International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 869-873

Received: 15-07-2018
Accepted: 20-08-2018

Prakasha G
Department of Agronomy
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

Mudalagiriyappa
AICRP for Dryland Agriculture
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

Ramachandrappa BK
Department of Agronomy
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

Nagaraju
Department of Agronomy
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

Hanumanthappa DC
AICRP for Agro-forestry
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

Sathish A
AICRP for Agro-forestry and Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

Correspondence
Prakasha G
Department of Agronomy
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

Factor productivity, nitrogen use efficiency and economics of maize under different precision nitrogen management practices

Prakasha G, Mudalagiriyappa, Ramachandrappa BK, Nagaraju, Hanumanthappa DC and Sathish A

Abstract
Field experiment was conducted at Zonal Agricultural Research Station, UAS, GKVK, Bengaluru to assess the factor productivity, nitrogen use efficiency and economics of maize under different precision nitrogen management practices with twelve treatments and replicated thrice using RCBD during *kharif* 2016. The results revealed that among different precision nitrogen management practices, significantly higher partial factor productivity (92.36 kg kg^{-1}) was recorded in nitrogen management through SPAD-40, $N_{25.}$ Recovery efficiency (97.27 %), agronomic efficiency (49.61 kg kg^{-1}) and physiological efficiency (56.90 kg kg^{-1}) were obtained in nitrogen management through Green Seeker as compared to recommended dose of nitrogen as per package of practices and absolute control. Higher gross returns and net returns (≠ 1,91 650 ha^{-1} and ≠ 1,38,100 ha^{-1}, respectively) were noticed in application of NPK fertilizers through STCR method for target yield of 11 t ha^{-1} but higher B: C ratio (3.60) was registered in nitrogen management through Green Seeker as compared to recommended dose of nitrogen as per package of practices and absolute control.

Keywords: precision nitrogen management, maize, nitrogen use efficiency and economics

Introduction

Maize (*Zea mays* L.) is one of the important cereal crops next to wheat and rice in the world. It is called as "Queen of Cereals" because of its productive potential compared to any other cereal crop and "King of Fodder" due to its great importance in animal diet. Globally, it is grown over an area of 185.90 m. ha with an annual production of 1,075.49 m. t with a productivity of 5790 kg ha^{-1} (Anon., 2016) [2]. In India, it stands third in area and production after rice and wheat. Currently it is cultivated in an area of 9.89 m. ha with a production of 25.90 m. t. and it contributes to nearly 9 per cent of the national food basket (Dass *et al*., 2012) [6]. However, the productivity in India is much lower (2620 kg ha^{-1}) than world average (Anon., 2016) [3]. The states that contributes, more than 80 per cent of total maize production are Andhra Pradesh (20.9%), Karnataka (16.5%), Rajasthan (9.9%), Madhya Pradesh (5.7%) and Himachal Pradesh (4.4%). In India, about 35 per cent of the maize produced is used for human consumption, 25 per cent each in poultry and cattle feed and 15 per cent in food processing industries for preparation of corn flakes, popcorn, starch, dextrose, corn syrup and corn oil etc. Karnataka is not only a major maize producing state but also a major seed producing state. In the state, maize is grown over an area of 1.18 m. ha with a production and productivity of 3.28 m. t and 2773 kg ha^{-1}, respectively (Anon., 2015) [2]. During the last ten years, the area under maize in Karnataka has increased by 41 per cent.

