Precision nitrogen management in drip irrigated maize (*Zea mays* L.)

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Abstract: The field experiment was conducted during *kharif* 2014 and 2015 at ZARS, V. C. Farm, Mandya to study the effect of precision nitrogen management on growth, yield and economics of drip irrigated maize. There were 9 treatments replicated thrice in Randomized Complete Block Design. Among the various treatments, drip fertigation of nitrogen through Soil Plant Analysis Development (SPAD) meter sufficiency index of 95-100 per cent under paired row (30/90) recorded significantly higher growth and yield parameters *viz*., plant height, LAI, total dry matter production, cob length, number of rows per cob, number of kernels per cob and cob weight along with kernel (85.73 and 86.78 q/ha) and stover yield (140.4 and 145.3 q/ha) during both the years of experimentation as compared to UAS Bangalore package with surface irrigation and normal spacing of 60 cm X 30 cm and was being on par with nitrogen management through Leaf Colour Chart (LCC) 6, SPAD sufficiency index of 90-95 per cent and LCC 5. The SPAD sufficiency index of 95-100 per cent registered higher net returns (Rs. 69,634 and Rs. 77,614, respectively) and B:C ratio (2.82 and 3.00, respectively) followed by LCC 6.

1 INTRODUCTION

Maize (*Zea mays* L.) has becoming very popular cereal crop in India because of the increasing market price and high production potential in both under irrigated as well as rainfed conditions. It occupies an important role next to rice and wheat in the farming sector and macro-economy of the agrarian countries. It is third most important cereal crop in India after rice and wheat that occupied about 9.86 million hectares producing 26.26 million tons with an average productivity of 2664 kg ha^{-1} during 2017-18 [1]. In India, twenty six per cent of the total maize produced being consumed as food by human beings, twelve per cent for starch extraction, two per cent seed and remaining sixty per cent is being used for animal and poultry feed industry [13].The productivity of maize in a region is determined by several factors including nitrogen as one of the important factor. Application of higher level of N-fertilizer is very common among Indian farmers, which attribute to positive growth response to N application [2]. Furthermore, large field to- field variability of soil N supply restricts efficient use of N fertilizer when broad-based blanket fertilizer N recommendations are used. When N application is not synchronized with crop demand, N losses from the soil plant system are large leading to low N use efficiency [15]. There is a need to synchronize N fertilizer application with plant need to optimize the nutrient use and minimize environmental pollution. Successful results in assessing N need at mid-season are found in several studies [10]. Effective management of fertilizer, particularly N is a major challenge for researchers and as well as for producers especially under drip irrigation condition. Hence, there is need for precision nitrogen management in maize by using tools like LCC (Leaf Colour Chart) and SPAD (Soil Plant Analysis Development) meter for better utilization of nitrogen and also to obtain optimum yield. Considering the benefits of these tools, a field experiment was laid out with an objective to study the effect of precision nitrogen management on growth, yield, nitrogen use efficiency and economics in drip irrigated maize.

2 MATERIAL AND METHODS

A study was conducted during *Kharif* 2014 and 2015 at Zonal Agricultural Research Station, V. C. Farm, Mandya (11^0 30' to 13^0 05' N latitude and 76^0 05' to 77^0 45' East longitude with an altitude of 695 meters above mean sea level). The soil of the experimental site was red sandy loam in texture with a pH of 6.60, 0.40 *per cent* organic carbon, 230.8 kg ha^{-1} of available soil nitrogen, 41.9 kg ha^{-1} of phosphorus and 146.2 kg ha^{-1} of potassium content. The experiment consisted of 9 treatments *viz.,*T_1: Nitrogen management through LCC3, T_2: Nitrogen management through LCC4, T_3: Nitrogen management through LCC5, T_4: Nitrogen management

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through LCC6, T_5: Nitrogen management through SPAD sufficiency index 85- 90 per cent, T_6: Nitrogen management through SPAD sufficiency index 90- 95 per cent, T_7: Nitrogen management through SPAD sufficiency index 95- 100 per cent, T_8: RDF with surface irrigation and paired row planting (30/90 cm), T_9: UAS (B) package with surface irrigation and normal spacing (60 cm x 30 cm) laid out in Randomized Complete Block Design and replicated thrice. For T_1 to T_7 treatments, basal dose of 10 kg N ha^{-1} was applied and remaining N was top dressed by using LCC and SPAD sufficiency index from 14 DAS to 50 per cent tasseling. In addition, for all the treatments full dose of P and K was applied as basal. But for the T8 and T9 treatments 75 kg N ha-1was applied as basal dose at 30 DAS. SPAD sufficiency index was calculated using the below formula:

$$\text{SPAD Sufficiency Index} = \frac{\text{Average bulk reading}}{\text{Average reference strip reading}} \times 100$$

