International Journal of Agricultural Sciences
Volume **13** | Issue 2 | June, 2017 | 305-310 ■ e ISSN-0976-5670
DOI:10.15740/HAS/IJAS/13.2/305-310
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RESEARCH PAPER

Field performance of maize (*Zea mays* L.) for precision nitrogen management under drip irrigated condition

P. NAGARJUN* AND S. B. YOGANANDA[1]
Department of Agronomy, University of Agricultural Sciences, G.K.V.K., BENGALURU (KARNATAKA) INDIA
(Email : nagarjunp009@gmail.com)

Abstract : The field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya, University of Agricultural Sciences, Bengaluru during *Kharif*, 2014 to study the effect of precision nitrogen management on growth, yield attributes, yield and economics of drip irrigated maize. The experiment consisted of 9 treatments replicated thrice in RCBD design. Among the various treatments imposed, drip fertigation of nitrogen through SPAD sufficiency index of 95-100 per cent under paired row (90/30) recorded significantly higher growth and yield parameters. In addition, this treatment also recorded significantly higher kernel and stover yield (85.73 and 140.43 q ha^{-1}, respectively), NUE (71.44 kg kg^{-1}) and also net returns (Rs. 69634 ha^{-1}) as compared to UAS (B) package with surface irrigation and normal spacing of 60 x 30 cm.

Key Words : Maize, Drip irrigation, Precision N management, LCC, SPAD sufficiency index

View Point Article : Nagarjun, P. and Yogananda, S.B. (2017). Field performance of maize (*Zea mays* L.) for precision nitrogen management under drip irrigated condition. *Internat. J. agric. Sci.*, **13** (2) : 305-310, **DOI:10.15740/HAS/IJAS/13.2/305-310.**

Article History : **Received :** 15.03.2017; **Revised :** 22.04.2017; **Accepted :** 06.05.2017

INTRODUCTION

Maize (*Zea mays* L.) has becoming very popular cereal crop in India because of the increasing market price and high production potential of hybrid varieties in both irrigated as well as rainfed conditions. More ever in irrigated areas farmers produce the income equal to the cash crops such as sugarcane, onion, cotton, etc. in comparatively short time period of 120-130 days by cultivating hybrid maize varieties. Hence, the trend of replacing some cash crops with maize in intensive cultivation is observed in present condition. 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 8.67 million hectares producing 22.25 million tons with an average productivity of 2566 kg ha^{-1} during 2013-14 (Anonymous, 2015). 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 (Singh *et al*., 2002).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 maize crop greenness and growth response to N application

*** Author for correspondence:**
[1]Zonal Agricultural Research Station, V.C. Farm, MANDYA (KARNATAKA) INDIA

(Balasubramanian *et al*., 2000). 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 (Thakur *et al*., 2015). 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 (Kitchen *et al*., 2010). Effective management of fertilizer, particularly N is a major challenge for researchers and as well as for producers. 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 consisting of N management in maize using LCC and SPAD meter to fine-tuning of fertilizer N programme to actual needs of plant under field conditions, reducing the risk of yield-limiting N deficiencies or costly over- fertilizing by using a chlorophyll meter and LCC was carried out with an objective to study the effect of precision nitrogen management on growth, yield, nitrogen use efficiency and economicsdrip irrigated maize.

Material and Methods

A study was conducted during *Kharif* 2014 at Zonal Agricultural Research Station, V.C. Farm, Mandya (11^0 30' to 13^0 05' N latitude and 76^0 05to $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} available soil nitrogen, 41.9 kg ha^{-1} phosphorus and 146.2 kg ha^{-1} 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 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 these treaments full dose of P and K was applied as basal. But for the T_8 and T_9 treatments 75 kg N ha^{-1} was applied as basal dose at 30 DAS. SPAD sufficiency index was calculated using the below formula :

$$\text{SPAD sufficiency index} = \frac{\text{Average bulk reading}}{\text{Average reference strip reading}} \text{x100}$$

Nitrogen uptake at harvest plant samples was determined by Kjeldahl's method as described by Jackson (1973). Economics is calculated by considering the prices in the market and also by depreciation over the drip irrigation system.

