The Andhra Agric. J 63 (4): 844-848, 2016

Management of Nitrogen Through the Use of Leaf Colour Chart (LCC) and Soil Plant Analysis Development (SPAD) or Chlorophyll Meter for Sweet Corn in Sandy Loam soils

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ABSTRACT

A field experiment was conducted in sandy loam soils of Agricultural College Farm, Bapatla, Andhra Pradesh, India to evaluate the best site specific real time nitrogen management strategies for sweet corn (var. sugar75) during *kharif* of 2014-15 by taking 120 kg N ha^{-1} and 150 kg N ha^{-1} in three to four splits as treatment combinations through SPAD and LCC. The experiment was laid out in randomized block design with nine treatments and replicated thrice. The experimental soil (0-15 cm) had pH 6.81; organic C 0.19 %; available N 242.8 kg ha^{-1}; available P_2O_5 20.6 kg ha^{-1} and available K_2O 164.2 kg ha^{-1}. The results show that values of both LCC and SPAD significantly increased with an increasing level of N. The mean values of LCC and SPAD varied from 3.0 to 5.4 and 42.2 to 51.2, respectively in sweet corn and they were significantly correlated with N content and uptake at 30 and 60 DAS. The results show that the amount of N can be saved as 20-40 and 40-60 kg N ha^{-1} through the use of SPAD and LCC in sweet corn over T_1 where 120 kg N ha^{-1} was applied in three splits. The plot received 120 kg N ha^{-1} in four splits and SPAD- treated N plots produced the maximum grain yield. The results further show that 40 kg N ha^{-1} as basal + 20 kg N ha^{-1} if SPAD value is <48.0 has been proved to be superior treatment for the best management of N in sweet corn in sandy loam soil.

Key words : Chlorophyll meter, LCC, Nitrogen uptake, Sweet corn ,Yield.

For achieving higher yields, farmers in many parts of the world tend to apply N in excess of the requirement. This is particularly true in sweet corn growing areas of the Southern India and it leads to further lowering of N fertilizer recovery efficiency, which is already not more than 50 per cent (Singh *et al.,* 2001).

When N application is non-synchronized with crop demand, N losses from the soil-plant system are large, resulting in low N fertilizer use efficiency. Hence, plant need-based application of N is crucial for achieving higher yield and N use efficiency. The chlorophyll meter, also known as SPAD (soil plant analysis development), can quickly and reliably assess the N status of a crop based on leaf area. It has been successfully used for rice (Follett *et al*., 1992). The high cost of the chlorophyll meter keeps it out of reach of many Asian farmers. The leaf colour chart (LCC) is inexpensive alternative to the chlorophyll meter. Like the chlorophyll meter or SPAD, the critical colour shade on the LCC needs to be determined to guide N application. Fertilizer N-use efficiency of sweet corn in sandy loam soils is relatively low due to rapid losses of applied N through volatilization and leaching in the soil. The leaf N content is closely related to photosynthetic rate (Peng *et al.,* 1996) and the N concentration on a dry weight basis of the topmost fully expanded leaf has been used as an index to determine the N top dressing.

Use of this approach in developing countries of Asia is very limited. The chlorophyll meter or SPAD and LCC provide a simple, quick and nondestructive method for estimating N of sweet corn leaves. Very limited research works are available so far to establish LCC and SPAD for sweet corn in southern India particularly in Andhra Pradesh. Therefore, the present investigation was conducted to evaluate site specific real time nitrogen management strategies for sweet corn using LCC and SPAD to save N without decreasing yield of sweet corn and to avoid expenditure on soil test for the recommendation of N fertilizers.

