Current Journal of Applied Science and Technology

31(2): 1-6, 2018; Article no.CJAST.45895
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Precision Nitrogen Management on Nutrient Uptake and Nitrogen Use Efficiency in Irrigated Wheat

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2018/45895

Original Research Article

Received 03 November 2018
Accepted 29 November 2018
Published 08 December 2018

ABSTRACT

A field experiment was conducted during *rabi* season 2017-18 at Research Farm of Birsa Agricultural University, Ranchi, Jharkhand to evaluate the nutrient uptake and nitrogen use efficiency of wheat variety HD2967 under precision nitrogen management guided by Greenseeker. The crop was sown on 25th November and was laid out in randomised block design replicated thrice. The soil of experimental plot was sandy loam in texture having low nitrogen (175.6 kg/ha), medium in phosphorous (15.38 kg/ha) and potassium (183.46 kg/ha) with slightly acidic having soil pH 5.5. The twelve treatments comprised of: T_1- absolute control, T_2 to T_4 - application of 120 kg N in two and three split doses, T_5 to T_7 - application of 150 kg N in two and three split doses, T_8 to T_{10} - application of 180 kg N in two and three split doses and T_{11} andT_{12} (guided by Greenseeker by NDVI technique taken at 45DAS and 65DAS) were applied with 136 kg N and 140 kg N in three split doses respectively. The two splits of nitrogen given at sowing and at CRI and for three splits nitrogen was applied at sowing, CRI and at tillering stage (45 DAS). Application of 140 kg N in three split doses i.e. 30 kg N as basal, 60 kg N at CRI and Greenseeker guided nitrogen application of 40 kg at 45 DAS (second irrigation) and 10 kg at 65 DAS (third irrigation) recorded the highest nitrogen uptake in grain (86.76 kg/ha), nitrogen uptake in straw (39.68 kg/ha), total nitrogen uptake (126.44 kg/ha), phosphorus uptake in grain (16.25 kg/ha), phosphorus uptake in straw (2.91 kg/ha), total phosphorus uptake (19.16 kg/ha), potassium uptake in grain (19.38 kg/ha), potassium uptake in straw (106.17 kg/ha), total potassium uptake(125.56 kg/ha), agronomic efficiency (19.68 %) and recovery efficiency (53.46 %).

Keywords: Greenseeker; wheat; nitrogen use efficiency; nutrient uptake.

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Note: Special issue with selected papers presented in National Conference on Biotechnological Initiatives for Crop Improvement (BICI 2018), December 08-09, 2018, Organized by Bihar Agricultural University, Sabour, Bhagalpur - 813210 (Bihar), India. Conference organizing committee and Guest Editorial Board completed peer-review of this manuscript.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereals in the human diet. Importance of wheat crop may be understood from the fact that it covers about one-fifth of the total area under food grains and accounts for about one-third of the total food grain production in India [1]. Wheat occupies a prominent place as an essential crop contributing more than 40% in the total food grain production in the country. After the introduction of high yielding varieties, wheat became an important crop. It provides nearly 55% of the carbohydrates and 20% of the food calories. The cultivation of wheat has also been symbolic of the green revolution, self-sufficiency in food and sustained production. It is grown in an area of about 218.5 million hectares with a production of 713.2 million tonnes and productivity of 3,265 kg/ha during 2013. It is cultivated on 30.5 million ha area with the production of 93.5 million tonnes and productivity of 3,145 kg/ha in India [2]. In the state of Jharkhand, wheat is grown as a second crop in sequence after *Kharif* crops. In this region, wheat is grown on 170.097 thousand ha area with the production of 335.932 thousand metric tonnes and productivity of 2123 kg/ha [3].

In growth and development of plants, nitrogen plays one of the most important factors. Nitrogen is subjected to different kinds of losses like denitrification, volatilisation and leaching which causes environmental threats. Global warming caused by nitrous oxide has more potential than carbon dioxide, and its emissions are affected by poor nitrogen management in intensive crop production which is major source for it. The potential for enrichment of ground and surface waters with nitrates also increases with excessive nitrogen fertiliser applications causing eutrophication of aquatic ecosystem and methamoglobinemia in infants [4]. However,, on the other hand, insufficient nitrogen availability to wheat plants results in low yields and significantly reduced profits compared to a properly fertilized crop.