The periodic growth and yield observations were taken in 5 randomly tagged plants in net plot area. Nitrogen uptake by crop at harvest was determined by Kjeldahl's method as described by [7]. Economics is calculated by considering the prices in the market and also by depreciation over the drip irrigation system. Fischer's method of analysis of variance was used for analysis and interpretation of the data as outlined by [6]. The level of significance used in 'F' and 'T' tests was p=0.05. Critical differences were calculated wherever 'F' test was significant.

3 RESULTS AND DISCUSSION

The growth parameters *viz.,* plant height and total dry matter production at harvest and LAI at 90 DAS varied significantly among the N management practices during both the years of experimentation. N management through SPAD sufficiency index 95-100 per cent recorded significantly higher plant height (203.8 and 210.3 cm, respectively) as compared to UAS (B) package (178.1 and 182.6 cm, respectively). However, it was at par with nitrogen management through LCC 6 (201.9 and 206.5 cm, respectively), SPAD sufficiency index 90-95 per cent (199.1 and 205.6 cm, respectively) and LCC 5 (198.1 and 195.8 cm, respectively). Whereas, the lowest plant height was observed in LCC 3 (164.9 and 170.2 cm, respectively). Similarly the total dry matter production at harvest was also significantly higher in N management through SPAD sufficiency index 95-100 per cent (325.7 and 328.9 g/plant, respectively) and was being on par with N management through LCC 6, SPAD sufficiency index 90-95 per cent and LCC 5. This increased plant height and total dry matter production in these treatments were mainly attributed to enhanced Leaf Area Index due to production of more number of leaves and leaf area resulted in increased synthesis of photosynthates. These results are in agreement with the findings of [8] in rice (Table 1).

Table 1. Growth and yield parameters of drip irrigated maize as influenced by precision nitrogen management practices

Treatments	**Plant height (cm)**		**Leaf Area Index at 90 DAS**		**Total Dry Weight (g $plant^{-1}$)**		**Cob length (cm)**	
	2014	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
T_1	164.9	170.2	5.77	5.82	212.2	220.3	10.1	10.2
T_2	175.6	178.4	6.28	6.32	253.9	256.9	11.1	11.6
T_3	198.1	195.8	7.53	7.52	312.7	321.5	14.4	14.8
T_4	201.9	206.5	8.03	8.12	323.7	326.5	15.4	15.9
T_5	167.4	168.9	5.88	6.12	246.3	252.3	10.3	10.8
T_6	199.1	205.6	7.62	7.62	316.2	320.1	14.7	15.0
T_7	203.8	210.3	8.06	8.21	325.7	328.9	15.5	16.0
T_8	182.0	185.4	6.71	6.82	288.6	292.3	12.1	12.8
T_9	178.1	182.6	3.21	6.32	283.7	285.6	12.1	12.4
S.Em.±	5.9	5.2	0.31	0.41	9.0	10.2	0.42	0.4
C.D. (P=0.05)	17.8	15.5	0.93	1.21	27.0	30.4	1.25	1.2

The yield parameters *viz.,* cob length, number of rows per cob, number of kernels per cob and 100 kernel weight were influenced significantly due to N management practices in both the experimental years (Table 2). Among the N management practices, SPAD sufficiency index 95-100 per cent recorded significantly higher cob length (15.5 and 16.0 cm, respectively), number of rows per cob (16.7 and 17, respectively), number of kernels per cob (522 and 531, respectively) and 100 kernel weight (42.93 and 43.33, respectively) as compared to others. However, it was on par with N management through LCC 6, SPAD sufficiency index 90-95 per cent and LCC 5. This increased yield attributes was mainly attributed to increased growth parameters due to enhanced photosynthesis. These increased growth and yield attributes which in turn enhanced due to precise application of nitrogen based on the crop requirement similar results were found by [12,14] in rice. While, lower yield attributes were recorded in LCC 3.