Results and Discussion

At 90 DAS, nitrogen management through SPAD sufficiency index 95-100 per cent recorded significantly higher plant height (202.13cm) as compared to UAS (B) package (175.23cm). However, it was at par with nitrogen management through LCC 6 (200.20 cm), SPAD sufficiency index 90-95 per cent (198.30cm) and LCC 5 (196.13cm). Whereas, the lowest plant height was observed in LCC 3 (163.80 cm). The similar trend was observed in other growth parameters like number of leaves plant^{-1}, leaf area, leaf index and total dry weight. These results are in agreement with the findings of Jayanthi *et al*. (2007) in rice (Table 1).

The yield parameters and yield of maize presented in Table 2. Kernel yield of maize were significantly different among the various nitrogen management practices. Nitrogen management through SPAD sufficiency index 95-100 per cent recorded significantly higher kernels yield (85.73 q ha^{-1}) as compared to UAS (B) package (70.83 q ha^{-1}). However, it was at par with nitrogen management through LCC 6 (85.27 q ha^{-1}), SPAD sufficiency index 90-95 per cent (78.23 q ha^{-1}) and LCC 5 (77.92 q ha^{-1}). While, lower kernel yield was recorded in LCC 3 (62.18 q ha^{-1}). Among the various nitrogen management practices applying nitrogen based on SPAD sufficiency index 95-100 per cent recorded significantly higher stover yield (140.43 q ha^{-1}) compared to UAS (B) package (110.81 q ha^{-1}). However, it was at par with nitrogen management through LCC 6 (139.32 q ha^{-1}), SPAD sufficiency index 90-95 per cent (127.52 q

ha^{-1}) and LCC 5 (121.93 q ha^{-1}). While, lower stover yield was recorded in LCC 3 (99.27 q ha^{-1}). Similar results are obtained in case of other yield parameters like cob length, number of rows per cob, number of kernels per cob and cob weight. The variation in the harvest index and 100 seed weight of maize as influenced by precision nitrogen management practices was not significant.

The higher kernel and stover yield of 85.73 and 140.43 q ha^{-1}, 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 q ha^{-1}), SPAD sufficiency index 90-95 per cent (78.23 q ha^{-1}) and LCC 5 (77.92 q ha^{-1}) (Table 3). The extent of increase in the yield in the above treatments was 17.4, 17.0, 9.4 and 9.1 per cent, respectively over UAS (B) package. 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 Banerjee *et al*. (2014) in

Table 1 : Growth parameters of drip irrigated maizeas influenced by precision nitrogen management practices

Treatments	Plant height (cm)	No. of leaves	Leaf area (cm^2 $plant^{-1}$)	Leaf area index	Total dry weight (g $plant^{-1}$)
T_1: Nitrogen management through LCC3	163.83	11.00	5213.17	5.77	218.13
T_2: Nitrogen management through LCC4	174.70	11.80	5654.33	6.28	251.33
T_3: Nitrogen management through LCC5	196.13	14.17	6786.40	7.53	281.77
T_4: Nitrogen management through LCC6	200.20	15.03	7227.53	8.03	293.26
T_5: Nitrogen management through SPAD sufficiency index 85- 90%	166.30	11.50	5294.70	5.88	230.63
T_6: Nitrogen management through SPAD sufficiency index 90-95%	198.30	14.30	6857.57	7.62	284.77
T_7: Nitrogen management through SPAD sufficiency index 95- 100%	202.13	15.37	7259.63	8.06	296.05
T_8: RDF with surface irrigation and paired row planting (30/90 cm)	180.40	12.07	6042.23	6.71	258.49
T_9: UAS (B) package with surface irrigation and normal spacing (60 cm x 30 cm)	175.23	11.87	5792.47	3.21	253.88
S.E.±	6.06	0.43	280.26	0.31	8.54
C.D. (P=0.05)	18.15	1.29	840.23	0.93	25.61

