Annals of Plant and Soil Research 19(3): 243-247 (2017)

Effect of need based nitrogen management in wheat (*Triticum aestivum*)

VINOD KUMAR, T. KUMAR, G. SINGH AND R.A. SINGH

Crop Research Station (N.D. Univ. of Agric. & Tech.) Ghaghraghat, Bahraich (U.P.) – 271 901

Received: March, 2017; Revised accepted: July, 2017

ABSTRACT

A field experiment was conducted at Crop Research Station, Ghaghraghat, Bahraich (U.P.) during rabi seasons of 2011-12 and 2012-13 to evaluate the response of wheat (Triticum aestivum L) to different levels of nitrogen (0, 60 and 90 kg Nha^{-1}) and to synchronize N application with crop demand for increased N use efficiency by need based nitrogen management in which fixed nitrogen dose 60 and 90 kg N ha^{-1} was applied in two equal splits at LCC=4 and LCC=5. Basal dose of 60kg N ha^{-1} was applied in all the treatments. Wheat crop responded significantly with increasing levels of nitrogen (0-90 kgNha^{-1}) applied in two equal splits at Ist and 2nd irrigation. Significantly highest grain (40.06 qha^{-1}) and straw (53.08 qha^{-1}) yield along with improved agronomic efficiency (17.4%) and recovery efficiency of N (45.2%), higher net income (Rs.56284 ha^{-1}), B: C ratio (2.02) were recorded with 90 kgN ha^{-1} indicating greater N response at this site. In need based nitrogen management, application of 90 kgNha^{-1} in two equal splits at LCC= 5 gave significantly higher grain (44.86 qha^{-1}) and straw (55.0 qha^{-1}) yield along with improved agronomic efficiency (20.6%) and recovery efficiency of N (54.3%), higher net income (Rs.62491ha^{-1}) and B: C ratio (2.25). There was negligible increase in cost of cultivation due to need based N application of 90 kg N ha^{-1} in two equal splits at LCC=5 as compared to blanket fertilizer N recommended dose of 60 kg N ha^{-1} in two equal splits at Ist and 2nd irrigation but it increased net return by 30.9%. Hence, the adoption of need based N application of 90 kgNha^{-1} in two equal splits at LCC= 5 along with basal dose of 60kg N ha^{-1} is suggested to be the best fertilizer N management practice.

Keywords: Need based N management, LCC, Critical value, N uptake, N use efficiency, Wheat

INTRODUCTION

Plant nutrient management, among various production practices, plays a pivotal role in enhancing the crop productivity. Nitrogen being a dominant nutrient particularly in wheat, the main staple for majority, occupies central role in crop nutrition to enhance productivity and its consumption has increased substantially in the past decades. But, the quantity of wheat grain produced per unit of applied fertilizer N (partial factor productivity) has continuously decreased to very low values (Dobermann *et al.* 2002) and N use efficiency following blanket fertilizer N recommendation consisting of two or three splits application has been reported as low as 30% in rice-wheat cropping system. The main region for low N use efficiency is an inefficient splitting of N doses or lack of synchronization between nitrogen demand and supply coupled with N applications in excess of crop requirements which results a large portion of the applied N is lost by leaching, ammonia volatilization, denitrification and reach to soil water and the atmosphere thus creating pollution problems. Enormous variability in soil N supply from field to field is another reason of low N use efficiency and yield reduction which makes blanket fertilizer N recommendation highly ineffective. In this way, the optimum crop yield potential cannot be realized without adequate N supply to the plant during the entire crop growth period. Sound N management practices need to established and followed to improve N use efficiency leading to higher grain yield level and minimal fertilizer N loss to the environment. Feeding crop N as per crop need is the most appropriate fertilizer N management strategy to improve N use efficiency. Since plant growth reflects the total N supply from all sources, either from the native supply or through external application. Plant N status at any given time may be better indicator of the N availability. The leaf colour chart (LCC) has been emerged as diagnostic tool which can determine the insitu crop N requirement by estimating indirectly crop N status in the field taking into account the variation in soil N supply and define time of N application when it needed. It helps farmers to optimize/synchronize N application with crop demand or to improve the existing fixed N recommendation for higher N use efficiency. So far, no systematic study has been carried out on the need based nitrogen management in wheat

Corresponding author e-mail address: uvkumar61@gmail.com

crop. Hence, this study was undertaken using wheat as test crop at Bahraich, eastern Uttar Pradesh.

