N /ha in three equal split	120	5.37 c	6.18 b
150kg N /ha in three equal split	150	6.26 b	6.76 a
Need based – LCC < 4.5 (V6 to before R1 stage)	120	7.48a	6.83 a
Need based – LCC < 5 (V6 to before R1 stage)	150	8.28 a	7.48 a
Need based – LCC < 4.5 (V6 to before R1 stage) and LCC < 5 (at R1 stage)	120	7.40 a	6.73 a
Need based – LCC <5 (V6 to before R1 stage) and LCC < 5.5 (at R1 stage)	150	8.22 a	7.23 a
CV %		10.5	11.2

Note: In each column, means followed by the same letter are not significantly different at 5% probability level

Results further showed that there was no significant response to N fertilizer application at silking stage with different LCC optimum values (Table 4). However, use of 5 as the optimal LCC value increased the crop yield in both seasons though the increment was not significant. This indicates that the critical LCC value for maize could be beyond 4.5 and this discrepancy could be the result of taking the 0.91 relative yield as the critical horizontal in the Cate and Nelson graphical representation. Hence it will be important to further improve this value in future attempts.

Agronomic efficiency of applied N.

When compared to the similar amount of total N application, need based fertilizer application treatments produced higher AE_N than fixed time application (Table 5). LCC value 4.5 as optimum value for vegetative growth stage had the highest AE_N for both seasons.

Data in Table 5 shows that at the same rate of need based N application can increase the agronomic efficiency of the applied N by nearly 10 kg/kg thus utilizing an increased quantity of N for grain production.

Table 5. Agronomic efficiency of different N management options for maize.

Treatment	Agronomic efficiency of N (kg/kg)		
	Maha 2013/14	Yala 2014	Mean
120kg N /ha in three equal split	16.1 b	31.3 b	23.7
150kg N /ha in three equal split	18.8 b	28.9 b	23.9
Need based – LCC < 4.5 (V6 to before R1 stage)	33.8 a	36.8 a	35.3
Need based – LCC < 5 (V6 to before R1 stage)	32.3 a	33.7 ab	33.0
Need based – LCC < 4.5 (V6 to before R1 stage) and LCC < 5 (at R1 stage)	33.1 a	35.9 ab	34.5
Need based – LCC <5 (V6 to before R1 stage) and LCC < 5.5 (at R1 stage)	31.9 a	30.9 b	31.4

In each column, means followed by the same letter are not significantly different at 5% probability level

This indicates that need based N management in maize can reduce the N loss compared to fixed time N management for maize. Hence application of need based N management system contribute not only for increasing crop yield, but also for reducing cost of production and saving the environment.

CONCLUSIONS

Maize responds to the application of N and both fixed time N management and need based N management can be used to fertilize the crop. LCC value of the fully opened mature maize leaf can be used to determine the N status of maize grown for both open pollinated and hybrid maize varieties irrespective of the cultivation season and the six panel LCC developed for rice can successfully be used for Maize crop also. By maintaining a LCC value of 4.5 from vegetative to silking stage by adopting a need based N management strategy, agronomic efficiency of applied N can be increased by nearly 50% as the agronomic efficiency of N was increased from nearly 23 to 33.

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