Note: T_1 to T_7 Paired row planting of 30 cm between rows and 90 cm between pairs with drip irrigation, RDF = Recommended dose of fertilizer (150: 75: 40 kg NPK ha^{-1}), DAS: Days after sowing and NS: Non-significant

Table 2: Yield parameters and yield of drip irrigated maize as influenced by precision nitrogen management practices

Treatments	Cob length (cm)	No. of rows percob	No. of kernels per cob	Cob weight per plant (g)	100 kernel weight (g)	Kernel yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index
T_1: Nitrogen management through LCC3	10.11	11.00	180.13	80.79	41.13	62.18	99.27	0.38
T_2: Nitrogen management through LCC4	11.08	12.77	291.20	112.44	41.73	70.54	110.40	0.39
T_3: Nitrogen management through LCC5	14.42	16.07	492.23	213.44	42.67	77.92	121.93	0.39
T_4: Nitrogen management through LCC6	15.37	16.50	517.27	226.56	42.87	85.27	139.32	0.38
T_5: Nitrogen management through SPAD sufficiency index 85- 90%	10.31	11.40	206.97	82.51	41.33	63.39	100.97	0.38
T_6: Nitrogen management through SPAD sufficiency index 90-95%	14.72	16.17	495.40	214.85	42.73	78.23	127.52	0.38
T_7: Nitrogen management through SPAD sufficiency index 95- 100%	15.54	16.73	522.27	227.97	42.93	85.73	140.43	0.38
T_8: RDF with surface irrigation and paired row planting (30/90 cm)	12.14	14.53	446.40	196.45	41.83	72.50	116.16	0.38
T_9: UAS (B) package with surface irrigation and normal spacing (60 cm x 30 cm)	12.05	14.47	433.00	195.36	41.70	70.83	110.81	0.39
S.E.±	0.42	0.54	15.78	5.87	0.41	2.74	3.62	0.02
C.D. (P=0.05)	1.25	1.63	47.30	17.61	NS	8.20	10.84	NS

Note: T_1 to T_7 Paired row planting of 30 cm between rows and 90 cm between pairs with drip irrigation, RDF = Recommended dose of fertilizer (150: 75: 40 kg NPK ha^{-1}) and NS= Non-significant maize; Ghosh *et al*. (2013) in rice and El-habbal *et al.* (2010) 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 *viz.*, plant height (202.13 cm), number of leaves per plant (15.37), leaf area (7259.63 cm^2 $plant^{-1}$), leaf area index (8.06), total dry weight (296.05 g $plant^{-1}$), cob length (15.54 cm), number of rows per cob (16.73), number of kernels per cob (522.27) and cob weight per plant (227.97 g $plant^{-1}$). Nitrogen management through LCC6, SPAD sufficiency index 90-95 per cent and LCC5 also produced at par yield attributes as that of SPAD sufficiency index 95-100 per cent. These results are in conformity with the findings of Singh *et al*. (2006) and Subbaiah *et al.* (2007).

Significantly higher nitrogen uptake by maize kernels was observed in nitrogen management through SPAD sufficiency index 95-100 per cent (154.63 kg ha^{-1}) compared to UAS (B) package (121.50 kg ha^{-1}). However, it was at par with nitrogen management through LCC 6 (153.40 kg ha^{-1}), SPAD sufficiency index 90-95 per cent (139.20 kg ha^{-1}) and LCC 5 (138.41 kg ha^{-1}). Whereas, lower nitrogen uptake by maize kernels was recorded in LCC 3 (98.00 kg ha^{-1}). Nitrogen management through SPAD sufficiency index 95-100 per cent recorded significantly higher nitrogen uptake by maize stover (54.27 kg ha^{-1}) compared to UAS (B) package (40.60 kg ha^{-1}). However, it was found at par

Table 3: Nitrogen use efficiency and nitrogen uptake at harvest in drip irrigated maize as influenced by precision nitrogen management practices