MATERIALS AND METHODS

A Field experiment was conducted during *rabi* seasons of 2011-012 and 2012- 2013 at the Crop Research Station, Ghaghraghat, Bahraich (U.P.). The soil of experimental site was sandy clay loam in texture having bulk density 1.39 Mg m^3, pH 8.0, SOC 4.6 g kg^{-1}, low in available N 230, medium in P 14.8 and K 202 kg ha^{-1}. The experiment included 7 treatments viz., different rates of N i.e. 0, 60 and 90 $kgha^{-1}$were applied in two equal splits at I^{st} and 2^{nd} irrigation to test the N response at this site and 4 need-based N management treatments in which fixed nitrogen dose i.e. 60 and 90 kg Nha^{-1} was applied in two equal splits using leaf colour chart (LCC) with critical value 4 and 5 tested in randomized block design replicated 4 times. A basal dose of 60 N + 60 P_2O_5 + 40K_2O kg ha^{-1} was applied as urea, diammonium phosphate and muriate of potash, respectively in all the treatments. Wheat crop var. PBW 502 was shown on 3^{rd} December in first year and 5^{th} December in second year using seed rate of 120 kg ha^{-1} at 20 cm spacing. LCC readings were taken starts from 21 days up to flowering. Nitrogen contents in plant material were determined by Kjeldahl method. Soil samples (0-15cm) were analyzed for available N (Subbiah and Asija, 1956), P (Olsen *et al.*, 1954), K (1 N NH_4OAc) and organic carbon (Jackson 1973). Bulk density was measured by core method. The N use efficiency such as physiological efficiency, agronomic efficiency, recovery efficiency, and factor productivity were computed using the following relationship developed by Cassman *et al.* (1996 a).

$$\text{Physiological efficiency (PE)} = \frac{\text{Increase in grain yield } (kg\ ha^{-1}) \text{ due to } N}{\text{Increase in plant N uptake } (kg\ ha^{-1}) \text{ due to } N}$$

$$\text{Agronomic efficiency (AE)} = \frac{\text{Increase in grain yield } (kg\ ha^{-1}) \text{ due to } N}{\text{Applied N level } (kg\ ha^{-1})}$$

$$\text{Recovery efficiency (RE)} = \frac{\text{Increase in plant N uptake } (kg\ ha^{-1}) \text{ due to } N}{\text{Applied N level } (kg\ ha^{-1})}$$

$$\text{Partial Factor productivity for applied N } (PFP_N) = \frac{\text{Grain yield in N control plot } (kg\ ha^{-1})}{\text{Applied N level } (kg\ ha^{-1})} + AE$$

RESULTS AND DISCUSSION

Growth and yield attributes

Plant height and spike m^{-2} increased with increasing levels of nitrogen from 0-90 kg N ha^{-1} (Table1). Plant height was increased significantly only up to 60 kg N ha^{-1} whereas spikes m^{-2} up to 90 kg N ha^{-1}. In need based N management, significantly highest plant height and spike m^{-2} were recorded with 90 kg N ha^{-1} LCC=5 over 60 kg N ha^{-1} LCC=4 and at par with 60 kg N ha^{-1} LCC=5 in case of plant height only and 90 kg N ha^{-1} LCC=4. Yield attributes i.e. grains $spike^{-1}$ and 1000-grain weight increased significantly with increasing levels of nitrogen up to 90 kg N ha^{-1}while in case of need based N management, significantly highest grain $spike^{-1}$ and 1000-grain weight was recorded with 90 kg N ha^{-1} LCC=5 over 60 kg N ha^{-1} LCC=4 and 60 kg N ha^{-1} LCC=5 and at par with 90 kg N ha^{-1} LCC=4. Improved growth and yield attributes with need based N management using 90 kg N ha^{-1} LCC=5 critical value might be due to adequate nitrogen supply as per crop demand.