MATERIAL AND METHODS

A field experiment was conducted in a sandy loam soils of orchard block, Agricultural College Farm, Bapatla, Andhra Pradesh, India for sweet corn (in *kharif*), replicated thrice in a randomized block design. Sugar 75 for sweet corn was taken as a test crop. The field was divided into 9 sub plots carrying the following treatments. The treatments comprising of T_1(120-60-50 NPK kg ha^{-1} RDF (N in three splits)), T_2 (150-60-50 NPK kg ha^{-1} (N in three splits)), T_3 (T_1 in four splits, T_4-T_2 in four splits), T_5 (N_{40} as basal +N20 if SPAD value is <48.0), T_6 (N_{50} as basal +N20 if SPAD value is <48.0), T_7 (N_{40} as basal + N20 if LCC value is <4), T_8 (N_{50} as basal + N20 if LCC value is <4), T_9 (Soil test based nitrogen recommendation). Recommended doses of P_2O_5 (60 kg ha^{-1}) and potash (50 kg ha^{-1}) were applied to all plots.

The chlorophyll meter and LCC were used for measurement on five topmost fully expanded leaves. The LCC and SPAD (Model, CCM-200) readings were taken at 10 day intervals at a specified time. An average of ten readings of leaves was taken in each plot until 60 days after sowing (DAS). Drymatter accumulation at different growth stages were recorded and calculated the nutrient uptake. All the data were statistically analyzed; correlation etc. following the standard procedures (Panse and Sukhatme 1978).

RESULTS AND DISCUSSION

LCC and SPAD values vs. drymatter production and grain yield

The LCC values increased significantly with an increase of N levels (Table 1). The recorded LCC values did not show any particular trend with the progress of crop growth, but mostly the LCC values increased up to 30 DAS and thereafter, decreased at 60 DAS. The range of LCC values were 3.1–5.2 irrespective of treatments and progress of crop growth. The SPAD or chlorophyll meter values increased significantly with increasing levels of N (Table 2). The trend of changes in SPAD was almost similar to that of LCC, however, the SPAD values increased significantly up to 75 DAS, then decreased thereafter. The range of SPAD values were 42.2–51.2 irrespective of treatments and progress of crop growth. The SPAD based N application was comparable and superior to the other treatments. The present findings also supported the results obtained by Maiti *et al.* (2004).

The mean LCC and SPAD values were positively and significantly correlated at all growth stages with mean grain yield of sweet corn (Table 2). The correlation coefficient (r) values between SPAD and LCC at different growth stages were found significant and positively correlated at 30 and 60 DAS (r= 0.96** and 0.73* respectively) (Table 4). The significant positive correlation of these parameters indicates that the top dressing of N can be practiced based on the LCC and SPAD. The SPAD showed higher correlation over LCC to achieve the greater yield, indicating an increased N-use efficiency significantly through the use of chlorophyll meter over LCC. But the LCC can also be used for N topdressing as it is low cost and easy to handle in the field as compared to SPAD, which is most expensive and requires technical skill for its operation. The LCC is now well accepted by farmers in developing countries. The mean LCC and SPAD values varied from 3.0 to 5.4 and 42.2 to 51.2, respectively.

The dry matter production at knee high stage varied from 1522 to 1802 kg ha^{-1}. Among the treatments at tasseling, significantly higher drymatter production was registered by the treatment T_9 (Soil Test Based Nitrogen) (3617 kg ha^{-1}) and was found to be at par with T_2 (3592 kg ha^{-1}) followed by T_1 (3486 kg ha^{-1}). However, compared to drymatter production during knee high stage substantial increase was noticed between tasseling and harvest in the present investigation. These results were in confirmation with the findings of Suryavanshi *et al.* (2008). The data revealed that the treatments received N in splits at different intervals based on LCC and SPAD values performed almost equal to T_1 (120 kg N ha^{-1} in three splits). Vigorous production in dry matter during the tasseling and harvesting stage draws support from the findings of Sutaliya and Singh (2005). Adequate supply of nitrogen is associated with vigorous vegetative growth which in turn putforth more photosynthetic surface, enhancing the carbohydrate metabolism thus contributing to more drymatter accumulation as reported by Singh and Sarkar (2001) and Yosef tabar (2012).