Treatments	NUE			Nitrogen (kg ha^{-1})		
	Kernel yield (q ha^{-1})	Total nitrogen used (kg)	Nitrogen use efficiency (kg kg^{-1})	Kernel	Stover	Total
T_1: Nitrogen management through LCC3	62.18	90	69.08	98.00	33.70	131.70
T_2: Nitrogen management through LCC4	70.54	100	70.54	119.63	40.43	160.06
T_3: Nitrogen management through LCC5	77.92	110	70.83	138.41	50.13	189.07
T_4: Nitrogen management through LCC6	85.27	120	71.05	153.40	54.10	207.50
T_5: Nitrogen management through SPAD sufficiency index 85- 90%	63.39	90	63.39	106.23	36.30	142.53
T_6: Nitrogen management through SPAD sufficiency index 90-95%	78.23	110	71.12	139.20	50.17	189.23
T_7: Nitrogen management through SPAD sufficiency index 95- 100%	85.73	120	71.44	154.63	54.27	208.90
T_8: RDF with surface irrigation and paired row planting (30/90 cm)	72.50	150	52.36	125.17	42.97	168.13
T_9: UAS (B) package with surface irrigation and normal spacing (60 cm x 30 cm)	70.83	150	47.22	121.50	40.60	162.10
S.E.±	2.74		2.22	6.23	1.40	5.38
C.D. (P=0.05)	8.20		6.65	18.67	4.19	16.12

Note: T_1 to T_7 Paired row planting of 30 cm between rows and 90 cm between pairs with drip irrigation, RDF = Recommended dose of fertilizer (150: 75: 40 kg NPK ha^{-1})

Table 4: 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
T_1: Nitrogen management through LCC3	38015	78388	40373	2.06
T_2: Nitrogen management through LCC4	38187	88821	50634	2.33
T_3: Nitrogen management through LCC5	38258	98108	59850	2.56
T_4: Nitrogen management through LCC6	38580	107653	69073	2.79
T_5: Nitrogen management through SPAD sufficiency index 85- 90%	38137	79576	41439	2.09
T_6: Nitrogen management through SPAD sufficiency index 90-95%	38258	98747	60489	2.58
T_7: Nitrogen management through SPAD sufficiency index 95- 100%	38630	108264	69634	2.82
T_8: RDF with surface irrigation and paired row planting (30/90 cm)	36581	91419	54838	2.50
T_9: UAS (B) package with surface irrigation and normal spacing (60 cm x 30 cm)	36581	89183	52601	2.44

Note: T_1 to T_7 Paired row planting of 30 cm b/w row and 90 cm b/w pair with drip irrigation adopted, RDF = Recommended dose of fertilizer (150: 75: 40 kg NPK ha^{-1})

with nitrogen management through LCC 6 (54.10 kg ha^{-1}), SPAD sufficiency index 90-95 per cent (50.17 kg ha^{-1}) and LCC 5 (50.13 kg ha^{-1}). Whereas, lower nitrogen uptake by maize stover was recorded in LCC3 (33.70 kg ha^{-1}). The total nitrogen uptake by maize kernel and stover was significantly higher in nitrogen management through SPAD sufficiency index 95-100 per cent (208.90 kg ha^{-1}) this is mainly due to precise application of nitrogen based on the crop requirement similar results were found by Manjappa *et al.* (2006) and Singh and Khind (2015) in rice (Table 3).

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 ha^{-1}) followed by nitrogen management through LCC6 (Rs. 1,07,653 ha^{-1}). Same trend was followed by former treatments with respect to net returns (Rs. 69634 and 69073 ha^{-1}, respectively) and benefit cost ratio (2.82 and 2.79, respectively) 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 Kenchaiah *et al.* (2000); Maiti and Das (2006) and El-Habbal *et al*. (2010) in wheat (Table 4).

Conclusion :

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 of maize than UAS (B) package under drip irrigated condition along with higher nitrogen use efficiency, nitrogen uptake and economic returns.

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