This problem can be solved by the concept of precision nitrogen management. Precision nitrogen management provides valuable information to farmers, enabling them to make the right decisions concerning management of crop input such as nitrogenous fertiliser. It involves the use of some tool like Greenseeker for nitrogen management through NDVI technique which helps in fulfilling the crop nitrogen requirement. The most widely known Normalized Difference Vegetation Index (NDVI) is the simple graphical indicator that can be used to analyse remote sensing measurements and is also a good indicator of biomass production. It is determined by dividing the difference of reflectance in the red (670 nm) and near-infrared (780 nm) by the sum of reflectance at these two wavebands. Green vegetation has an NDVI ranges from 0.00 to 0.99.

NDVI is also required to improve the nutrient uptake and nitrogen use efficiency. Insufficient nutrient availability to wheat plants results in low yields and significantly reduced profits compared to a properly fertilised crop. Efficient nitrogen management programmes supply plant nutrient in adequate quantities to sustain maximum crop productivity and profitability while minimising environmental impacts of nutrient use [5]. Ensuring optimum nutrient availability through effective nitrogen management practices requires knowledge of the interactions between the soil, plant and environment which enhances the nutrient uptake. On the other hand, nitrogen use efficiency (NUE) for cereal production including wheat is approximately 33% [6]. The main reason for low N use efficiency is an inefficient splitting of nitrogen doses coupled with nitrogen applications more than crop requirements. Thus the use of NDVI technique is important to optimize the nitrogen use efficiency of the nitrogenous fertilisers to increase the yield.

2. MATERIALS AND METHODS

A field experiment was conducted in upland areas of research farm of the Birsa Agricultural University Farm, Kanke, Ranchi ($23^{0}17'$ N latitude, $85^{0}10'$ E longitude and 625.22 m above mean sea level), India during *Rabi* season of 2017-18 to evaluate the growth parameter, yield attributed, yield and economics of wheat variety HD2967 under precision nitrogen management guided by Greenseeker. The crop was sown on 25^{th} November and was laid out in randomised block design replicated three times. The soil of experimental plot was sandy loam in texture having low nitrogen (175.6 kg/ha), medium in phosphorous (15.38 kg/ha) and medium in potassium (183.46 kg/ha) with slightly acidic having soil pH 5.5. The mean minimum and maximum temperature throughout the cropping season ranged from 2.0ºC to 37.4ºC, and average rainfall was 10.43 mm during 2017-18. Seed rate applied was 125 kg/ha, and the wheat was sown in rows at 20 cm apart as per treatment scheduled. The crop received full dose of P (60 kg/ha) and K (40 kg/ha) as basal, while nitrogen was applied as per treatments i.e. 120 kg/ha, 150 kg/ha, 180 kg/ha and nitrogen application as guided by Greenseeker (at 45 DAS and at 65 DAS). Nitrogenous fertiliser was applied in two (at sowing and at CRI) and three (at sowing, at CRI and at tillering) split doses. Greenseeker (NDVI technique) was applied at 45 DAS (second irrigation) and 65 DAS (third irrigation) in treatments T_{11} and T_{12}. The sources of nutrient were urea, DAP and muriate of potash for N, P and K, respectively. Agricultural operations and practices were applied as recommended for the crop under irrigated condition. The crop was harvested on the first fortnight of April. Data on nutrient uptake and nitrogen use efficiency were recorded as per normal procedure.

The data recorded were statistically analysed using analysis of variance method of simple Randomised Block Design [7] to get the simple treatment effect of different combinations respectively. The tables were consulted for the purpose of comparison of the 'F' values 't' values for determination of critical difference at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Nutrient Uptake

The result of the experiment revealed that nitrogen, phosphorus and potassium uptake in grain and straw showed significant difference concerning control and were higher in respect to nitrogen management by Greenseeker. The NPK uptake in grain and straw increased with increasing level of fertility. Nitrogen (N) uptake in grain and straw was significantly higher than control, 120 kg N and 150 kg N but at par with 180 kg N. Better timing and splitting of fertiliser nitrogen application during the season was probably the major reason to increase in uptake of nitrogen by crop which resulted in enhanced biomass and leads to higher nitrogen accumulation in plants. The enhanced nutrition led improved nitrogen uptake in crop is widely in similar ecology [8].