Nitrogen is one of the most important factors for growth and development of plants and most limiting nutrient in the crop production particularly in cereals. The absorption of N by crops is variable among and between seasons, as well as between locations in the same field, even when the N supplies are high. The N supply from soil to crop varies spatially. Consequently, the demand for N by the crop also varies. As a result, the crop's nutritional status is a good indicator of the necessary N rate application. The current approaches to detect soil and plant N levels are soil-testing, visual diagnosis and foliar analysis. However, these conventional approaches are time consuming, expensive; require considerable effort for soil collection or plant sampling, processing and results are not immediately available. Therefore, to provide appropriate recommendations of spatial N applications, it is necessary to use several tools simultaneously, such as crop and soil sensors, to achieve reliable measurements of N availability from soil and crops need. The evaluation of nitrogen use efficiency (NUE) in agriculture is an important way to evaluate the density of N applied and its role in yield. Because crop responses to N application depend on the organic matter in the soil, strategies of N management in cereal crops that include reliable predictions of the response index in each season could increase NUE. In this scenario, sensors are becoming more prevalent in agricultural lands. Using variable rate equipment or application, it is possible to detect variability in crops and make rapid decisions in the field. Some sensors allow real time changes in agricultural practices by detecting variability and responding to that variability.

The purpose of this study was to develop precision nitrogen management technologies and to improve growers' knowledge for effective nitrogen (N) management. The overall goal is to improve the nitrogen use efficiency and increase crop productivity in a sustained manner.

Material and Methods

A field experiment was conducted at ZARS, UAS, Bengaluru during *Kharif* 2016. The site is located at 13^0 05' 2'' N latitude and 77^0 34' 02'' E longitudes with an altitude of 930 m above mean sea level. The soil of the experimental site was sandy loam. The initial pH was 5.97 and electrical conductivity was 0.18 dS m^{-1}. The available nitrogen, phosphorus and potassium were 215 to 267 kg ha^{-1}, 37 to 58 kg ha^{-1} and 234 to 265 kg NPK ha^{-1}, respectively. The experiment was laid out in Randomized Complete Block Design (RCBD) with twelve treatments and replicated thrice and the treatments includes T_1: Nitrogen management through SPAD sufficiency index 85-89 per cent, T_2: Nitrogen management through SPAD sufficiency index 90-95 per cent, T_3: Nitrogen management through SPAD sufficiency index 96-100 per cent, T_4: Nitrogen management through SPAD-30, N_{25}, T_5: Nitrogen management through SPAD-35, N_{25}, T_6: Nitrogen management through SPAD-40, N_{25}, T_7: Green Seeker based nitrogen management, T_8: Nitrogen management through SSNM for target of 11 t ha^{-1}, T_9: STCR based N management for target of 11 t ha^{-1}, T_{10}: STCR based NPK management for target of 11 t ha^{-1}, T_{11}: Recommended dose of N as per package of practices and T_{12}: Absolute control.

The land was brought to fine tilth before sowing by ploughing twice with tractor drawn disc plough and passing cultivator and two harrowing. Drip system including pump, filter units, main line and sub lines were installed. In line laterals of 16 mm size within lines spaced at 45 cm apart with 4 lph capacities were laid out at a distance of 60 cm apart and thereby lateral spacing of 60 cm was fixed. There were 14 maize rows at a distance of 60 cm apart in each treatment extending to 8.4 meter length. Seeds of Hema (NAH-1137) maize hybrids (two seeds per hole) were dibbled at 30 cm interval in the furrows spaced at 60 cm apart. The required fertilizer were calculated and applied as per the treatments. Based on the soil test results in case of SPAD and Green Seeker based nitrogen management, 25 per cent of the recommended dose of nitrogen was applied as basal along with full dose of P_2O_5 and K_2O. Remaining nitrogen was supplied as per the treatments. In case of SSNM and STCR 50 per cent of the nitrogen was applied as basal and the balance 50 per cent N was applied at 30 and 45 DAS along with recommended P_2O_5 and K_2O were applied at the time of sowing. In case of recommended practices, nitrogen (150 kg ha^{-1}) was applied as per package of practices. Recommended dose of FYM (10 t ha^{-1}) was applied to all the treatments except in case of absolute control and mixed into the soil 15 days prior to sowing. Irrigation was scheduled at weekly interval through drip based on the rainfall, soil and crop appearance during the crop periods. Irrigation was withheld 10 days before the crop attained maturity. Atrazine @ 1 kg *a.i.* ha^{-1} was applied as pre-emergence spray at one day after sowing of maize followed by one hand weeding was attended at 30 days after sowing to control the weeds. During the season earthing up was carried out at 30 days after sowing. Plant population was maintained in all the treatments by thinning out of excess seedlings at 15 DAS and leaving one seedlings per spot. Healthy crop stand was ensured by adopting need based crop protection and recommended packages of practices. Five plants were selected at random and tagged. These plants were used for recording growth parameters, yield and yield attributes. Nitrogen use efficiency was calculated by using following formula and expressed in kg kg^{-1} (Crass well and Godwin, 1984) [5]. Different measures of nitrogen use efficiency - recovery efficiency (RE), agronomic efficiency (AE), physiological or internal efficiency (PE) and partial factor productivity (PFP) are calculated by following formula.