Table 2. Yield parameters of drip irrigated maize as influenced by precision nitrogen management practices

Treatments	No. of rows per cob		No. of kernels per cob		100 kernel weight (g)		Kernel yield (q ha^{-1})		Stover yield (q ha^{-1})	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
T_1	11.0	11.5	180	185	41.13	41.23	62.18	63.45	99.27	100.8
T_2	12.8	13.0	291	300	41.73	41.89	70.54	72.56	110.4	112.3
T_3	16.1	16.5	492	495	42.67	42.1	77.92	78.67	121.93	125.7
T_4	16.5	16.8	517	525	42.87	42.67	85.27	86.78	139.32	142.7
T_5	11.4	11.8	207	211	41.33	41.89	63.39	65.43	100.97	103.4
T_6	16.2	16.6	495	501	42.73	43.21	78.23	80.12	127.52	130.8
T_7	16.7	17.0	522	531	42.93	43.33	85.73	86.78	140.4	145.3
T_8	14.5	15.2	446	468	41.83	42.14	72.5	73.45	116.16	120.2
T_9	14.5	14.9	433	442	41.7	42.3	70.83	72.43	110.81	113.4
S.Em. ±	0.54	0.55	15.78	16.8	0.41	0.45	2.74	2.82	3.62	3.87
C.D. (P = 0.05)	1.63	1.66	47.30	50.9	NS	NS	8.2	8.5	10.84	10.58

The higher kernel (85.73 and 86.78 q^{-1} ha, respectively) and stover yield (140.40 and 145.3 q^{-1} ha, respectively) was recorded under nitrogen management through SPAD sufficiency index 95-100 per cent as compared to other nitrogen management practices. However, it was at par with LCC 6 (85.27 and 86.78 q ha^{-1}, respectively), SPAD sufficiency index 90-95 per cent (78.23 and 80.12 q ha^{-1}, respectively) and LCC 5 (77.92 and 78.67 q ha$^{-1,}$ respectively). The extent of increase in the yield in the above treatments was 17.5, 17.0, 9.5 and 9.0 per cent, respectively over UAS (B) package (Table 2). The increase in the yield in these treatments was attributed due to application of right quantity of N fertilizer as per the crop demand and resulted in reduced losses lead to higher N use efficiency. The results are in agreement with the findings of [3] in maize; [5] in rice and [4] in wheat. The yield ability of the crop is the reflection of growth and yield attributing characters. The increase in kernel yield of maize could be traced back to increase in growth and yield attributes.

Economics is the ultimate criteria for acceptance and wider adoption of any technology. Among different indicators of economics efficiency in any production system, net returns and B:C have greater impact on the practical utility and acceptance of the technology by the farmers. In the present study, comparative economics of precision nitrogen management practices are indicated. The economics of maize varied with respect to gross returns, which was a result of prices and yield of marketable produce, cost of cultivation which varies in relation to different inputs used, and in turn net returns and B:C. Among the various nitrogen management treatments nitrogen management through SPAD sufficiency index 95-100 per cent recorded higher gross returns (Rs.1,08, 264 and Rs. 1,16,444 ha^{-1}, respectively), net returns (Rs. 69,634 and Rs. 77,614, respectively) and B:C ratio (2.80 and 3.00, respectively) (Table 3). Same trend was followed by former treatments with respect to net returns and benefit cost ratio in comparison with other precision nitrogen management practices. The consequence of higher yield and lower cost on N fertilizer resulted in higher B:C. This increased net returns and B:C in SPAD sufficiency index 95-100 per cent and LCC 6 was mainly due to increase in yield as well as reduction in the application of N fertilizer. These results are in agreement with the findings of [9, 11, 4] in wheat.

Table 3. Economics of drip irrigated maize as influenced by precision nitrogen management practices

Treatments	Cost of cultivation (Rs. ha^{-1})		Gross returns (Rs. ha^{-1})		Net returns (Rs. ha^{-1})		B:C	
	2014	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
T_1	38015	38215	78388	84800	40373	46585	2.06	2.22
T_2	38187	38387	88821	96593	50634	58206	2.33	2.52
T_3	38258	38458	98108	105698	59850	67240	2.56	2.75
T_4	38580	38780	107653	116134	69073	77354	2.79	2.99
T_5	38137	38337	79576	86954	41439	48617	2.09	2.27
T_6	38258	38458	98747	106886	60489	68428	2.58	2.78
T_7	38630	38830	108264	116444	69634	77614	2.80	3.00
T_8	36581	36781	91419	98516	54838	61735	2.50	2.68
T_9	36581	36781	89183	96701	52601	52601	2.44	2.63

4 CONCLUSIONS

From the present study it is clear that nitrogen management through SPAD sufficiency index 90-100 per cent and LCC 5 and 6 helps in achieving higher yield and economics of maize under drip irrigated condition than UAS (B).