A significant effect of nitrogen management practice was observed in phosphorus (P) uptake in grain and straw. It was significantly higher with nitrogen management combined with Greenseeker application (T_{11} and T_{12}) over control but remained at par with 120 kg N, 150 kg N and 180 kg N. Better nutrition lead to enhanced concentration of phosphorus in grain and straw of wheat which ultimately gave higher biomass, yields and resulted in more uptake of phosphorus in these treatments. The increase in plant phosphorus accumulation with SSNM which was at par with Greenseeker based balanced nutrition also reported [8].

Potassium (K) uptake in grain and straw were significantly higher than 120 kg N and control but at par with 150 kg N and 180 kg N. Similar to nitrogen and phosphorus uptake due to higher grain and straw yield lead to significant increase in potassium uptake in these treatments. Khurana et al. [8] also reported a significant increase in potassium accumulation with SSNM which was at par with Greenseeker.

3.2 Nitrogen Use Efficiency

Nitrogen use efficiency under different nitrogen management treatments for the wheat was estimated regarding recovery efficiency (RE), agronomic efficiency (AE) and physiological efficiency (PE).

Achievable levels of RE depend on crop demand for nitrogen, the supply of nitrogen from indigenous sources, fertiliser rate, timing product and mode of application. Recovery efficiency depends on the compatibility between plant demand and nutrient release from fertilizer and is affected by the application method (amount, timing, placement, nitrogen form) and factors that determine the size of the crop nutrient sink (genotype, climate, plant density, abiotic/biotic stresses). Agronomic efficiency is a product of nutrient recovery from mineral or organic fertiliser (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.

Irrespective of the level of fixed rate applied N, Greenseeker guided nitrogen application at second and third irrigation in treatment T_{12} fertilized with 140 kg N in split doses achieved significantly higher AE which was at par with 150 kg N and 180 kg N whereas significantly comparable to 120 kg N. Application of recommended dose of N in three split resulted in significantly higher AE than two split application through both the treatments were statistically at par.

Table 1. Precision nitrogen management on nutrient (nitrogen, phosphorus and potassium) uptake of wheat

Treatments	Grain Yield (q/ha)	Straw Yield (q/ha)	Nitrogen uptake ((kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
			Grain	Straw	Total uptake	Grain	Straw	Total uptake	Grain	Straw	Total uptake
T_1: (control)	20.83	36.50	33.05	18.54	51.59	6.20	1.31	7.52	7.22	47.96	55.18
T_2: (120=60+60) kg N	39.13	57.13	64.24	29.16	93.40	11.79	2.10	13.89	13.99	77.24	91.23
T_3: (120=60+30+30) kg N	41.15	59.15	68.95	30.68	99.63	12.67	2.22	14.89	15.18	81.94	97.12
T_4: (120=40+40+40) kg N	40.49	58.42	66.62	30.09	96.71	12.13	2.15	14.29	14.66	80.19	94.85
T_5: (150=75+75) kg N	41.86	61.86	71.17	32.53	103.75	12.99	2.34	15.33	15.74	86.91	102.64
T_6: (150=75+37.5+37.5) kg N	43.11	63.11	73.23	33.48	106.70	13.55	2.43	15.98	16.43	89.82	106.25
T_7: (150=50+50+50) kg N	42.78	62.78	72.00	33.15	105.16	13.32	2.39	15.71	16.04	88.79	104.83
T_8: (180=90+90) kg N	44.34	65.34	77.38	34.93	112.31	14.23	2.55	16.78	17.27	94.08	111.35
T_9: (180=90+45+45) kg N	46.19	68.19	81.79	36.97	118.76	15.18	2.70	17.88	18.22	99.61	117.83
T_{10}: (180=60+60+60) kg N	45.60	66.60	79.83	35.91	115.73	14.80	2.61	17.41	17.82	96.39	114.21
T_{11}:{136=30+30+GS=48 (45DAS)+28(65 DAS)}kg N	47.50	70.83	84.92	38.83	123.75	15.83	2.86	18.68	18.90	103.50	122.40
T_{12}:{140=30+60+GS=40 (45DAS)+10(65DAS)}kg N	48.39	71.72	86.76	39.68	126.44	16.25	2.91	19.16	19.38	106.17	125.56
SEm±	1.71	2.87	3.32	2.09	7.84	1.22	0.25	1.55	1.40	7.20	7.88
CD (P=0.05)	5.02	8.43	9.73	6.14	23.00	3.57	0.72	4.54	4.09	21.11	23.10
CV (%)	7.10	8.05	8.02	11.04	12.99	15.90	17.91	17.15	15.20	14.21	13.16