$$\text{NUE or PFP} = \frac{\text{Grain yield (kg ha-1)}}{\text{Nitrogen applied (kg ha}^{-1}\text{)}}$$

$$\text{RE (\%)} = \frac{\text{(Total N uptake in N fertilized plot – Total N uptake in no N plot)}}{\text{(Quantity of N fertilizer applied in N fertilized plot)}} \times 100$$

$$\text{AE} = \frac{\text{(Grain yield in N fertilized plot - Grain yield in no N plot)}}{\text{(Quantity of N fertilizer applied in N fertilized plot)}}$$

$$\text{PE} = \frac{\text{(Grain yield in N fertilized plot - Grain yield in no N plot)}}{\text{(Total N uptake in N fertilizer plot – Total N uptake in no N plot)}}$$

Where,

NUE – nitrogen use efficiency (kg grain kg^{-1} N fertilizer applied)

RE (%) - recovery efficiency

AE- Agronomic efficiency (kg grain kg^{-1} N)

PE- Physiological efficiency (kg grain kg^{-1} N uptake)

N uptake was the total N uptake in grain and stover

The cost of various inputs used and prices of outputs in the prevailing local markets were considered for cost of cultivation, gross returns and net returns per hectare.

Net returns were calculated by deducting the cost of cultivation from total gross returns. Benefit cost ratio was worked out as follows.

$$\text{Benefit: cost ratio} = \frac{\text{Gross return (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

All the data were statistically analyzed by using standard procedure (Gomez and Gomez, 1984) [9] and results are presented and discussed at a probability level of 5 per cent.

Results and Discussion

Partial factor productivity (PFP)

The data present in Table 1 showed that, application of N fertilizer through SPAD-40, N_{25} recorded significantly higher (92.36 kg kg^{-1}) partial factor productivity over rest of the treatments and it was on par with application of nitrogen based on Green Seeker device and nitrogen management through SPAD sufficiency index 96-100 per cent (86.06 kg ka^{-1} and 85.77 kg kg^{-1}, respectively). This increase in NUE was mainly due to reduced N application in split doses according to crop demand in turn reduces the losses of N by various means. This was in accordance with Maiti *et al.* (2004) [12] and Ghosh *et al*. (2013) [13] in rice. No nitrogen use efficiency was observed under absolute control. Similar results of lower efficiencies was observed by Singh *et al*. (2002) [15], due to more N losses from soil-plant system leading to low NUE, when N application is not synchronized with crop demand.

Recovery efficiency (%)

Achievable level of recovery efficiency was registered in Green Seeker based nitrogen management (97.27 %) over other treatments and it as on par with nitrogen management through SPAD sufficiency index 96-100 per cent and nitrogen management through SPAD-40, N_{25} (93.26 and 90.23 %, respectively). Absolute control treatment recodes no recovery efficiency due to without application of fertilizer. Increased level of RE depends on crop demand for N, supply of N from indigenous sources, fertilizer rate, timing product and mode of application. Recovery efficiency depends on the congruence between plant demand and nutrient release from fertilizer and is affected by the application method (amount, timing, placement and N form) and factors that determine the size of the crop nutrient sink (genotype, climate, plant density, abiotic/biotic stresses) Similar results were obtained by Peng and Cassman (1998) [14] and Khurana *et al*. (2008) [10] in wheat.

