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RESEARCH PAPER

Effect of optical sensor based nitrogen management on N, P and K content and uptake by irrigated wheat (*Triticum aestivum* L.)

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Abstract : A field experiment was conducted at CCSHAU, Hisar to study the effect of optical sensor based N management on N, P and K content of grain and straw as well as N, P and K uptake by grain and straw by wheat crop during rabi season of 2013-14. N content in grain was more in treatments having N application at 3rd irrigation as compared to N application at 2nd irrigation. Total N, P and K uptake as well as N, P and K uptake separately by grain and straw, generally increased at increasing the level of fixed rate N application, when equivalent treatments (*i.e.* treatments having same time of GreenSeeker (GS) guided N application) were compared. Significantly higher N uptake by grain in two stage (*i.e.* at 2nd and 3rd irrigation stage) applied N using GS over 2nd irrigation applied N indicated that 3rd irrigation applied N is important regarding the grain N uptake.

Key Words : Wheat, Nutrient content, Plant nutrient uptake, Optical sensor (GreenSeeker)

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INTRODUCTION

Nitrogen is a key element for plant growth and development. N is most dynamic nutrient and N losses from soil-plant system are large due to lack of synchrony between crop N demand and N supply from fertilizer. Therefore, all N management strategies are based on ensuring the presence of N in soil in plant available form during peak requirement of crop. Daily uptake of N by crop over per unit area is very small therefore, split application of nitrogenous fertilizer is best method to increase nitrogen use efficiency (Prasad, 2007). For example, Prasad (2006) reported that rice crop takes up only 1-1.2 kg N/ha/day and available nitrogen present in excess is lost form soil-plant system through various processes so split application is highly desirable. Generally blanket recommendations of nutrients are made for a large region based on similar agro-climatic and soil conditions. Such recommendations regarding nitrogen application in wheat are to be in two split dosesat basal and at crown root initiation stage, however, through this method nitrogen use efficiency can be increased only to a certain limit (Singh, 2008) due to various losses, applied

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N is not fully utilized by crop. Generally 50% of the N applied is not taken up by the crop plants (Tilman *et al.*, 2002; Dobermann and Cassman, 2004).

Cassman *et al.* (996) also reported the limited efficiency of blanket recommendation of N because of field to field and season to season variability of indigenous soil N supply.

Real time nitrogen management strategies include rapid assessment of leaf N content which is indicator of N requirement of crop in real time. Spectral characteristics of leaf can be used to assess leaf N status. Evolution of optical sensing technology for N fertilizer management through measurement of early season red and NIR reflectance in wheat has been thoroughly described by Raun *et al.* (2001). Optical sensor is one such instrument which measures requirement of N based on current plant N status, yield potential of standing crop and possible responsiveness of crop to applied N. The study was conducted using GreenSeeker® (Trimble Navigation Ltd., Sunnyvale, CA, USA) to assess the effect of precision N management on irrigated wheat.

MATERIAL AND METHODS

The field experiment was conducted at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar on wheat crop (variety 'WH 711') during 2013-14. The soil was sandy loam with pH 8.3, low in available N (135 kg/ha), medium in available in P (16 kg/ha) and high in available K (351 kg/ha). The experiment was laid out in Randomized Complete Block Design with three replications. There were 12 treatments comprising N application with and without using GreenSeeker. N application without using consisted of two treatments having recommended dose (150 kg/ha) in two (75 kg/ha each) and three (50 kg/ha each) equal splits. GreenSeeker guided N application was combined with fixed rate (75, 100 and 125 kg/ha) and fixed time of N application (nine treatments) as basal and at 25 days after sowing (DAS) *i.e.* at CRI stage. GreenSeeker was used with each fixed level of N application at 2nd (50 DAS) and/or 3rd irrigation (65 DAS). One treatment was control where no fertilizer N was applied. Phosphorus and potassium fertilizers were drilled @ 60 kg/ha and 40 kg/ha, respectively.

For analysis of NPK, oven dried plant materials (grain and straw at harvest) from each plot were grinded separately with grinder. Nitrogen (Nessler's reagent method, Lindner, 1944), phosphorus (Vanadomolybdo-phosphoric acid yellow colour method, Jackson, 1973) and potassium (Flame photometer method, Richards, 1954) contents in sample were analyzed.