Table 1. Effect of different treatments of N on SPAD and LCC readings* at different growth stages of sweet corn (Sugar 75)

Treatments	SPAD- chlorophyll meter readings			LCC readings		
	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS
T_1 $N_{120}P_{60}K_{50}$RDF(N in three splits)	49.2	48.4	46.8	4.8	4.3	3.3
T_2 $N_{150}P_{60}K_{50}$ (N in three splits)	50.1	50.8	48.4	5.0	5.2	4.3
T_3T_1 (N in four splits)	48.2	48.1	48.6	4.1	4.0	4.4
T_4T_2 (N in four splits)	48.6	48.2	49.4	4.4	4.1	4.8
T_5 N_{40} as basal +N_{20}if SPAD value is <48.0	46.2	46.0	48.4	3.3	3.1	4.3
T_6 N_{50} as basal +N_{20} if SPAD value is <48.0	43.8	48.4	48.6	3.0	3.0	4.5
T_7 N_{40} as basal + N_{20} if LCC value is <4.0	46.8	42.8	48.0	3.4	3.5	4.0
T_8 N_{50} as basal + N_{20} if LCC value is <4.0	45.6	42.2	48.0	3.1	3.3	4.1
T_9 STB N (Soil Test Based Nitrogen) ($N_{150}P_{75}K_{50}$)	50.4	51.2	49.9	5.1	5.4	4.4
SEm±	1.4	1.6	2.1	0.2	0.2	0.2
CD (P=0.05)	4.2	11.2	NS	0.5	0.6	0.5
CV (%)	5.1	9.8	7.4	7.6	9.1	7.5

* Mean of three replications

Table 2. Effect of different treatments of N on dry matter production (kg ha^{-1})* at different growth stages of sweet corn (Sugar 75).

Treatments	Knee high	Tasseling	Stover	Grain
T_1 $N_{120}P_{60}K_{50}$RDF(N in three splits)	1663.1	3486.3	4828	2864.0
T_2 $N_{150}P_{60}K_{50}$ (N in three splits)	1659.3	3592.1	5246.8	2619.2
T_3T_1 (N in four splits)	1567.2	3282.3	4870.1	3083.7
T_4T_2 (N in four splits)	1802.6	3424.2	4953.4	2690.3
T_5 N_{40} as basal +N_{20}if SPAD value is <48.0	1544.1	3267.2	4665.0	2968.2
T_6 N_{50} as basal +N_{20} if SPAD value is <48.0	1548.1	3248.1	4765.3	2732.0
T_7 N_{40} as basal + N_{20} if LCC value is <4.0	1522..1	3394.0	4628.1	2712.1
T_8 N_{50} as basal + N_{20} if LCC value is <4.0	1528.3	3424.0	4630.2	2724.0
T_9 STB N (Soil Test Based Nitrogen) ($N_{150}P_{75}K_{50}$)	1793.5	3617.7	5026.6	3042.6
SEm±	58.3	80.3	111.0	90.1
CD (P=0.05)	174.7	240.6	333.0	270.2
CV (%)	6.1	5.8	5.6	5.7

* Mean of three replications

Drymatter production and grain yield vs x N Uptake

An increase in grain yield from applied N ranged from 2619.2 to 3083.7 kg ha^{-1} (Table 2) depending on treatments. Grain yields in fixed timing N treatments *viz.*, 120 and 150 kg N ha^{-1} in three splits averaged 2864 and 2619 kg ha^{-1}, respectively. The largest yield of 3083 kg ha^{-1} was obtained in T_3 with 120 kg N ha^{-1} in four splits which was statistically at par with T_5 (40 kg N ha^{-1} as basal + 20 kg N ha^{-1} if SPAD value is <48.0) receiving total applied N of 100 kg ha^{-1}. The LCC based N plot produced a grain yield that was not significantly different from fixed timing N treatment T_4 where N was applied at 150 kg ha^{-1} in four splits, however LCC based N treatment saved up to 60 kg N ha^{-1} as compared to $T_{4,}$ without reduction in yield. The SPAD based N produced significantly higher or at

Table 3. Effect of different treatments of N on the uptake of N (kg ha^{-1}) *at different growth stages of sweet corn (Sugar 75).