Agronomic efficiency

Agronomic efficiency is a product of nutrient recovery from mineral or organic fertilizer (RE) and the efficiency with which the plant uses each additional unit of nutrient (PE). It depends on management practices that affect RE and PE. Significantly higher (49.61 kg kg^{-1}) agronomic efficiency was obtained (Table 1) in nitrogen based on Green Seeker method and it was on par with nitrogen management through SPAD sufficiency index 96-100 per cent (49.31 kg kg^{-1}) nitrogen management through SPAD-40, N_{25} (46.79 kg kg^{-1}). Better timing and splitting of fertilizer N applications during the season was probably the major reason to the increase in agronomic N-use efficiency. Similar results were reported by Khurana *et al*. (2008) [10] and Pasuquin *et al.* (2010) [13] also reported that significant increases in agronomic efficiency of applied N (AEN) through the site-specific N management by 53 per cent compared to the FFP and average AEN under SSNM dose to 25.1 kg kg^{-1}. No agronomic efficiency was observed under absolute control. The higher AE was mainly due to lesser application of N fertilizer. This lower agronomic use efficiency was due to absence of fertilizer. Similar results were also observed by Gilkes and Prakongkep (2010) [8].

Physiological efficiency

The data in Table 1 showed that significantly higher physiological efficiency (56.90 kg kg^{-1}) under Green Seeker based nitrogen management and it was followed by nitrogen management through SPAD-40, N_{25} (51.51 kg kg^{-1}). Absolute control recorded no physiological efficiency due to absence of external fertilizer. These results clearly showed that when fertilizer N is applied in right quantity and right time when crop can translate it's effectively in to grain yield, higher fertilizer N use efficiency can be expected (Peng and Cassman, 1998) [14] and Mahajan *et al*. (2013) [11] also reported STCR-IPNS technology ensures higher nutrient use efficiencies.

Table 1: Nitrogen use efficiency (kg kg^{-1}) of maize as influenced by precision nitrogen management practices

Treatments	Nitrogen use efficiency (kg grain kg^{-1} N applied)	Recovery efficiency (%)	Agronomic efficiency (kg grain kg^{-1} N applied)	Physiological efficiency (kg grain kg^{-1} N uptake)
T_1	80.60	69.36	35.03	47.28
T_2	84.37	77.27	38.80	47.37
T_3	85.77	93.26	49.31	50.27
T_4	82.44	74.07	36.87	46.90
T_5	85.19	75.71	39.62	49.84
T_6	92.36	90.23	46.79	51.51
T_7	86.06	97.27	49.61	56.90
T_8	37.76	43.68	22.01	46.67
T_9	32.74	35.21	18.02	47.49
T_{10}	33.38	39.12	19.65	47.09
T_{11}	57.97	53.12	27.59	50.38
T_{12}	0.00	0.00	0.00	0.00
S.Em±	3.12	3.07	1.58	2.21
CD at 5%	9.14	9.01	4.64	6.48

T_1: Nitrogen management through SPAD sufficiency index 85-89 %
T_2: Nitrogen management through SPAD sufficiency index 90-95 %
T_3: Nitrogen management through SPAD sufficiency index 96-100 %
T_4: Nitrogen management through SPAD-30, N_{25}
T_5: Nitrogen management through SPAD-35, N_{25}
T_6: Nitrogen management through SPAD-40, N_{25}
T_7: GreenSeeker based nitrogen management
T_8: Nitrogen management through SSNM for target of 11 t ha^{-1}
T_9: STCR based N management for target of 11 t ha^{-1}
T_{10}: STCR based NPK management for target of 11 t ha^{-1}
T_{11}: Recommended dose of N as per package of practices
T_{12}: Absolute control
RDF: 150: 75: 40, N, P_2O_5 and K_20 kg ha^{-1} FYM: 10 t ha^{-1}

Economics

The economics of maize cultivation differed due to precision nitrogen management (Table 2) practices and with respect to gross returns, which was the result of prices and yield of marketable produce, cost of cultivation which varied in relation to different input used and net returns and B: C ratio.