Yield

The different N treatments (T_1 – T_7) increased the grain yield from 13.95 to 44.86 qha^{-1} whereas the straw yield ranged from 20.65 to 55.0 qha^{-1}(Table 1). Increasing levels of nitrogen from 0-90 kg N ha^{-1} increased the grain and straw yield significantly up to 90 kg N ha^{-1}. The percent increase in grain and straw yield due to application of nitrogen @ 60, 90 $kgha^{-1}$ i.e., 147.3, 187.1 and 123.4, 157.0 respectively over control indicating greater N response at this site. Regarding need based N management treatments, significantly highest grain (44.86 q ha^{-1}) and straw (55.0 q ha^{-1}) yield was recorded with 90 kg N ha^{-1} LCC=5 as compared to the rest of the need based N management treatments except straw yield which is at par with 90 kg N ha^{-1} LCC=4. The percent increase in grain and straw yield due to need based N application of 60 kg N ha^{-1}LCC=4, 60 kg N ha^{-1} LCC=5, 90 kg N ha^{-1} LCC=4, 90 kg N ha^{-1} LCC=5 i.e., 155.8, 166.6, 202.1, 221.5 and 126.8, 129.7, 165.2, 166.3 respectively over control. Increased yield of wheat with right dose of N coupled with right time of application by need based N management using LCC was also reported by Birader *et al.* (2012a). Fertilizer N management strategy based on application of prescriptive doses of 25 kg N ha^{-1} at planting and 45 kg N ha^{-1} at Ist irrigation and then a dose of 45 kg N ha^{-1} at 2^{nd} irrigation stage depending upon the colour of the leaf to >LCC4 or < LCC4 resulted in high yield levels of wheat as well as improved agronomic and recovery efficiencies of fertilizer N (Singh *et al.* 2012). Singh *et al.* 2014 reported that LCC based N management could adequately take care to field to field and temporal variation in N supply to plant and thus hold promise to efficient fertilizer N use due to that produced more grain yield than blanket recommendation in rice, maize and wheat crops.

Table1: Effect of need based N management on growth parameters, yield attributes, yield, percent response and harvest index of wheat (mean of 2 years)

Treatments	Growth parameters		Yield attributes		Yield (qha^{-1})		Percent response		Harvest Index (%)
	Plant height (cm)	Spike m^{-2}	Grains $spike^{-1}$	Test weight (g)	Grain	Straw	Grain	Straw	
T_1	80.5	127	34.6	32.1	13.95	20.65	-	-	40.3
T_2	93.6	214	44.0	36.6	34.50	46.15	147.3	123.4	42.7
T_3	96.3	225	46.2	38.1	40.06	53.08	187.1	157.0	43.0
T_4	93.8	218	44.4	36.8	35.69	46.84	155.8	126.8	43.2
T_5	94.3	222	45.0	37.2	37.20	47.44	166.6	129.7	43.9
T_6	96.8	230	47.0	39.6	42.15	54.77	202.1	165.2	43.4
T_7	98.0	234	47.9	40.4	44.86	55.00	221.5	166.3	44.9
CD (P=0.05)	3.81	8.3	2.14	1.41	2.54	3.40	-	-	1.38