The uptake of each nutrient was computed as:

$$\text{Nutrient uptake}\left(\frac{\text{kg}}{\text{ha}}\right) = \frac{\text{Per cent nutrient content x Yield}\left(\frac{\text{kg}}{\text{ha}}\right)}{100}$$

RESULTS AND DISCUSSION

N, P and K content in grain and straw were not

Table 1 : Effect of time and rate of GreenSeeker based N application on NPK content (%) in grain and straw of wheat

Treatments	N application (kg/ha)	Total N (kg/ha)	N (%)		P (%)		K (%)	
			Grain	Straw	Grain	Straw	Grain	Straw
T_1	75-75-0-0	150	1.73	0.41	0.33	0.06	0.43	1.80
T_2	50-50-50-0	150	1.78	0.47	0.33	0.07	0.45	1.79
T_3	25-50-34*-0	109	1.77	0.46	0.32	0.06	0.46	1.79
T_4	25-50-0-36**	111	1.81	0.43	0.29	0.05	0.45	1.66
T_5	25-50-33*-31**	139	1.86	0.48	0.33	0.06	0.46	1.85
T_6	25-75-29*-0	129	1.83	0.49	0.32	0.06	0.45	1.97
T_7	25-75-0-33**	133	1.87	0.45	0.29	0.05	0.43	1.86
T_8	25-75-28*-23**	151	1.95	0.51	0.33	0.06	0.46	1.90
T_9	50-75-20*-0	145	1.90	0.48	0.31	0.06	0.44	1.81
T_{10}	50-75-0-28**	153	1.91	0.47	0.31	0.05	0.43	1.83
T_{11}	50-75-19*-18**	162	1.93	0.50	0.34	0.06	0.43	1.83
T_{12}	Control	0	1.70	0.39	0.30	0.07	0.45	1.73
S.E.±			0.07	0.03	0.01	0.00	0.02	0.09
C.D. (P=0.05)			NS	NS	NS	NS	NS	NS

* indicates GreenSeeker guided N application at 2nd irrigation. NS=Non-significant
** indicates GreenSeeker guided N application at 3rd irrigation

significantly influenced by different N application treatments (Table 1). However, numerical comparison of the treatments revealed that grain N content was highest when GS guided N was applied both at 2nd and 3rd irrigation stages (T_5, T_8 and T_{11}) followed by the treatments having single stage GS guided N application at 3rd d irrigation (T_4, T_7 and T_{10}). Wuest and Cassman (1992a) reported that recovery of N applied at planting ranged from 30-55% while that applied at anthesis ranged from 55 to 80%. Lestache *et al.* (2004) also reported that application of half or one third of total fertilizer nitrogen at stem elongation improved grain nitrogen content with respect to application at sowing alone or both at sowing and tillering. However, P and K content in grain and straw and N content in straw were highest in treatment having GS guided N application both at 2nd and 3rd irrigation stages followed by the treatments having single stage GS guided N application at 2nd irrigation (T_3,T_6 and T_9).

Data related to N, P and K uptake by grain and straw are given in Table 2. N, P and K uptake by grain and straw were statistically similar in both the treatments having recommended dose of N (T_1 and T_2) but three time N splitting (T_2) recorded 7.0, 3.4 and 9.1% higher N, P and K uptake by grain, respectively and 16.5, 6.1 and 1.4% higher N, P and K uptake by straw, respectively; as compared to two time splitting (T_1). The reason may be that more frequent application of N resulted into increased availability of N throughout the active growth period when it was most needed. Dhuka *et al.* (1992) reported that application of N in three splits resulted into highest grain and straw N uptake. Khalil and El-Aref (1999) also reported that splitting the nitrogen fertilizers into three equal applications significantly increased the uptake of nitrogen, phosphorus and potassium in grains. Comparison of same fixed level N application treatments (for example T_3, T_4 and T_5) with each other revealed that avoiding the N application at 2nd irrigation stage (T_4) significantly reduced N, P and K uptake by grain and straw as compared to other two treatments. Coventry *et al.* (2011) and Kaur *et al.* (2010) revealed the importance of N application at later stages in increasing the N uptake. Treatments having GS guided N application only at 2nd irrigation also led to significantly lower N, P and K uptake in grain as compared to two stage GreenSeeker guided N application treatments (*i.e.* both at 2nd and 3rd irrigation stages), irrespective of the level of fixed rate N application. Significantly higher N, P and K uptake by grain and straw in two stage GS guided N application may be due to increased and uniform availability of total N throughout the growth period resulting into higher N, P and K content in grain and straw and higher yield.

Total N, P and K uptake was 9.4, 3.9 and 2.7% higher, respectively in treatment having recommended dose in three splits (T_2) as compared to two split application (T_1) (Table 3). These results were corroborated with that of Khalil and El-Aref (1999).