STCR based NPK management for target of 11 t ha^{-1} incurred more cost of production (Table 2) (≠ 53,550 ha^{-1}) followed by nitrogen management through SSNM for target yield of 11 t ha^{-1} (≠ 53,350 ha^{-1}). Due to higher cost towards fertilizers based on targeted yield approach, the cost of production was higher in the higher targets. However, lower cost of production was recorded in absolute control (≠ 33,450 ha^{-1}) due to without application of fertilizer.

Table 2: Gross returns, Cost of cultivation, Net returns and Benefit cost ratio (B: C ratio) of maize as influenced by precision nitrogen management practices

Treatments	Gross returns(≠ ha^{-1})	Cost of cultivation(≠ ha^{-1})	Net returns(≠ ha^{-1})	B: C ratio
T$_1$	123450	45320	78130	2.72
T$_2$	124565	44250	80315	2.82
T$_3$	165430	46230	119200	3.58
T$_4$	127230	44510	82720	2.86
T$_5$	127890	44980	82910	2.84
T$_6$	129800	45230	84570	2.87
T$_7$	175490	48790	126700	3.60
T$_8$	190560	53350	137210	3.57
T$_9$	147850	48250	99600	3.06
T$_{10}$	191650	53550	138100	3.57
T$_{11}$	145320	49540	95780	2.93
T$_{12}$	71230	33450	37780	2.13

T$_1$: Nitrogen management through SPAD sufficiency index 85-89 %
T$_2$: Nitrogen management through SPAD sufficiency index 90-95 %
T$_3$: Nitrogen management through SPAD sufficiency index 96-100 %
T$_4$: Nitrogen management through SPAD-30, N$_{25}$
T$_5$: Nitrogen management through SPAD-35, N$_{25}$
T$_6$: Nitrogen management through SPAD-40, N$_{25}$
T$_7$: GreenSeeker based nitrogen management
T$_8$: Nitrogen management through SSNM for target of 11 t ha^{-1}
T$_9$: STCR based N management for target of 11 t ha^{-1}
T$_{10}$: STCR based NPK management for target of 11 t ha^{-1}
T$_{11}$: Recommended dose of N as per package of practices
T$_{12}$: Absolute control
RDF: 150: 75: 40, N, P_2O_5 and K_20 kg ha^{-1} FYM: 10 t ha^{-1}

Due to higher grain yield and better market price, the gross returns (≠ 1, 91, 650 ha^{-1}) was higher with the application of NPK fertilizers based on STCR method for target yield of 11 t ha^{-1} followed by application of nitrogen fertilizer through SSNM method for target yield of 11 t ha^{-1} and Green Seeker based nitrogen management (≠1, 90, 560 ha^{-1} and ≠ 1, 75, 490 ha^{-1}, respectively). Higher net returns was obtained in application of NPK fertilizers based on STCR method for target yield of 11 t ha^{-1} (≠1,38,100 ha^{-1}) followed by application of nitrogen through SSNM for target of 11 t ha^{-1} and Green Seeker based nitrogen management (≠ 1,37,210 ha^{-1} and ≠ 1,26,700 ha^{-1}, respectively) but higher B: C ratio was registered in Green Seeker based nitrogen management (3.60) followed by nitrogen management through SPAD sufficiency index 96-100 per cent STCR based NPK management for target of 11 t ha^{-1} and nitrogen management through SSNM for target of 11 t ha^{-1} (3.58, 3.57 and 3.57, respectively). Despite increase in the cost of cultivation with higher targets, the large increase in yield of maize has resulted in higher returns and B: C ratio under SSNM and STCR methods but numerically higher B: C ratio was obtained in Green Seeker sensors due to reduced cost on nitrogen as compared to SSNM and STCR methods.