Note GS= Greenseeker

Table 2. Precision nitrogen management on nitrogen use efficiency of wheat

Treatments	Nitrogen use efficiency		
	Agronomic Efficiency (kg grain increased/ kg N applied)	**Recovery Efficiency (%)**	**Physiological Efficiency (kg grain increased/ kg N uptake)**
T_1:(control)	-	-	-
T_2:(120=60+60) kg N	15.25	34.84	43.41
T_3:(120=60+30+30) kg N	16.93	40.03	43.84
T_4:(120=40+40+40) kg N	16.33	37.60	44.12
T_5:(150=75+75) kg N	14.02	34.77	40.29
T_6:(150=75+37.5+37.5) kg N	14.85	36.74	39.88
$T_{7:}$(150=50+50+50) kg N	14.63	35.71	41.34
$T_{8:}$(180=90+90) kg N	13.06	33.73	39.40
T_9:(180=90+45+45) kg N	14.09	37.32	38.21
T_{10}:(180=60+60+60) kg N	13.76	35.64	39.74
T_{11}:{136=30+30+GS=48(45DAS)+28(65DAS)}kg N	19.61	53.06	38.21
T_{12}:{140=30+60+GS=40(45DAS)+10(65DAS)}kg N	19.68	53.46	37.89
SEm±	1.25	2.89	2.74
CD (P=0.05)	3.68	8.48	8.03
CV (%)	15.13	13.88	12.75

Note: GS = Greenseeker

Likewise, agronomic efficiency, higher recovery efficiency was also reported in treatments T_{11} and T_{12} which were guided by Greenseeker based nitrogen management but statistically remained at par with all the treatments. Here also three split was found to be significantly higher RE than two split. However, physiological efficiency followed the reverse trend because the comparative decrease in recovery efficiency was higher while a decrease in agronomic efficiency was lower and recovery efficiency being denominator caused an increase in physiological efficiency. Physiological efficiency was significantly higher in 120 kg N (in two split dose). Physiological efficiency of three split nitrogen application without using Greenseeker was numerically lower than that of two split nitrogen application.

Based on the study, the result clearly showed that when fertiliser nitrogen was applied in the right quantity and right time when the crop can translate it efficiently into grain yield through which higher fertiliser nitrogen use efficiency can be expected. Ratanoo et al. [9] and Bijay-Singh et al. [10] were reported the same result i.e. Greenseeker technology ensures higher nitrogen use efficiency.

4. CONCLUSION

On the basis of one year of experimentation, it can be concluded that application of 140 kg N in three split doses i.e. 30 kg N as basal, 60 kg N at CRI and Greenseeker guided nitrogen application of 40 kg at 45 DAS (second irrigation) and 10 kg at 65 DAS (third irrigation) recorded the highest nitrogen uptake in grain (86.76 kg/ha), nitrogen uptake in straw (39.68 kg/ha), total nitrogen uptake (126.44 kg/ha), phosphorus uptake in grain (16.25 kg/ha), phosphorus uptake in straw (2.91 kg/ha), total phosphorus uptake (19.16 kg/ha), potassium uptake in grain (19.38 kg/ha), potassium uptake in straw (106.17 kg/ha), total potassium uptake (125.56 kg/ha), and the increased agronomic efficiency from 13.06% to 19.68% and recovery efficiency from 33.73% to 53.46% with a saving of 10 kg N in comparison to 150 kg N.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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