** T_1-Control, T_2 -60 kg Nha^{-1} in two equal splits at 1^{st} and 2^{nd} irrigation, T_3 -90 kg Nha^{-1} in two equal splits at 1^{st} and 2^{nd} irrigation, T_4 – 60 kg Nha^{-1} in two equal splits at LCC=4, T_5- 60 kg Nha^{-1} in two equal splits at LCC=5, T_6 - 90 kg Nha^{-1} in two equal splits at LCC=4, T_7 - 90 kg Nha^{-1} in two equal splits at LCC=5*

Harvest index

Increasing levels of nitrogen (0 - 90 kg N ha^{-1}) increased the harvest index up to 90 kg N ha^{-1}(Table 1). Significantly highest harvest index (42.7%) was recorded only up to 60 kg N ha^{-1}. In need based N management, significantly highest harvest index (44.9%) was recorded with 90 kg N ha^{-1}LCC=5 as compared to 60 kg N ha^{-1}LCC=4 and 90 kg N ha^{-1}LCC=4 and at par with 60 kg N ha^{-1}LCC=5, Higher harvest index with 90 kg N ha^{-1}LCC=5 might be due to N applied based on plant need and *insitu* crop requirement was better transformed into grain yield. Similar findings were also reported by Sen *et al.* (2011).

Nitrogen Uptake

The total N uptake ranged from 30.7 to 112.15 kg N ha^{-1} with nitrogen treatments from control to 90 kg N ha^{-1}LCC=5(T_1 – T_7) (Table 2). Increasing levels of nitrogen increased the nitrogen uptake significantly from 0 - 90 kg N ha^{-1}. The highest N uptake (98.63 kg N ha^{-1}) was recorded with 90 kg N ha^{-1}. In need based N management treatments (T_4 – T_7), significantly highest N uptake (112.15 kg N ha^{-1}) was recorded with 90 kg N ha^{-1} LCC=5 as compared to the rest of the need based N management treatments. Higher N uptake in this treatment might be due to increased availability of nitrogen to the plant by plant need based N supply using LCC with critical value of 5. These results are in accordance with the findings of Kumar *et al.* (2015).

Economics

Increasing levels of nitrogen (0 - 90 kg N ha^{-1}) increased the net income and benefit cost ratio (Table 2). The highest net income and benefit cost ratio (Rs.56284 $ha^{-1}$and 2.02) was recorded with 90 kg N ha^{-1}. In need based N management treatments, the highest net income and benefit cost ratio (Rs. 62491 $ha^{-1}$and 2.25) was recorded with 90 kg N ha^{-1} LCC=5 as compared to rest of the need based nitrogen management treatments mainly due to higher grain and straw yield .There is negligible increase in cost of cultivation due to need based N application of 90 kg N ha^{-1}in two equal splits at LCC=5 but it increased net return (Rs. 62491ha^{-1}) by 30.8% over blanket fertilizer N recommended dose of 60 kg N ha^{-1} in two equal splits at I^{st} and 2^{nd} irrigation. The B:C ratio also improved to 2.25 due to need based fertilizer N application of 90 kg N ha^{-1}in two equal splits at

LCC=5 from 1.74 with the application of 60 kg N ha^{-1} in two equal splits at I^{st} and 2^{nd} irrigation. Birader *et al.* (2012a) reported increased net return with N application based on LCC mainly due to right time of N application in maize-wheat cropping system. Similar findings were also reported by Kumar *et al.* (2015) in rice crop in rice-wheat cropping system.

Table 2: Effect of need based N management on N uptake, N use efficiency and economics (mean of 2 years)

Treatments	Total N uptake (kg ha^{1})	N - Use efficiency (%)				Economics		
		PE_N	RE_N	AE_N	FP_N	Cost of cultivation (Rs ha^{-1})	Net income (Rs ha^{-1})	B:C ratio
T_1	30.70	-	-	-	-	17885	19245	1.07
T_2	82.84	39.4	43.4	17.1	28.7	27461	47745	1.74
T_3	98.63	38.4	45.2	17.4	26.7	27791	56284	2.02
T_4	85.38	39.8	45.6	18.1	29.7	27461	49232	1.79
T_5	90.07	39.2	49.5	19.3	31.0	27461	51432	1.87
T_6	105.84	37.5	50.0	18.8	28.1	27791	58581	2.11
T_7	112.15	37.9	54.3	20.6	29.9	27791	62491	2.25
CD (P=0.05)	5.1	-	-	-	-	-	-	-