Treatments	Knee high	Tasseling	Stover	Grain
T_1 $N_{120}P_{60}K_{50}$RDF(N in three splits)	50.11	98.65	59.38	52.12
T_2 $N_{150}P_{60}K_{50}$ (N in three splits)	47.32	104.89	61.91	45.31
T_3T_1 (N in four splits)	48.14	90.26	60.88	59.81
T_4T_2 (N in four splits)	54.80	96.21	59.93	50.03
T_5 N_{40} as basal +N_{20}if SPAD value is <48.0	46.91	88.54	55.98	56.39
T_6 N_{50} as basal +N_{20} if SPAD value is <48.0	46.73	87.05	53.37	50.27
T_7 N_{40} as basal + N_{20} if LCC value is <4.0	38.22	75.01	49.54	49.58
T_8 N_{50} as basal + N_{20} if LCC value is <4.0	39.33	74.64	51.37	48.82
T_9 STB N (Soil Test Based Nitrogen) ($N_{150}P_{75}K_{50}$)	55.61	104.53	64.33	59.93
SEm±	1.85	3.73	2.62	2.64
CD (P=0.05)	5.56	11.20	7.87	7.92
CV (%)	6.77	7.11	7.92	8.73

* Mean of three replications

Table 4. Simple Correlation Matrix Showing the Relationship of SPAD and LCC at Different Growth Stages of Sweet corn with Grain yield.

Parameter	$SPAD_{30}$	$SPAD_{60}$	LCC_{30}	LCC_{60}	Grain yield	Grain N uptake
$SPAD_{30}$	1.000					
$SPAD_{60}$	0.615*	1.000				
LCC_{30}	0.966**	0.764*	1.000			
LCC_{60}	0.935**	0.730*	0.953**	1.000		
Grain yield	0.827**	0.918**	0.497*	0.774**	1.000	
Grain N uptake	0.872**	0.810**	0.542*	0.483*	0.872**	1.000

* Significant at the 0.05 probability level and ** significant at the 0.01 probability level.
LCC30, LCC60 are LCC values at 30 and 60 DAS, respectively.
$SPAD_{30}$, $SPAD_{60}$ are SPAD values at 30 and 60 DAS, respectively

par yield and saved 20-40 kg N ha^{-1} as compared to fixed timing N treatment T_1 where 120 kg N $ha^{-1}$was applied in three splits.

The total N uptake was proportional to total N rates and the highest N uptake was observed in the treatment T_9 where N was applied on the basis of soil test (55.6-kg ha^{-1}) (Table 3) followed by fixed-timing N plot where N was applied at 120 kg ha^{-1} in four splits. The SPAD-based N application proved better over LCC which might be due to better utilization of N, suggesting that savings in fertilizer N can be accomplished without sacrificing yield using the chlorophyll meter–based N management strategy. Similar views were also reported by Maiti and Das (2004) and Peng *et al.*(1996) . LCC and SPAD were also successfully used by Hussain *et al.*(2000). At tasseling, maximum N uptake was achieved by the application of 150 kg N ha^{-1} in three splits (T_2). Lin *et al.* (2009) gave the supportive results as increasing N application from N_{120} to N_{150} kg ha^{-1} increased the uptake N. N-uptake by maize exhibited a positive trend with increased levels of nitrogen application at all stages of crop growth. These findings are in accordance with those reported by Baskaran *et al.* (1992), Ashokkumar (2009).

Conclusion

N topdressing can be practiced in the field of sweet corn on the basis of LCC and SPAD values by taking the threshold limit of 4 and 48, respectively, in sandy loam soils of Bapatla. Through the use of LCC and SPAD, 40-60 and 20-40 kg N ha^{-1} can be saved, respectively, over that of the highest level of fixed-timing N applications without reduction in yield. Use of LCC and SPAD is economically viable and cost effective.

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(Received on 31.07.2015 and revised on 05.12.2015)