References

1. Anonymous, www.indiastat.com, Area production and productivity of major cereals (2018)
2. V. Balasubramanian, A.C. Morales, R.T. Cruz, T.M. Thiyagarajan, R. Nagarajan, M. Babu, S. Abdulrachman, L.H. Hai. *Application of the chlorophyll meter (SPAD) technology for real-time N management in rice* Review, IRRI Notes, **25**(1) 4-8 (2000)
3. M. Banerjee, Bhuiya, Gopal Sing, G.C. Malik, Dutta, Sudarshan. *Precision nutrient management through use of LCC and nutrient expert in hybrid maize under laterite soil of India* Universal Journal of Food and Nutritional Sciences, **2**(2) 33-36 (2014)
4. M.S. El-Habbal, F. Ashmawy, H.S. Saoudi, K.H. Iman Abbas. *Effect of nitrogen fertilizer rates on yield, yield components and grain quality measurements of wheat cultivars using SPAD meter* Egypt Journal of Agricultural Research, **88**(1) 14-18 (2010)
5. M. Ghosh, Swain, Dillip Kumar, Jha, Madan Kumar, Kumar, Virendra. *Precision nitrogen management using chlorophyll meter for improving growth, productivity and N use efficiency of rice in subtropical climate* Journal of Agricultural Sciences, **5**(2) 253-266 (2013).
6. K.A. Gomez, A.A. Gomez, *Statistical procedures for agricultural research* (2nd Edition Chichesler, UK:John Wiley and Sons 1984)
7. M.L. Jackson, *Soil chemical analysis*, Prentice Hall of India, Pvt Ltd New Delhi, p 498 (1973)
8. T. Jayanthi, S.K. Gali, V.P. Chimmad, V.V. Angadi, *Leaf colour chart based n management on yield, harvest index and partial factor productivity of rainfed rice* Karnataka Journal of Agricultural Sciences, **20**(2) 405-406. (2007)
9. K. Kenchaiah, H.K. Veeranna, K.M. Devaraju. *India workshop cum group meeting in direct seeding and seeders in rice, Mysore, LCC and SPAD based-N management under different method of sowing in rice* In abstract of the 3rd CREMNET,18-19 (2000)
10. N.R. Kitchen, K.A. Sudduth, S.T. Drummond, P.C. Scharf, H.L. Palm, D.F. Roberts, E.D. Vories. *Ground based canopy reflectance sensing for variable-rate nitrogen corn fertilization* Agronomy Journal, **102** 71 (2010)
11. D. Maiti, D.K. Das. *Management of nitrogen through the use of leaf colour chart (LCC) and soil plant analysis development (SPAD) in wheat under irrigated ecosystem* Archives Agronomy and Soil Science, **52**(1) 105-112 (2006)
12. K. Manjappa, N. Kataraki, S.V. Kelaginamani. *Leaf colour chart a simple tool for integrated nitrogen management in rainfed lowland rice.* Karnataka Journal of Agricultural Sciences, **19**(1) 84-89 (2006)
13. N.N. Singh, H. Pervez, Zaidi. *Changes in priorities of maize research in India and relation to CIMMYT regional activities* Maize Research India, pp 561-570 (2002)
14. Singh, Jagdeep, C.S. Khind. *Enhancing fertilizer nitrogen use efficiency in irrigated rice by using a chlorophyll meter and leaf colour chart* The Bioscan, **9**(1&2) 663-666 (2015)
15. Thakur, Ashwani Kumar, Thakur, Dushyant Singh, Patel, Rakesh Kumar, Pradhan, Adikant and Kumar, Prafull. *Effect of different plant geometry and nitrogen levels, in relation to growth characters, yield and economics on sweet corn (Zea mays Sachharata L.) at bastar plateau zone*. The Bioscan, **10**(3) 1223-1226 (2015)