Nitrogen Use Efficiency

Four indices have been included to describe nitrogen use efficiency: partial factor productivity ($PFP_{N,}$ kg crop yield per kg N applied as fertilizer N and indigenous Soil N both), agronomic efficiency ($AE_{N,}$ kg crop yield increase per kg N applied), apparent recovery efficiency ($RE_{N,}$ kg N taken up per kg N applied) and physiological efficiency ($PE_{N,}$ kg crop yield increase per kg N uptake). The partial factor productivity for applied N (PFP_N) is useful measure of N-use efficiency. The PFP_N is an aggregate efficiency index that includes contribution to crop yield derived from uptake of indigenous soil N, fertilizer N uptake efficiency and the efficiency with which N acquired by the plant is converted to grain yield. Agronomic efficiency received in range from 17.1 - 20.6 kg grain kg^{-1} N applied with nitrogen treatments (T_1 – T_7) (Table 2). The highest AE (20.6) was recorded with 90 kg N ha^{-1} LCC=5 closely followed by 60 kg N ha^{-1} LCC=5 (19.3) whereas the lowest value of AE (17.1) was recorded with blanket recommendation of fertilizer N i.e. 60 kg N ha^{-1} applied in two equal splits. Thus need based N management using LCC can help in achieving the optimum recommended AE vales of 20-25 kg grain yield increase per kg N applied with proper N management as per Dobermann and Fairhurst (2000). The nitrogen use efficiency can be increased with LCC threshold over blanket N (Maiti and Das, 2006). For wheat, LCC threshold 4 gave higher grain yield, N uptake and N use efficiency over 120 kg Nha^{-1} in three splits (Shukla *et al.*, 2006). The physiological efficiency received in range from 37.5 – 39.8 kg grain kg^{-1} N uptake with N treatments. The higher PE_N was recorded with lower level of nitrogen and decrease with increasing level of nitrogen. RE_N received in ranged from 43.4- 54.3% with N treatments. The highest RE_N (54.3%) was recorded with 90 kg N ha^{-1} LCC=5 and lowest (43.4%) was with 60 kg N ha^{-1}in two equal splits at I^{st} and 2^{nd} irrigation. The PFP_N means the yield produced for each kg of N applied as fertilizer N and indigenous soil N both. The grain yield in N control treatment was 13.95 q ha^{-1} and the total N uptake 30.70 kg ha^{-1} which represents the indigenous soil N supply. The PFP_N ranged from 26.7 to 31.0 kg grain kg^{-1}N-added was recorded with N treatments could be increased by increasing N uptake of indigenous soil N and applied N to produce grain. Singh *et al.* (2007) also observed improved N use efficiency with saving of 9.4 to 54.2 $kgNha^{-1}$ and increased partial factor productivity for N (PFP_N) from 48 to 65 kg grain kg^{-1}N in on farm experiments in Punjab, when LCC based fertilizer N management was compared with farmers' practice of applying blanket N at fixed time intervals. Thus PFP_N will serve a useful parameter for identifying the constraints. Field specific N management will improve the N use efficiency.

It could be concluded from above findings that higher yield and net return in wheat crop can be obtained by need based N application of 90 kg N ha^{-1} in two equal splits at LCC=5 alongwith basal dose of 60 kg N ha^{-1} as compared to blanket fertilizer N recommended dose of 60 kg N ha^{-1} in two equal splits at I^{st} and 2^{nd} irrigation alongwith basal dose of 60 kg N ha^{-1} in sandy clay loam soil low in available N in Ghaghraghat of Bahraich district of U.P.