The lower gross return, net return and B: C ratio was obtained in absolute control (≠ 71,230 ha^{-1}, ≠ 37,780 ha^{-1} 2.13, respectively). This was mainly due to lower fertilizer usage and decreased yield. These results were in close proximity with the findings of Anil kumar *et al*. (2005) [1] and Biradar *et al*. (2012) [4].

From the study, it can be concluded that nitrogen management through Green Seeker, SPAD sufficiency index of 96-100 per cent, application of NPK fertilizer through STCR and SSNM method for target yield of 11 t ha^{-1} are the best precision nitrogen management practices in maize for achieving higher nitrogen use efficiency with higher monetary advantage.

References

1. Anil Kumar, Thakur KS, Sanjay Sharma, Integrated nutrient management in maize (*Zea mays* L.)–gobhi sarson (*Brassica napus*) cropping system under rainfed condition. Indian J Agron. 2005; 50(4):274-277.
2. Anonymous. Area, production and productivity of major cereals in India, 2015. http//www.indiastat.com.
3. Anonymous. Area, production and productivity of major cereals in India, 2016. http//www.indiastat.com.
4. Biradar DP, Aladakatti YR, Basavanneppa MA. Enhancing the productivity and economic returns of field crops with balanced nutrient application through site specific nutrient management approach. Proc. Agro-Informatics and Precision Agric., 1-3 August, Hydrabad, India, 2012, 146-151.
5. Crasswell ET, Godwin DC. The efficiency of nitrogen fertilizers applied to cereals in different climates. In: *Advances in plant nutrition*. Praeger Publishers, New York, 1984, 55.
6. Dass S, Jat SL, Chikkappa GK, Kumar B, Kaul Jyothi, Parihar CM, *et al.* Genetic enhancement and crop management lead maize revolution in India. Maize J 2012; 1(1):7-12.

7. Ghosh M, Dillip Kumar Swain, Madan Kumar, Virendra Kumar. Precision nitrogen management using chlorophyll meter for improving growth, productivity and N use efficiency of rice in subtropical climate. J Agric. Sci. 2013; 5(2):253-266.
8. Gilkes RJ, Prakongkep N. A new site-specific nutrient management approach for maize in the favorable tropical environments of Southeast Asia. Paper Presented at Symposium on Soil solutions for a changing world. 19th World Congress of Soil Science. Brisbane, Australia. 2010; 1-6:4-7.
9. Gomez KA, Gomez AA. Statistical Procedure for Agricultural Research – An International Rice Research Institute Book, A Wiley Inter science, John Wiley and Sons Inc., New York, USA, 1984.
10. Khurana HS, Phillips SB, Singh B, Alley MM, Dobermann A, Sidhu AS, *et al.* Agronomic and economic evaluation of site-specific nutrient management for irrigated wheat in northwest India. Nutr. Cycl. Agroecosyst. 2008; 82:15-31.
11. Mahajan GR, Pandey RN, Datta SC, Kumar D, Sahoo RN, Parsad R. Soil test based fertilizer recommendation of nitrogen, phosphorus and sulphur in wheat (*Triticum aestivum* L.) in an alluvial soil. Int. J Agri. Environ. Biotechnol. 2013; 6(2):271-281.
12. Maiti D, Das DK, Karak T, Banerjee M. Management of nitrogen through the use of leaf color chart (LCC) and soil plant analysis development (SPAD) or chlorophyll meter in rice under irrigated ecosystem. The Scientific World J, 2004; 4:838-846.
13. Pasuquin JM, Pampolino MF, Witt C. Closing yield gaps in maize production in Southeast Asia through site specific nutrient management. Field Crop Res. 2010a; 156:219-230.
14. Peng S, Cassman KG. Upper thresholds of nitrogen uptake rates and associated nitrogen fertilizer efficiencies in irrigated rice. Agron J. 1998; 90:178-85.
15. Singh B, Singh Y, Ladha JK, Bronson KF, Balasubramanian V, Singh J, *et al.* Chlorophyll Meter– and Leaf Color Chart–based nitrogen management for rice and wheat in northwestern India. Agron. J. 2002; 94(4):821-829.