Table 2 : Effect of time and rate of GreenSeeker based N application on NPK uptake (kg/ha) in grain and straw of wheat

Treatments	N application (kg/ha)	Total N (kg/ha)	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)	
			Grain	Straw	Grain	Straw	Grain	Straw
T_1	75-75-0-0	150	109.3	34.0	20.7	5.2	27.4	148.8
T_2	50-50-50-0	150	117.0	39.6	21.4	5.6	29.9	151.0
T_3	25-50-34*-0	109	98.1	33.6	17.7	4.4	25.5	130.0
T_4	25-50-0-36**	111	94.8	28.7	15.1	3.2	23.6	111.5
T_5	25-50-33*-31**	139	122.8	37.3	21.8	4.8	30.4	144.3
T_6	25-75-29*-0	129	103.7	35.9	17.9	4.5	25.4	144.1
T_7	25-75-0-33**	133	101.3	30.5	15.5	3.6	23.2	126.2
T_8	25-75-28*-23**	151	113.1	39.2	19.4	4.6	26.7	145.8
T_9	50-75-20*-0	145	108.9	35.8	18.0	4.6	25.2	135.1
T_{10}	50-75-0-28**	153	108.3	33.2	17.4	3.6	24.3	129.1
T_{11}	50-75-19*-18**	162	124.8	39.9	21.9	5.2	27.6	146.2
T_{12}	Control	0	38.2	12.9	6.7	2.2	10.1	56.7
S.E.±			3.9	1.9	0.7	0.2	1.1	3.4
C.D. (P=0.05)			11.6	5.6	2.0	0.9	3.2	10.1

* indicates GreenSeeker guided N application at 2nd irrigation
** indicates GreenSeeker guided N application at 3rd irrigation

Table 3 : Effect of time and rate of GreenSeeker based N application on total NPK uptake (kg/ha) by wheat

Treatments	N application (kg/ha)	Total N (kg/ha)	Nutrient uptake (kg/ha)		
			N	P	K
T_1	75-75-0-0	150	143.3	25.9	176.2
T_2	50-50-50-0	150	156.7	26.9	180.9
T_3	25-50-34*-0	109	131.7	22.0	155.5
T_4	25-50-0-36**	111	123.6	18.3	135.1
T_5	25-50-33*-31**	139	160.1	26.6	174.7
T_6	25-75-29*-0	129	139.7	22.4	169.5
T_7	25-75-0-33**	133	131.8	19.1	149.4
T_8	25-75-28*-23**	151	152.3	24.0	172.6
T_9	50-75-20*-0	145	144.7	22.7	160.2
T_{10}	50-75-0-28**	153	141.5	21.0	153.3
T_{11}	50-75-19*-18**	162	164.6	27.1	173.8
T_{12}	Control	0	51.1	8.9	66.8
S.E.±			3.9	0.6	3.6
C.D. (P=0.05)			11.6	1.84	10.6

* indicates GreenSeeker guided N application at 2nd irrigation.
** indicates GreenSeeker guided N application at 3rd irrigation

Total N, P and K uptake generally increased at increasing the level of fixed rate N application, when equivalent treatments (*i.e.* treatments having same time of GS guided N application; for example T_3, T_6 and T_9) were compared. This might be due to higher dry matter accumulation and higher yields under increased N levels. Prasad *et al.* (2000) reported that total N uptake increased from 54.9 kg/ha to 145.8 kg/ha at increasing the N level from 0 to 121-180 kg/ha. However, increasing the fixed rate N level from 75 (T_5) to 100 kg/ha (T_8) had lower total N, P and K uptake when GS guided N was applied both at 2nd and 3rd irrigation. Moderate doses at planting and CRI stage and comparatively higher doses at later stages (2nd and 3rd irrigation) (T_5) affected the yield attributes and crop growth positively which resulted into higher dry matter accumulation as compared to T_8 where 75 kg N/ ha at CRI stage was in excess of the crop requirement and probably could not be taken up completely by the crop.Singh *et al.* (2012) reported that successive increase in N doses resulted in reduced N uptake and N use efficiency due to loss of excess N that could not be taken up by the crop.

Therefore, it can be concluded that application of moderate doses of N at earlier stages combined with GS guided N application at later stages (*i.e.* both at 2nd and 3rd irrigation stages) results into higher grain N content (hence more protein content) and higher uptake of nutrients due to availability of nutrients in the soil in adequate amounts throughout the crop growth stages. Wuest and Cassman (1992b) also observed the effect of late-season N application on higher N content and uptake.

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