REFERENCES

Birader, D.P., Shivkumar, Aladakatti, Y.R., Shivamurthy, D., Satyanarayana and Majumdar, (2012a) Managing fertilizer nitrogen to optimize yield and economics of maize-wheat cropping system in Northern Karnataka. *Better Crops*, 6(1): 19-21.

Cassman, K.G., Gines, G.C., Dizon, M.A., Simson, M.I. and Alcantara, J.M. (1996a) Nitrogen use efficiency in tropical lowland rice system: Contribution from indigenous and applied nitrogen. *Field Crops Research* 47: 1-12.

Dobermann, A. and Fairhurst, T.H. (2000) Assessing nitrogen use efficiency. (in) Rice: Nutrient Disorders and Nutrient Management. *IRRI Handbook Series* pp155-160.

Dobermann, A., Witt, C., Dawe, D., Gines, HC., Nagarajan, R., Satawathananont, S., Son, TT., Tan, PS., Wang, GH., Chien, NV., Thoa VTK., Phung, CV., Stalin, P., Muthukrishnan, P., Ravi , V., Babu, M., Chatuporn, S., Kongchum, M., Sun, Q., Fu, R., Simbahan, GC., Adviento, MAA. (2002) Site-specific nutrient management for intensive rice cropping systems in Asia. *Field Crops Research* 74:37-66.

Jackson, M.L. (1973) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Kumar, V., Kumar, T., Singh, R.V., Singh, G. and Singh, R.A. (2015) Performance of real-time nitrogen management strategy in lowland rice. *Annals of Plant and Soil Research* 17 (3):314-317.

Maiti, D. and Das, D.K. (2006) Management of nitrogen through the use of leaf colour chart (LCC) and soil plant analysis development (SPAD) in wheat under irrigated ecosystem. *Archieves of Agronomy Soil Sciences* **52**(1): 105-112

Olsen, S.R., Cole, C.V., Watanable, F.S. and Dean, L.A. (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United State Department of Agriculture, Circular 939, Washington, D.C.

Sen, Avijit, Srivastava, V.K., Singh, M.K., Singh, R.K. and Kumar, S. (2011) Leaf colour chart vis-vis nitrogen management in different rice genotypes. *American Journal of Plant Sciences* **2**:223-236.

Shukla, A.K., Singh, V.K., Diwedi, B.S., Sharma, S.K. and Singh (2006) Nitrogen use efficiency using leaf colour chart in rice-wheat cropping system. *Indian Journal of Agricultural Sciences* 76(11): 651-656.

Singh, V.P., Singh, Y., Singh, B., Gupta, R.K., Singh, J., Ladha, J.K. and Balasubramaniam, V. (2007) Performance of site specific nitrogen management for irrigated transplanted rice in North Western India. *Archieves of Agronomy Soil Sciences* **53**: 567-579.

Singh, V.P, Singh, B., Singh, Y., Thind, H.S., Singh, G., Kaur, S., Kumar, A. and Vashistha, M. (2012) Establishment of threshold leaf colour greenness for need-based fertilizer nitrogen management in irrigated wheat (*Triticum aestivum L.*) using leaf colour chart. *Field Crops Research* **130**: 109-119

Singh, V.P., Singh, B., Thind, H.S., Singh, Y., Gupta, R.K., Singh, S., Singh, M., Kaur, S., Singh, M., Brar, J.S., Singh, A., Singh, J., Kumar, A., Singh, S., Kaur, A. and Balasubramaniam, V. (2014) Evaluation of leaf colour chart for need-based nitrogen management in rice, maize and wheat in north western India. *Journal of Research (Punjab Agriculture University)* **51**:239-245

Subbiah, B.V. and Asija, G.L. (1956) A rapid method for the estimation of nitrogen in soils. *Current Sciences* **26**: 259-260.